

SCOLIOSIS RESEARCH SOCIETY

49th ANNUAL MEETING & COURSE

SEPTEMBER 10-13, 2014 • DENA'INA CENTER

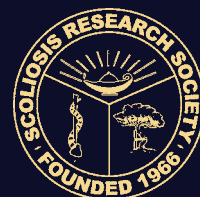
A N C H O R A G E



F I N A L P R O G R A M

www.srs.org/professionals/meetings/am14

Sponsored by the Scoliosis Research Society



DOUBLE DIAMOND LEVEL SUPPORT



DIAMOND LEVEL SUPPORT



GOLD LEVEL SUPPORT

Globus Medical

OrthoPediatrics

Stryker Spine

BRONZE LEVEL SUPPORT

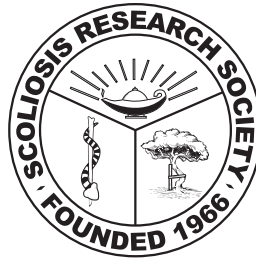
Alphatec Spine
AXS Medical
DIERS Medical Systems
Ellipse Technologies
EOS Imaging
Implanet

LifeSpine
Mazor Robotics
Medyssey
Misonix
Paradigm Spine
Sentio

SI Bone
Siemens Healthcare
SpineGuard
Thieme Publishing
Zyga Technologies

General Meeting Information



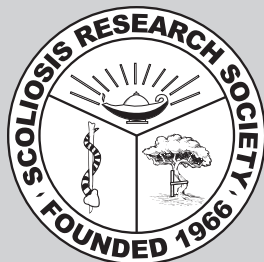


The Scoliosis Research Society gratefully acknowledges
Biomet for their support of the Pre-Meeting Course
and Annual Meeting E-News.

BIOMET[®]
SPINE

TABLE OF CONTENTS

Corporate Supporters	Inside Cover	Case Discussion and Education Program	111
General Meeting Information	2	Case Discussion Program	111
President's Message	2	Educational Program	113
Board of Directors — 2013-2014	3	Hibbs Society Meeting — Tuesday, September 9, 2014	113
Annual Meeting Committees	4	Lunchtime Symposia — Wednesday, September 10, 2014	114
General Meeting Information	5	Half-Day Courses — Thursday, September 11, 2014	115
CME Information	7	Lunchtime Symposia — Friday, September 12, 2014	118
Dena'ina Center Floorplans	8	Scientific Program	121
Meeting Outline	9	Thursday, September 11, 2014	121
Guest Lectures	10	Friday, September 12, 2014	125
Social Events & Tours	12	Saturday, September 13, 2014	133
Restaurant Guide	14	Case Discussion & Podium Presentation Abstracts	139
Opening Ceremonies Agenda — Wednesday, September 10, 2014	15	Case Discussion Abstracts	139
Conflict of Interest Disclosures	19	Podium Presentation Abstracts	149
Pre-Meeting Course Program	49	E-Poster Abstracts	213
		Author Index	263
		About SRS	275
		Board of Directors, Councils, Committees & Taskforces	276
		Meeting Outline	Back Cover



SCOLIOSIS RESEARCH SOCIETY
 555 E. Wells Street, Suite 1100
 Milwaukee, WI 53202-3823 USA
 Phone: +1-414-289-9107
 Fax: +1-276-3349
 info@srs.org • meetings@srs.org • www.srs.org



**3RD SPINE DEFORMITY SOLUTIONS:
 A HANDS-ON COURSE**
 FROM the Scoliosis Research Society (SRS)
OCTOBER 9-11, 2014
 Spine Education and Research Center (SERC)
 Burr Ridge, IL, USA
 Course Chairs: Lawrence G. Lenke, MD and Christopher I. Shaffrey, MD

PRESIDENT'S MESSAGE



Friends & Colleagues:

On behalf of the Scoliosis Research Society (SRS), it is my great pleasure to welcome to you to the 49th Annual Meeting & Course in Anchorage, Alaska. Alaska is a spectacular site for this year's meeting, and I hope that you will take this opportunity to enjoy the natural beauty of this magnificent and untamed region.

I would like to express my thanks to our Local Host James M. Eule, MD and his family for helping to introduce us to the wilds of Alaska. I know that he would welcome your questions on how best to take advantage of the many incredible sites and activities that are unique to Alaska.

While the surroundings are spectacular, the quality of this year's program will make breaking away very difficult. The Pre-Meeting Course, organized by Education Committee Chair Lori A. Karol, MD, examines how we teach and how we learn. The course includes an outstanding faculty and will be highlighted by debates between well-known mentors and their now equally well-known disciples.

Late Wednesday afternoon, following the Pre-Meeting Course, we will once again begin the Annual Meeting with a series of Case Discussion Sessions. This year's topics will include AIS; Adult Deformity; Cervical; Congenital and Neuromuscular Deformity; Neurological Deterioration and Other Major Complications. Following the Case Discussions, we invite you to join us for the Opening Ceremonies which will be highlighted by the Howard Steel Lecture "Travelogue Alaska: Negotiating 1000+ miles with a Dog Team" by Martin Buser. Mr. Buser's experiences crossing the Alaskan tundra will certainly be a memorable highlight of the meeting.

On Thursday, we begin the three-day scientific program. Thanks to a tremendous effort by the Program Committee and Program Chair James O. Sanders, MD, we have an absolutely outstanding program this year. The committee reviewed over 1,600 abstracts and the 129 papers selected for this year's meeting represent the cream of the crop. Other highlights of the meeting will include the Harrington Lecture by Jean-Pierre C. Farcy, MD and presentation of Lifetime Achievement Awards to David S. Bradford, MD and Alvin H. Crawford, MD.

Additional elements of the Educational Program include the Hibbs Society Meeting on Tuesday, September 9 from 1:00-5:00pm and Luncheon Symposia on Wednesday and Friday. There will be three outstanding Half-Day Courses offered on Thursday afternoon. These options include Surgical Techniques in the Management of Adult Spinal Deformity: Tips and Tricks, Safety in Spine Surgery and Early Onset Scoliosis. The Safety in Spine Surgery afternoon course, chaired by Kit M. Song, MD, MHA and Mark Weidenbaum, MD, will inaugurate a new SRS initiative in online learning, as the program will be broadcasted live over the Internet to members who could not join us in Anchorage.

The Farewell Reception will offer a unique insight into the culture of Alaska. It is being held at the Anchorage Museum which includes the Smithsonian Arctic Studies Center. A guided tour of this remarkable display of native Alaskan exhibits should make this an outstanding event. The museum is just a short walk from the Denaina Center and our meeting hotels.

Finally, I would just like to take this opportunity to thank the SRS Board of Directors, Council Chairs, Committee Chairs and all our devoted members for making my year as SRS President an incredibly rewarding experience. I give unlimited credit to the SRS staff, who are so devoted to the Society and deserve tremendous credit for our success. And of course, I would like to especially thank John P. Dormans, MD, Kamal N. Ibrahim, MD, FRCS(C), MA and David W. Polly, MD who have served with me on the Presidential Line. I know that I am leaving the Society in excellent hands.

Thank you so much for the honor of allowing me to serve as President of the SRS this year.

Sincerely,

Steven D. Glassman, MD

Scoliosis Research Society President 2013-2014

BOARD OF DIRECTORS — 2013-2014



Steven D. Glassman, MD
President



John P. Dormans, MD
President-Elect



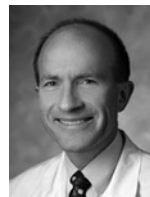
David W. Polly, Jr., MD
Vice President



Hubert Labelle, MD
Secretary



Mark Weidenbaum, MD
Secretary-Elect



Paul D. Sponseller, MD
Treasurer



Kamal N. Ibrahim, MD,
FRCS(C), MA
Past-President I



B. Stephens Richards, III, MD
Past-President II



Todd J. Albert, MD
Director at Large



David H. Clements, MD
Director at Large



Muharrem Yazici, MD
Director at Large



Laurel C. Blakemore, MD
Director at Large



Munish C. Gupta, MD
Director at Large



Stefan Parent, MD, PhD
Director at Large



Kenneth MC Cheung, MD
Research Council Chair



Frank J. Schwab, MD
Research Council Chair-Elect



Daniel J. Sucato, MD, MS
Education Council Chair



2014 SRS PRESIDENT

Steven D. Glassman, MD

2014 LOCAL ORGANIZING HOST

James M. Eule, MD

2014 SRS EDUCATION COMMITTEE

Lori A. Karol, MD, Chair

John R. Dimar, II, MD, Past Chair

Sigurd H. Berven, MD, Chair Elect

Jahangir K. Asghar, MD

Marinus de Kleuver, MD, PhD

Nicholas D. Fletcher, MD

John C. France, MD

Daniel W. Green, MD, MS, FACS

Eric O. Klineberg, MD

Nathan H. Lebowhl, MD

Jean-Christophe A. Leveque, MD

Jwalant S. Mehta, FRCS(Orth)

Praveen V. Mummaneni, MD

Chris J. Neal, MD

Elias C. Papadopoulos, MD

Miguel H. Puigdevall, MD

S. Rajasekaran, MD, FRCS, MCh, PhD

Scott S. Russo, MD

Maria Cristina Sacramento Dominguez, MD, PhD

James O. Sanders, MD

Frank J. Schwab, MD

Kit M. Song, MD

Mark Weidenbaum, MD

2014 SRS PROGRAM COMMITTEE

James O. Sanders, MD, Chair

Suken A. Shah, MD, Past Chair

Ronald A. Lehman, Jr., MD, Chair Elect

Theodore J. Choma, MD

Charles H. Crawford, III, MD

Benny T. Dahl, MD, PhD, DMSci

Paul A. Glazer, MD

Han Jo Kim, MD

Stanley S. Lee, MD

James F. Mooney, MD

Frank J. Schwab, MD

Justin S. Smith, MD, PhD

John G. Thometz, MD

2014 SRS PROGRAM REVIEWERS

Jahangir K. Asghar, MD

Patrick Cahill, MD

Samuel K. Cho, MD

Nicholas D. Fletcher, MD

Tenner J. Guillaume, MD

Andrew H. Jea, MD

Jeffrey S. Kanel, MD

Khaled Kebaish, MD

Eric O. Klineberg, MD

D. Raymond Knapp, Jr., MD

Toshiaki Kotani, MD, PhD

A. Noelle Larson, MD

Jean-Christophe A. Leveque, MD

Ahmad Nassr, MD

Joseph R. O'Brien, MD, MPH

Matthew E. Oetgen, MD

Cagatay Ozturk, MD

Ahmed M. Shawky, MD, PhD

Clifford B. Tribus, MD

Mark Weidenbaum, MD

Adam L. Wollowick, MD

Muharrem Yazici, MD

GENERAL MEETING INFORMATION

VENUE INFORMATION

Dena'ina Center
600 W 7th Ave.
Anchorage, AK 99501

ABSTRACT VOLUME

All abstracts accepted for presentation at the 49th Annual Meeting have been published in the Final Program (pages 139-260). Each attendee will receive one copy of the program along with their registration materials. Abstracts have also been posted online to the Program tab of the SRS Annual Meeting website (www.srs.org/professionals/meetings/am14/program.php).

ADMISSION TO SESSIONS

Official name badges will be required for admission to all sessions. All Annual Meeting attendees receive a name badge with their registration materials. Name badges should be worn at all times inside the Dena'ina Center, as badges will be used to control access to sessions and activities. Attendees are cautioned against wearing their name badges while away from the venue, as badges draw unwanted attention to your status as visitors to the city.

ADMISSION BY TICKETS

The Half-Day Courses on Thursday, September 11 require a ticket for admission. Tickets for these sessions are not included in the meeting's base registration fees, but are available for an additional \$30. Tickets will be collected by ushers in exchange for lunch prior to the sessions. A limited number of tickets may be available at the Registration Desk. In addition, tickets will be required for admission to the Farewell Reception. The Farewell Reception will take place at the Anchorage Museum, at an additional \$25 fee per ticket for registered delegates and registered guests. If you pre-registered, tickets may be found in your registration materials. A limited number of tickets may be available at the Registration Desk.

ATTIRE

Business casual (collared shirts and jeans or khakis) is appropriate for meeting sessions and for all Annual Meeting & Course sessions; ties are not required. Casual is also appropriate for the Farewell Reception.

CELL PHONE PROTOCOL

Please ensure that cell phone ringers, pagers and electronic devices are silenced or turned off during all sessions.

EMERGENCY & FIRST AID

The Dena'ina Center is fully prepared to handle emergency requests and first aid. Contact an SRS staff person for support. Remember to note all emergency exits within the venue.

E-POSTERS

There are over 100 E-Posters available for your review on the E-Poster kiosks in Idlughet 3 on Level 1. The E-Posters are also available on the CD-ROM included with your registration materials.

*E-Poster Kiosks are supported, in part, by grants from Orthofix and K2M.
E-Poster CD-ROMs are supported, in part, by a grant from K2M.*

EVALUATIONS

Please take time to complete the online evaluation forms provided for each session you attend. Your input and comments are essential in planning future Annual Meetings. Evaluations will be available at www.srs.org/professionals/meetings/am14 upon the commencement of the meeting.

GUEST HOSPITALITY PROGRAM

Registered guests of the Annual Meeting & Course are welcome to attend the Welcome Reception for the base registration fee on Wednesday, September 10 and the Farewell Reception on Friday, September 12 for the additional cost of \$25.

Registered guests of the Annual Meeting & Course are welcome to meet and plan their days over a continental breakfast in the Guest Hospitality Suite. The Guest Hospitality Suite is open Thursday, September 11 through Saturday, September 13 from 7:30 – 10:00 am in the Whitby Room at the Captain Cook Hotel, one of the headquarter hotels of the Annual Meeting & Course.

All registered guests are also welcome to take part in the Guest Hospitality Program on Thursday, September 11 which will feature a hands-on, interactive native beading class. Each guest will receive beads, skins and a key ring to create their own traditional Alaskan souvenir! **Please sign up on-site at the registration desk to participate if you have not pre-registered.**

INTERNET KIOSKS & INTERNET ACCESS

LOCATION: IDLUGHET 3; LEVEL 1

Attendees can search the Internet and check email at the Internet kiosks.

Wednesday, September 10	6:30am – 6:00pm
Thursday, September 11	6:30am – 4:30pm
Friday, September 12	6:30am – 5:30pm
Saturday, September 13	6:30am – 12:45pm

Wireless Internet access is available throughout the convention center, to log on select the Dena'ina network, no password needed.

Internet Kiosks are supported, in part, by grants from K2M and Orthofix.

LANGUAGE

English will be the official language of the SRS Annual Meeting & Course.

LOST & FOUND

Please feel free to stop by the SRS Registration Desk if you have lost or found an item during the Annual Meeting and Course.

MEMBERS BUSINESS MEETINGS

LOCATION: TIKAHNU AB, LEVEL 3

All SRS members are encouraged to attend the Members Business Meetings, held Thursday, September 11 through Saturday, September 13 from 6:30 – 7:45am in the Tikahtnu AB on Level 3 of the Dena'ina Center. Agendas will include reports from the various SRS committees, presentations by the 2014 Travelling Fellows and Edgar Dawson Scholarship recipients, and updates on SRS activities and programs. A hot breakfast will be served.

GENERAL MEETING INFORMATION

MESSAGES

A self-service message board (non-electronic) will be available in the Registration Area for attendees to post notes or leave messages for other attendees. Please remember to check for any messages that may be left for you.

This message center is supported, in part, by a grant from K2M.

NON-MEMBERS CONTINENTAL BREAKFAST

LOCATION: IDLUGHET 3, LEVEL 1

All non-member delegates to the SRS Annual Meeting are invited to meet with their colleagues, view posters and network over coffee and a continental breakfast served Thursday, September 11 through Saturday, September 13 from 6:30 – 7:45am in Idlughet 3 on the first level of the Dena'ina Center.

Breakfast is supported, in part, by a grant from Mazor Robotics.

PHOTOGRAPHY POLICY

SRS will be taking photographs throughout the Annual Meeting & Course. SRS will use these photos in publications and to produce related literature and products for public release. Individuals photographed will not receive compensation for the use and release of these photos and will be deemed to have consented to the use and release of photos in which they appear. If you are opposed to being photographed, please immediately notify the photographer or an SRS staff member if your picture is taken. Thank you for your cooperation.

REGISTRATION DESK

LOCATION: LEVEL 1 LOBBY

Tuesday, September 9	2:00 – 6:00pm
Wednesday, September 10	6:30am – 6:00pm
Thursday, September 11	6:30am – 4:30pm
Friday, September 12	6:30am – 5:15pm
Saturday, September 13	6:30am – 12:45pm

SMOKING POLICY

Smoking is not permitted during any meeting activity or event.

SPEAKER UPLOAD AREA

LOCATION: IDLUGHET 1/2, LEVEL 1

Presenters may upload their PowerPoint presentations in the Presentation Upload Area, located at the back of the general session room, Idlughet Hall, Level 1.

****Presentations may not be uploaded in individual rooms but must be uploaded in the Presentation Upload Area.****

Wednesday, September 10	6:30am – 6:00pm
Thursday, September 11	6:30am – 4:30pm
Friday, September 12	6:30am – 5:30pm
Saturday, September 13	6:30am – 12:45pm

SPECIAL NEEDS

If you have any health issues for which you may require special accommodations or assistance, please notify the SRS staff at the Registration Desk. We will make every effort to accommodate any special needs.

VIDEO RECORDING PROHIBITED

SRS does not allow personal video recording of the presentations of any kind. SRS holds the right to confiscate any and all recordings taken of any of the presentations. All session rooms will be recorded and will be available to delegates after the meeting on the SRS website.

SRS ANNUAL MEETING & COURSE MOBILE APP

A mobile and online app will be available to all delegates during the 49th Annual Meeting & Course. The app is designed to provide all the information about the Annual Meeting & Course and Anchorage in one convenient location and can be accessed from any smart phone or computer with an internet connection. To download the app visit <http://eventmobi.com/srsam14> or scan the QR code below with your smart phone.

- Download all the abstracts and final program right from the app!
- An offline mode will allow delegates to access all static content, including the agenda, speaker listing and info booth, on the app without an internet connection.
- A detailed Annual Meeting agenda that allows delegates to create a personalized schedule.
- An information booth featuring everything you need to know about the Annual Meeting & Course, and its host city of Anchorage, including scientific and social program details, information on the Dena'ina Center, as well as downtown Anchorage dining and attractions.
- Live audience polls during the Pre-Meeting Course, Half-Day Course and a Hibbs Award voting poll on Friday, September 12.
- Maps of the Dena'ina Center and meeting space.
- An alert system for real-time updates from SRS - program changes, tour and social event notifications, and breaking news as it happens.
- A complete list of Annual Meeting faculty and podium presenters, including presentation titles, times, dates and locations.

To learn more about the app or how to use the QR code, please refer to the insert in your registration bag or visit www.srs.org.

** Please remember to activate your wireless access on your mobile device or tablet to utilize the mobile app without incurring international fees and charges!*



<http://eventmobi.com/srsam14>



CME INFORMATION

MEETING DESCRIPTION

The Scoliosis Research Society (SRS) Annual Meeting & Course is a forum for the realization of the Society's mission and goals, the improvement of patient care for those with spinal deformities. Over 125 papers will be presented on an array of topics, including adolescent idiopathic scoliosis, growing spine, kyphosis, adult deformity, trauma, neuromuscular scoliosis and tumors.

LEARNING OBJECTIVES

Upon completion of the Annual Meeting, participants should be able to:

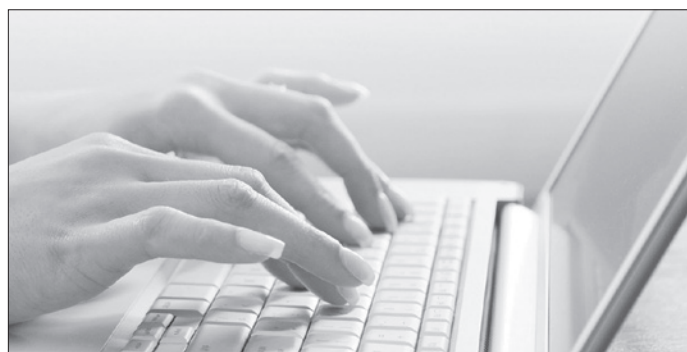
- Detect factors which may contribute to higher complication rates or risk of reoperation and incorporate pre- and peri-operative steps that help to avoid complications in spinal deformity surgery.
- Assess clinical and radiographic factors that contribute to positive or negative outcomes in spinal deformity surgery and utilize this knowledge to prevent adverse outcomes.
- Describe new techniques for the treatment of patients with spinal deformity.
- Identify the short and long-term effect of fusion for patients with spinal deformity using a variety of correction strategies and implants.

TARGET AUDIENCE

Spine surgeons (orthopaedic and neurological surgeons), residents, fellows, nurses, nurse practitioners, physician assistants, engineers and company personnel.

ACCREDITATION STATEMENT

This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education (ACCME) through the sponsorship of the Scoliosis Research Society (SRS). SRS is accredited by the ACCME to provide continuing medical education for physicians.



VIDEO ARCHIVES

Instant video archives will be available to all meeting delegates on the SRS website (<http://www.srs.org/meetings/>) four to six weeks after the meeting. All session rooms, both main ballrooms and break-out rooms, are being recording. If you were unable to attend a concurrent session, don't forget to watch it on the website!

CREDIT DESIGNATION

SRS designates this live activity for a maximum of 28 (8.25 for Pre-Meeting Course, 19.75 for Annual Meeting) *AMA PRA Category 1 Credit(s)*[™]. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

DISCLOSURE OF CONFLICT OF INTEREST

It is the policy of SRS to insure balance, independence, objectivity and scientific rigor in all of their educational activities. In accordance with this policy, SRS identifies conflicts of interest with instructors, content managers and other individuals who are in a position to control the content of an activity. Conflicts are resolved by SRS to ensure that all scientific research referred to, reported or used in a CME activity conforms to the generally accepted standards of experimental design, data collection and analysis. Complete faculty disclosures will be included in the final program.

FDA STATEMENT (UNITED STATES)

Some drugs and medical devices demonstrated during this course have limited FDA labeling and marketing clearance. It is the responsibility of the physician to be aware of drug or device FDA labeling and marketing status.

INSURANCE/LIABILITIES AND DISCLAIMER

SRS will not be held liable for personal injuries or for loss or damage to property incurred by participants or guests at the Annual Meeting & Course including those participating in tours and social events. Participants and guests are encouraged to take out insurance to cover loss incurred in the event of cancellation, medical expenses or damage to or loss of personal effects when traveling outside of their own countries.

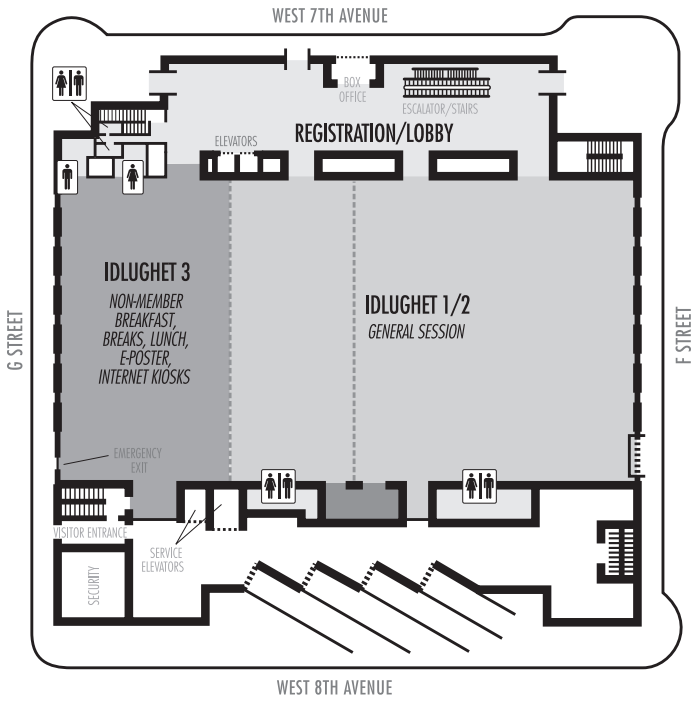
SRS cannot be held liable for any hindrance or disruption of the Annual Meeting & Course proceedings arising from natural, political, social or economic events or other unforeseen incidents beyond its control. Registration of a participant or guest implies acceptance of this condition.

The materials presented at this Continuing Medical Education activity are made available for educational purposes only. The material is not intended to represent the only, nor necessarily best, methods or procedures appropriate for the medical situations discussed, but rather is intended to present an approach, view, statement or opinion of the faculty that may be helpful to others who face similar situations.

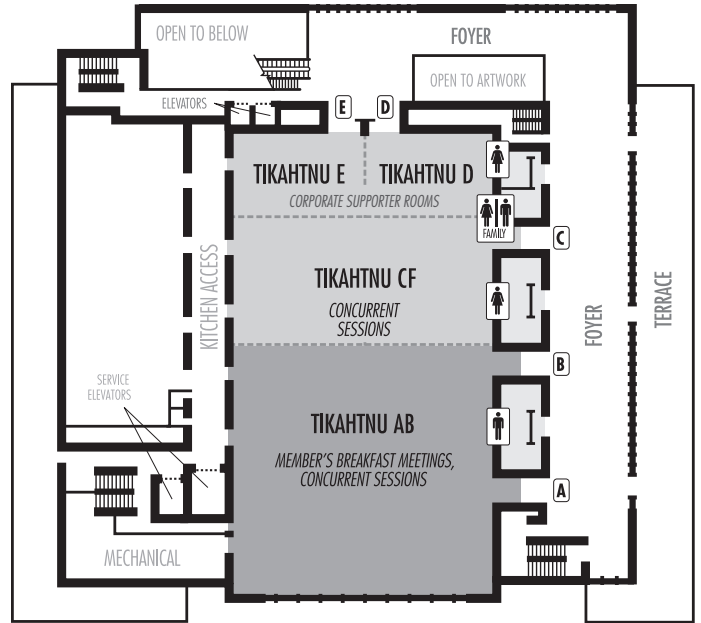
SRS disclaims any and all liability for injury or other damages resulting to any individual attending a scientific meeting and for all claims that may arise out of the use of techniques demonstrated therein by such individuals, whether these claims shall be asserted by a physician or any other person.

DENA'INA CENTER FLOORPLANS

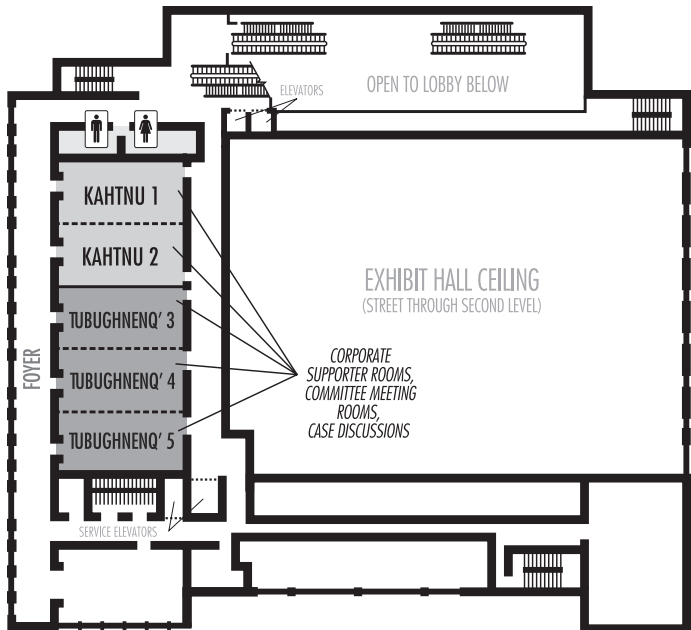
LEVEL 1



LEVEL 3



LEVEL 2



MEETING OUTLINE *(subject to change)*

MEETING OVERVIEW

Monday, September 8, 2014	
8:00 AM – 4:00 PM	Board of Directors Meeting
Tuesday, September 9, 2014	
7:00 AM – 5:00 PM	SRS Committee Meetings
1:00 – 5:00 PM	Hibbs Society Meeting
2:00 – 6:00 PM	Registration Open
7:00 – 10:00 PM	SRS Leadership Dinner (by invitation only)
Wednesday, September 10, 2014	
6:30 AM – 6:00 PM	Registration Open/ Internet Kiosks, E-Posters Open
7:45 – 11:55 AM	Pre-Meeting Course – Morning Sessions
12:10 – 1:10 PM	Lunchtime Symposia
1:20 – 4:30 PM	Pre-Meeting Course – Afternoon Sessions
4:45 – 5:45 PM	Case Discussions
6:00 – 7:15 PM	Opening Ceremonies
7:15 – 9:00 PM	Welcome Reception
Thursday, September 11, 2014	
6:30 AM – 4:30 PM	Registration Open/ Internet Kiosks, E-Posters Open
6:30 – 7:45 AM	Members Business Meeting/ Non-Members Continental Breakfast
7:30 – 10:00 AM	Spouse Hospitality Suite (at the Captain Cook)
7:55 AM – 12:30 PM	Scientific Program
12:30 – 1:30 PM	Lunch & Networking for Half-Day Course Participants Member Information Session
1:30 – 4:30 PM	Half-Day Courses
Friday, September 12, 2014	
6:30 AM – 5:15 PM	Registration Open/ Internet Kiosks, E-Posters Open
6:30 – 7:45 AM	Members Business Meeting/ Non-Members Continental Breakfast
7:30 – 10:00 AM	Spouse Hospitality Suite (at the Captain Cook)
7:55 – 11:50 AM	Scientific Program
12:00 – 1:00 PM	Lunchtime Symposia
1:15 – 5:15 PM	Scientific Program
7:00 – 10:00 PM	Farewell Reception
Saturday, September 13, 2014	
6:30 AM – 12:45 PM	Registration Open/ Internet Kiosks, E-Posters Open
6:30 – 7:45 AM	Members Business Meeting/ Non-Members Continental Breakfast
7:30 – 10:00 AM	Spouse Hospitality Suite (at the Captain Cook)
7:55 AM – 12:45 PM	Scientific Program
1:00 – 3:30 PM	Board of Directors Meeting

GUEST LECTURES

HOWARD STEEL LECTURE

Wednesday, September 10, 2014

Martin Buser

Four-Time Iditarod Winner

"Travelogue Alaska: Negotiating 1000+ miles with a Dog Team"



Born in Winterthur, Switzerland in 1958, Martin became fascinated with sled dogs while still a teen. He came to Alaska in 1979 to enhance his knowledge of care and training of sled dogs. He began working and training with long-time Alaskan mushers Earl and Natalie Norris and ran his first Iditarod in 1980. Martin and wife Kathy Chapoton, a

retired teacher, reside in Big Lake, Alaska, where the family owns and manages Happy Trails Kennel. Their sons, Nikolai and Rohn, both named after Iditarod checkpoints, have been involved with dogs at various times in their lives. Nikolai currently resides in Seattle. Rohn lives near the kennel and is an integral part of the kennel operation. Rohn completed his first Iditarod in 2008, as a senior in high school.

Martin spends a great deal of time speaking in schools on the humanitarian care of animals and the spirit of the Iditarod. A favorite celebrity of the children of Alaska, Martin treats them with surprise visits from his dogs and puppies.

Martin runs the race each year with his dogs to test the success of their breeding, training and physical endurance. He regards his racers as true competitive athletes and prides his team on their longevity and spirit of competition. Says Martin, "I run the Iditarod to prove that my dogs, bred, trained and raced by Happy Trails Kennels, are the best amongst the world's long distance athletes." For nine years, Martin's 2002 team held the record for the Fastest Iditarod by completing the race in 8 days, 22 hours, 46 minutes and 2 seconds.

As tribute to his treatment of his racers, Martin was awarded the coveted Leonhard Seppala Award in 1988, 1993, 1995 and again in 1997 for the most humanitarian care of his dogs. The award was named for the most famous Alaskan musher who ran the longest and most dangerous stretch of the 1925, 674-mile diphtheria serum run from Nenana to Nome, which saved hundreds of lives.

Following Martin's 2002 Iditarod victory, the process for his becoming a naturalized citizen of the United States was completed under the burlud monument. He then turned around in Nome and made the trip from Nome to Big Lake with his family by snowmachine.

Upon completion of the 2005 Iditarod after a woodworking accident 4 days prior to the race start resulting in the amputation of a part of his finger; he was awarded both the Sportsmanship and Most Inspirational Awards by his fellow mushers.

Martin is an honorary member of Rotary. He is always involved with some project around the kennel or house. While he and Kathy moved into the retirement home that Martin built, they are still working on finishing all the details, your typical Alaskan self built home that is never quite finished.

In the summer, Martin and his family give tours of their working kennel. The tour begins with a DVD trip from Anchorage to Nome narrated by Buser and includes his unique anecdotal stories gathered over 23 Iditarods. Visitors are offered a glimpse of a mock up of the Cripple Checkpoint complete with campfire and wall tent. Veterinary and dog care topics are discussed and of course, there's the cuddling of puppies. The tour ends with a riotous symphony of dogs barking as a team is hooked up and taken on a demo run to show folks the dogs in action.

Sprocketheads, LLC produced a DVD featuring the unique lifestyle made possible by training and racing sled dogs. The DVD, *For the Love of Dogs*, is available from www.buserdog.com along with other Happy Trails Merchandise. The DVD captures a sled dog's life from puppyhood to racing and Martin's interaction with his athletic friends.

HARRINGTON LECTURE

Thursday, September 11, 2014

Jean Pierre Farcy, MD, FACS

"50 Years of Spine Deformity Surgery"



Jean-Pierre Farcy, MD, graduated from Marseille-Aix Medical School. After successfully completing a competitive exam was named "Interne des Hôpitaux," and trained as a surgeon specializing in trauma. The thesis on Scheuermann's disease demonstrated a major interest in spine pathology and surgery. Board certified in France as an orthopedic surgeon, he pursued an academic career first in Marseille followed by 30 years in the USA where he had the opportunity to teach orthopedic spine deformity surgery at both Columbia and New York Universities.

Dr. Farcy has published extensively about spine and co-authored many textbooks. A member of national and international scientific societies, he has been invited as visiting professor at several universities in the US and in other countries. In 2001 Dr. Farcy served as President of the 76th Reunion of the French Academy of Orthopedic Surgery (S.O.F.C.O.T.) in Paris.

With pre-eminent colleagues in the field of spine surgery and research, he has created the, "Balance Research Foundation" dedicated to a better understanding of how balance affects our quality of life.

WALTER P. BLOUNT HUMANITARIAN AWARD RECIPIENT

The 2014 Walter P. Blount Humanitarian Award will be presented on Wednesday, September 10, acknowledging outstanding service to those with spinal deformity, and for generosity to the profession and society.



Steven M. Mardjetko, MD, FAAP is Division Chief of Spine Surgery in the Department of Orthopaedic Surgery at Advocate Lutheran General Hospital, Park Ridge, Illinois and is an Associate Professor at Rush University Medical Center, in Chicago, Illinois.

GUEST LECTURES

Dr. Mardjetko graduated from the University of Illinois College of Medicine in 1982 and performed his residency in Orthopaedic Surgery at the University of Illinois Medical Center. He completed a spinal deformity fellowship at Rush Presbyterian-St. Luke's Medical Center in 1988 and a Pediatric Orthopaedic Fellowship at the Chicago Shriners Hospital for Children in 1989. He was board certified by the American Board of Orthopaedic Surgery in 1992.

Dr. Mardjetko is an active member of the American Academy of Orthopaedic Surgeons, Illinois Association of Orthopaedic Surgeons and the Scoliosis Research Society where he has served on its Board of Directors.

Dr. Mardjetko's commitment to providing medical care to the underprivileged began in 1992 with the formation of the Silver Service Pediatric Orthopaedic Mission to Cali, Colombia. From 2000-2006 he was the Director of the Cali Colombia Pediatric Spinal Deformity Mission. In 2007, Dr. Mardjetko assisted in the development and implementation of the Bulgaria Pediatric Spinal Deformity Mission. He served as Director of the SRS Bulgaria Mission from 2007-2013.

LIFETIME ACHIEVEMENT AWARD RECIPIENTS

The 2014 Lifetime Achievement Awards will be presented on Thursday, September 11. The Lifetime Achievement Award Recipients were chosen from among the SRS membership, based on long and distinguished service to the Society and spinal deformity research and care.



David S. Bradford, MD

Dr. David S. Bradford was born in Charlotte, NC. He received his college education at Davidson College, medical training at the University of Pennsylvania Medical School where he graduated in 1962. He received his surgical and orthopedic training at Columbia Presbyterian Medical School which

he completed in 1970. He joined the Orthopedic Surgical Department of the University of Minnesota in 1970 where he subsequently became a full professor and directed the spine service. He was recruited to UCSF in 1990 as Professor and Chairman, a position he held until he stepped down in 2005.

He has been President of the Association of Bone and Joint Surgeons, the Scoliosis Research Society and the Federation of Spine Surgeons. He has held a variety of academic and administrative positions at U of M as well as UCSF. He has lectured extensively throughout North and South America, Europe and Asia. He has been a recipient of NIH funding for over 20 years, and has published over 200 papers in peer reviewed journals. He has also served as Chairman of United Health Group Advisory Board for Neuroscience and Orthopedics from 2005 - 2013. He is a member of a number of scientific advisory boards of med tech companies and has been a Venture Partner of KVP on S/F for the last seven years.

Dr. Bradford is a co-founder of Nocimed and Relievent, and a member of the Board of Directors of PDP, a company focused on episode of care and bundle

payment management. He holds over 12 patents and has been listed as one of the best doctors in America over the past 20 plus years.

Dr. Bradford is married to Sharon Whittier Hodges and they have four children together. She is an active horsewoman and sits on the Board of Directors of Casa del Herero, SB Zoo and Direct Relief International. Their hobbies include golf, tennis and travel. They are members of the Valley Club of Montecito and Birnam Wood.



Alvin H. Crawford, MD

Alvin H Crawford MD, FACS graduated Cum Laude from Tennessee State University, where he became the first African American to graduate from the University Of Tennessee College Of Medicine. He completed his residency at Boston (Chelsea) Naval Hospital and at the combined Harvard University Orthopaedic Program. His postgraduate fellowships included the OREF Carl-Berg International fellowship; Otto Aufranc Reconstructive Surgery of the Hip; Pediatric Orthopaedics at Children's Hospital, Boston, MA; the Alfred I. DuPont Institute, Wilmington, DL, and the Senior Scoliosis Research Society Asian Traveling Fellowship. Dr. Crawford was Chief of Orthopaedic Surgery at Cincinnati Children's Hospital Medical Center for 29 years. He has trained 54 fellows in Pediatric Orthopaedics and Spine Surgery. He has published more than 200 peer-reviewed articles, more than 63 chapters and six books. He is a fellow of the American Academy of Orthopaedic Surgeons, American Academy of Cerebral Palsy, the American Academy of Pediatrics, the American College of Surgeons and Scoliosis Research Society. Among his long list of positions, honors and awards include president of the Scoliosis Society in 2001; presidential guest speaker 2004 AAOS; the 2007 Diversity Award from the American Academy of Orthopaedic Surgeons; the 2009 Candle in the Dark Award from Morehouse college for his contributions in the field of Medicine; and the 2008 Hall of Fame of Historically Black Colleges and Universities. He presented the prestigious Paul Harrington, MD Lecture at the Scoliosis Research Society in 2012; Presidential Oration at the Indian Pediatric Orthopaedic Society in 2013; received the Lifetime Achievement Award in Medicine from Closing the Health Gap in Cincinnati; Mayor Mark Mallory proclaimed May 8, 2013 to be Dr Alvin Crawford day in Cincinnati; the Laurel Wreath Award from Kappa Alpha Psi fraternity in 2013, its highest award for a members' achievement in service; and the Distinguished Achievement Award from the Pediatric Orthopaedic Society in 2014. Currently, Dr. Crawford is a prep student in Clarinet at the Cincinnati College Conservatory of Music performing in the Queen City Concert Orchestra and University Community Band. He is Professor Emeritus in Pediatrics and Orthopaedic Surgery at the University Of Cincinnati College Of Medicine; and has been married to Alva Jean for 50 wonderful years. They have two children, Alvin and Carole; and are proud grandparents to Mia, Elle and Uma.

SOCIAL EVENTS

OPENING CEREMONIES & WELCOME RECEPTION

Wednesday, September 10, 2014

6:00 – 9:00 PM

Open to all registered delegates and their registered guests at no additional fee. Name badges are required.

The Annual Meeting will officially begin with the Opening Ceremonies and this year's Howard Steel Lecture is presented by Martin Buser, four-time Iditarod winner. The evening will include an introduction of the SRS officers and honored presidents from other spine societies. All delegates and registered guests are invited and encourage to attend the Opening Ceremonies. Following the Opening Ceremonies, we will move to a hosted reception featuring heavy hors d'oeuvres, cocktails and plenty of lively conversations and reunions with colleagues and friends.

The Welcome Reception is supported, in part, by grants from Medtronic and SpineCraft.

FAREWELL RECEPTION

Friday, September 12, 2014

7:00 – 10:00 PM

Open to all registered delegates and registered guests. Tickets are \$25 each and should be purchased in advance. A limited number of tickets may be available onsite but SRS strongly urges delegates and guests to purchase tickets at the time of registration. Name badges are required.

The 49th Annual Meeting & Course will culminate with a cultural experience at the Anchorage Museum at Rasmuson Center. Enjoy exhibits about Alaskan culture and heritage including guided tours of the Smithsonian Arctic Studies Center. The exhibition features more than 600 objects from the Smithsonian's collections that were selected and interpreted with help from Alaska Native advisers. In addition, 2014 marks the 50th anniversary of the Great Alaskan Earthquake of 1964 which measured a magnitude of 9.2 on Good Friday, March 27, 1964. A special exhibit commemorating this event will be on display at the museum.

The museum is just a short walk from the Dena'ina Center and the headquarter hotels; directions will be provided with your ticket. A limited number of buses will be departing the Hilton and Captain Cook at 7:00 PM, and will continue between the headquarter hotels and the museum until 10:00 PM.

The Farewell Reception is supported, in part, by a grant from OrthoPediatrics and SpineCraft.

TOURS

OPTIONAL TOURS

The following tours are available to registered delegates and guests through Alaska Destination Specialists (ADS), our partners in Anchorage. **Any questions including tour availability, registration or tour details should be directed to ADS by calling +1-907-276-5500 or emailing srs@alaskadestinations.com.**

Tuesday, September 9		
Prince William Sound	9:30 AM – 7:30 PM	\$226.70
Wednesday, September 10		
National Park Zip Lining	8:00 AM – 6:00 PM	\$320.50
Coastal Trail Bike Ride	1:00 – 4:00 PM	\$60.00
Thursday, September 11		
Ride and Row	10:00 AM – 4:30 PM	\$143.00
Anchorage Highlights Tour	12:30 – 4:00 PM	\$102.00
Friday, September 12		
Anchorage Highlights Tour	8:30 AM – 12:00 PM	\$102.00
National Park Zip Lining	8:00 AM – 6:00 PM	\$320.50

Prince William Sound

Tuesday, September 9, 2014

9:30 AM – 7:30 PM

\$226.70 per person

Travel by exclusive motorcoach along the beautiful coast of the Turnagain Arm to Portage and through the Whittier Tunnel, the longest tunnel in North America. Tunnel through the Chugach Mountain Range and emerge in the small town harbor of Whittier, the gateway to Prince William Sound. Board a high-speed catamaran for a spectacular sightseeing glacier cruise. In addition to viewing glaciers, participants will have the opportunity to view sea otters, bald eagles, fur seals, doll porpoise, sea lions and whales during the cruise. The most common whales in Prince William Sound are Humpback and the Orca or killer whale. Passengers may also spot wildlife such as bear or mountain goats. This cruise will travel to Barry Arm to view Cascade, Barry and Cox Glaciers as well as into the Harriman Fjords and on to Surprise Glacier. Travel over 135 miles into Prince William Sound and come face to face with these towering masses of ice while the calm protected waters of Prince William Sound offer a rare no seasickness policy. Lunch is included during the cruise.

Price includes roundtrip transportation, driver gratuity, five-hour glacier cruise and lunch.

National Park Zip Lining

Wednesday, September 10, 2014

Friday, September 12, 2014

8:00 AM – 6:00 PM

\$320.50 per person

Travel two hours north of Anchorage with an experienced guide narrating the trip to the quaint town of Talkeetna. Once in Talkeetna, explore Alaska's boreal forests and take in stunning views of Mt. McKinley (Denali) and the Alaska Range from tree-top platforms or while careening through the air. Learn about the natural history of the area and rappel through it. Afterward, take a guided walking tour through downtown Talkeetna; explore the climbing mountain and stop for lunch at one of the locally owned, historic eateries for a hearty Alaskan lunch before making the return to Anchorage.

Price includes roundtrip transportation, three-hour zip line adventure, lunch, snacks, bottled water and guide gratuity.

Coastal Trail Bike Ride

Wednesday, September 10, 2014

1:00 – 4:00 PM

\$60.00 per person

Anchorage is fortunate to have an award-winning trail system throughout the city and along the scenic coastline. On this trip, participants will take a guided ride along the inlet on the route voted best trail to view moose in Anchorage! Participants can expect to enjoy panoramic views of the Cook Inlet and the chance to view Mt. McKinley as they ride along this paved trail. The trail is non-technical and good for all skill levels.

Price includes three-hour guided bike tour, snacks, bottled water, equipment rental (helmet mandatory) and guide gratuity.

Ride and Row

Thursday, September 11, 2014

10:00 AM – 4:30 PM

\$143.00 per person

Travel north on the Glenn Highway for a scenic drive through Alaska's backcountry and arrive at the seven-mile long lake created by the retreat of Eklutna Glacier which is fed by glacial and fresh water streams. An experienced guide will lead participants in kayaks across the lake pointing out any wildlife sightings along the way. Participants may encounter moose, waterfowl, dall sheep and porcupines, just to name a few, as they make their way through the pristine waters. Once across the lake, participants will stop for a lake-side lunch and campfire before making the guided return trip via mountain bikes. No experience necessary, a kayaking lesson will be provided by the guide.

Price includes roundtrip transportation, driver gratuity, guided kayaking, safety equipment (mandatory), guided mountain bike trail ride, lunch and guide gratuity.

TOURS

Anchorage Highlights

Thursday, September 11, 2014

12:30 – 4:00 PM

Friday, September 12, 2014

8:30 AM – 12:00 PM

\$102.00 per person

Tour begins with a curbside pick-up from the hotel at 9:00 AM and 1:00 PM. This narrated tour of Anchorage includes highlights such as Lake Hood, the world's largest float plane base and historic downtown. Learn about how the 1964 earthquake changed the face of Anchorage as we know it today. There will be a stop at the Alaska Native Heritage Center, a renowned cultural center and museum, for a guided tour. Guests will hear the history of our great state beginning with the first people coming to Alaska across the Bering Sea Land Bridge to present day as they walk a wooded path around beautiful Lake Tiulana and visit six life-sized Alaskan native culture sites. This tour will share the rich heritage of Alaska's eleven native cultural groups drawing upon the ways of life from long ago and time-honored traditions.

Price includes roundtrip transportation, driver gratuity, three-hour guided tour, bottled water, snacks and admission fees.

TOUR GUIDE RECOMMENDATIONS

By Local Host, James M. Eule, MD

ALASKAN SALMON OR RAINBOW TROUT FISHING ON THE KENAI RIVER

Fenton Bros

+1-907-262-2502

www.fentosbrosfishing.com

Try your luck for some Alaskan salmon or large rainbow trout on the Kenai River! A three-hour drive or one-hour flight gets you to the banks of the Kenai River that over 2 million salmon run up a year! Spend a day or week fishing with top guides for salmon or trout. If you're an avid fly fisherman or a novice who's always wanted to try, you can get into some great fishing. Don't worry about bringing any of your fishing gear to Alaska, just show up and catch some fish! Lodging can also be arranged in the Kenai River area.

CUSTOM DESIGN YOUR OWN FLIGHT-SEEING TOUR

Madura Air II

Mark

+1-907-243-7133

Pick your adventure and see Anchorage, Denali, glaciers and wildlife from the sky! Tours are available from one to four hours in length and can be customized to your liking.

PRE- AND POST-CONFERENCE ACTIVITY SUGGESTIONS

Bear Viewing – Leave Anchorage via floatplane to Silver Salmon Creek Lodge, approximately a 75-minute flight. Land in Silver Salmon Creek Lake, canoe or boat about a ½ mile to trailhead and hike approximately ¾ mile to lodge (four wheelers available for non-hikers). Bear viewing followed by lunch at lodge and return to Anchorage.

Day Raft Trip on Lake Creek – Departure from Quiet Lake which is approximately one hour by float plane from Anchorage. After a short ¾ mile downhill hike to Lake Creek, raft 19 miles while possibly seeing bears, moose and eagles. Grab lunch at RiverSong Lodge sandbar and return to Anchorage that evening.

Fly-Out Day Fishing Trip – Fly to Yenta River Lodge from Anchorage and fish Silver Salmon from boats. Other fishing opportunities for large Northern Pike or Trout are available on request.

Horseback Riding in Rainy Pass – Fly into the Alaska Range in Rainy Pass where the Iditarod runs through. Take a scenic horseback ride through the wilderness

Alaska Railroad Tours – See Alaska by Rail. Trips available through www.alaskarailroad.com

RESTAURANT GUIDE

4-5 STAR RESTAURANTS IN ANCHORAGE:

Crow's Nest – 20th floor of Captain Cook Hotel: Steak and seafood (Fine dining)

Simon and Seafort's – Steak and seafood (Fine dining)

Sullivan Steakhouse

Club Paris – Steakhouse

Glacier Brewhouse – Local brew with something for everyone

Marx Brothers – Steak and seafood (Fine dining)

Sack's Café – (Fine dining)

Orso's – Casual atmosphere with wide array of good food

Jen's – Don't let the strip mall location fool you (Fine dining)

Villa Nova – Casual atmosphere with wide array of good food

Sushi Places:

Peter's Sushi Spot

Samurai Sushi

Dish Sushi

In Girdwood:

Double Musky – New Orleans Cajun meets Alaska (Casual dining)

Jack Sprat – Fine dining, mostly organic

Seven Glaciers – Ride the tram to the top of Alyeska for fine dining

OPENING CEREMONIES

Wednesday, September 10, 2014
DENA'INA CENTER – ANCHORAGE ALASKA

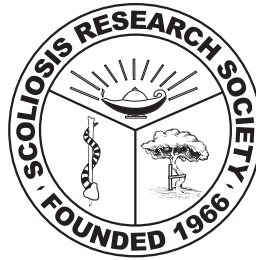
- 6:00 – 6:05 PM **Welcome to Anchorage**
James M. Eule, MD
- 6:05 – 6:10 PM **Presidential Welcome**
Steven D. Glassman, MD, President
- 6:10 – 6:20 PM **Introduction of Visiting Presidents**
Introduction of SRS Traveling Fellows
Introduction of Fellowship and Award Recipients
Steven D. Glassman, MD, President
- 6:20 – 6:25 PM **Presentation of Blount Humanitarian Award**
Introduction by Steven D. Glassman, MD, President
Presentation by John M. Wattenbarger, MD, Awards & Scholarships Committee Chair
- 6:25 – 6:35 PM **Acknowledgement of Corporate Supporters**
Introduction by Steven D. Glassman, MD, President
Presentation by Kamal N. Ibrahim, MD, FRCS(C), MA, Past President & Corporate Relations Committee Chair
- 6:35 – 6:40 PM **Introduction of Howard Steel Lecturer**
James M. Eule, MD
- 6:40 – 7:10 PM **Howard Steel Lecture**
"Travelogue Alaska: Negotiating 1000+ miles with a Dog Team"
Mr. Martin Buser
- 7:10 – 7:15 PM **Closing Remarks**
Steven D. Glassman, MD, President

Please join us for the Welcome Reception, immediately following the Opening Ceremonies
7:15 – 9:00 PM

The Welcome Reception is supported, in part, by grants from Medtronic & SpineCraft

Conflict of Interest Disclosures

Conflict of Interest
Disclosures



The Scoliosis Research Society gratefully acknowledges
DePuy Synthes for their support of the
Half-Day Course Webcast, Pre-Meeting Course,
Half-Day Courses and overall support of the
49th Annual Meeting & Course.



AUTHOR DISCLOSURES

SCOLIOSIS RESEARCH SOCIETY BOARD OF DIRECTORS

Steven D. Glassman, MD	USA	Medtronic (g); N2QOD (e); Norton Healthcare (a,f); NuVasive (a); Scoliosis Research Society (e)
John P. Dormans, MD	USA	Brooke (g); Elsevier (g); Mosby (g); Shriner (e); Veritas Health (e)
David W. Polly, Jr., MD	USA	No Relationships
Hubert Labelle, MD	Canada	DePuy Synthes (a,f); Medtronic (f); Spinologics (g)
Mark Weidenbaum, MD	USA	No Relationships
Paul D. Sponseller, MD	USA	DePuy Synthes (a,b,g); Globus Medical (g); J Bone Joint Surgery (e); Oakstone Medical Publishers (e)
Kamal N. Ibrahim, MD, FRCS(C), MA	USA	DePuy Synthes (g); SpineCraft (g)
Todd J. Albert, MD	USA	Biomerix (e,g); Biomet Spine (g); DePuy Synthes (b,g); Facetlink (b); In Vivo (e,g); K2M (e,g); Paradigm (e); Pioneer (e,g); PMIG (g); Spinicity (g); United Healthcare (e); Vertech (e)
Laurel C. Blakemore, MD	USA	K2M (a,b,e); Stryker (b)
Kenneth M. Cheung, MBBS(UK), MD, FRCS(England), FHKCOS, FHKAM(ORTH)	Hong Kong	Ellipse Technologies (a,b)
David Clements, MD	USA	DePuy Synthes (a,b,d,g)
Munish C. Gupta, MD	USA	DePuy Synthes (b,e,g); FOSA (e); Medtronic (b); Orthofix (b); Spinal Ventures (g)
Stefan Parent, MD, PhD	Canada	DePuy Synthes (a,b); EOS Imaging (a,b); Medtronic (b); Setting Scoliosis Straight Foundation (a); Spinologics (g)
B. Stephens Richards, III, MD	USA	Journal of Pediatric Orthopedics (e); Pfizer (c); POSNA (e); Saunders – Elsevier (g); Scoliosis Research Society (e)
Frank J. Schwab, MD	USA	AO (a); DePuy Synthes (a,b); ISSG (a); K2M (b,d,g); Medicea (g); MSD (a,b,d); Nemaris (d,g); NIH (a)
Daniel J. Sucato, MD, MS	USA	DePuy Synthes (a); NuVasive (a)
Muharrem Yazici, MD	Turkey	DePuy Synthes (b); K2M (b)

STAFF

Kathryn Agard	USA	No Relationships
Shahree Douglas, MS	USA	No Relationships
Tressa Goulding, CAE, CMP	USA	No Relationships
Courtney Kissinger	USA	No Relationships
Ashtin Kitzerow	USA	No Relationships
Cydni Schaeffler	USA	No Relationships
Stephanie Tesch	USA	No Relationships
Nilda Toro	USA	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

PROGRAM COMMITTEE *(if not listed above)*

Theodore J. Choma, MD	USA	DePuy Synthes (b); Gentis (e); Stryker Spine (b)
Charles H. Crawford, III, MD	USA	Alphatec (b); DePuy Synthes (d); Medtronic (b)
Benny Dahl, MD, PhD, DMSci	Denmark	Globus Medical (a,b); Medtronic (b); K2M (a)
Paul A. Glazer, MD	USA	Axiomed (e); Biomet Spine (b); NuVasive (b)
Han Jo Kim, MD	USA	CSRS (a); K2M (d); Medtronic (e); SRS (a)
Stanley S. Lee, MD	USA	No Relationships
Ronald A. Lehman, MD	USA	DePuy Synthes (a); DMRDP (a); Centinel Spine (a)
James F. Mooney, MD	USA	No Relationships
James O. Sanders, MD	USA	NIAMS (a); GE (g); Abbott Labs (g); Hospira (g); Abbie (g); Biomeical Enterprises (g); CWSDSG (a)
Suken A. Shah, MD	USA	DePuy Synthes (a,b,g); K2M (b)
Justin S. Smith, MD, PhD	USA	Biomet Spine (b,d); DePuy Synthes (a,b,d); Medtronic (b); Globus Medical (b,d); AOSpine North America (d,e)
John G. Thometz, MD	USA	No Relationships

EDUCATION COMMITTEE *(if not listed above)*

Jahangir Asghar, MD	USA	DePuy Synthes (b); Fox Study Group (a); Setting Scoliosis Straight (a)
Sigurd H. Berven, MD	USA	Acculif (b); AO Spine (a); AOA (a); Baxano (b); Biomet Spine (d); DePuy Synthes (d); Globus Medical (d); Loma Vista Medical (b); Medtronic (d,g); OREF (a); Providence Medical (b); Sempirica (b); Stryker Spine (d)
Marinus De Kleuver, MD, PhD	Netherlands	DePuy Synthes (b,d)
John R. Dimar, II, MD	USA	DePuy Synthes (b,d); Global Spine Journal (e); JBJS,Spine (e); Journal of Spinal Deformity (e); Medtronic (b,d,g); Norton Healthcare (a,f); NuVasive (a)
Nicholas D. Fletcher, MD	USA	Arthur and Susan Harrison Foundation (a); Biomet Spine (b); Medtronic (b); OrthoPediatrics (b)
John C. France, MD	USA	No Relationships
Daniel W. Green, MD, MS, FACS	USA	No Relationships
Lori A. Karol, MD	USA	Elsevier (g); JAAOS (e)
Eric Klineberg, MD	USA	AO (d); DePuy Synthes (a,b); OREF (a)
Nathan Lebowhl, MD	USA	DePuy Synthes (b)
Jean-Christophe A. Leveque, MD	USA	No Relationships
Jwalant S. Mehta, FRCS (Orth)	United Kingdom	K2M (e)
Praveen V. Mummaneni, MD	USA	DePuy Synthes (d,g); Globus Medical (d); Quality Medical Publishers (g); Spinicity (c); Thieme Publishers (g)
Chris J. Neal, MD	USA	No Relationships
Elias C. Papadopoulos, MD	Greece	No Relationships
Miguel H. Puigdevall, MD	Argentina	No Relationships
S. Rajasekaran, MD, FRCS, PhD	India	No Relationships
Scott S. Russo, MD	USA	Biomet (a,e); Guidepoint Global (b); Medtronic (d)

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support **(b)** Consultant **(c)** Stock/ Shareholder (self-managed) **(d)** Speaker's Bureau
(e) Advisory Board or Panel **(f)** Salary, Contractual Services **(g)** Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Maria Cristina Sacramento-Dominguez, MD, PhD	Spain	No Relationships
Kit M. Song, MD, MHA	USA	No Relationships

PROGRAM REVIEWERS *(if not listed above)*

Patrick J. Cahill, MD	USA	DePuy Synthes (a,b,d,g); Medtronic (a,b,d)
Samuel K. Cho, MD	USA	OREF (a); Stryker Spine (b)
Tenner S. Guillaume, MD	USA	No Relationships
Henry F.H. Halm, MD	Germany	DePuy Synthes (b); NuVasive (b,g)
Andrew H. Jea, MD	USA	No Relationships
Jeffrey S. Kanel, MD	USA	OrthoPediatrics (e,g)
Khaled Kebaish, MD	USA	Boxano Surgical (e); DePuy Synthes (a,b,g); K2M (b); Orthofix (b)
Raymond Knapp, MD	USA	Biomet Spine (g)
Toshiaki Kotani, MD, PhD	Japan	No Relationships
Ahmad Nassr, MD	USA	No Relationships
Joseph R. O'Brien, MD, MPH	USA	DePuy Synthes (b); Doctors Research Group (e); Globus Medical (b,g); Medtronic (b); NuVasive (b,g); Relivant (b); Smith and Nephew (b); Stryker Spine (b)
Matthew E. Oetgen, MD	USA	Medtronic (b)
Cagatay Ozturk, MD	Turkey	Medtronic (b); Signus (a)
Ahmad M. Shawky, MD, PhD	Germany	No Relationships
Clifford B. Tribus, MD	USA	Amedica (g); ESM Technologies (g); Stryker Spine (b,g); Zimmer Spine (b)
Adam L. Wollowick, MD	USA	DePuy Synthes (a,b); Stryker Spine (a,b)

CME COMMITTEE *(if not listed above)*

Andrew M. Casden, MD	USA	No Relationships
Sumeet Garg, MD	USA	DePuy Synthes (b)
Purnendu Gupta, MD	USA	DePuy Synthes (b)
Lawrence L. Haber, MD	USA	NuVasive (b); OrthoPediatrics (b,e)
G. Ying Li, MD	USA	No Relationships
Douglas A. Linville, II, MD	USA	Pioneer Surgical (b, g); Spinewave (b)
Glenn R. Rechtine, II, MD	USA	No Relationships
Kris Siemionow, MD	USA	Amedica (g); Captureproof (g); DePuy Synthes (a,d); Globus Medical (d); LifeSpine (g); Qualgenix (g); Teraphysics (b)
Jonathan R. Stieber, MD	USA	NuVasive (b); Stryker Spine (b)

MODERATORS *(if not listed above)*

Ahmet Alanay, MD	Turkey	DePuy Synthes (a,b)
Lloyd A. Hey, MD, MS	USA	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support **(b)** Consultant **(c)** Stock/ Shareholder (self-managed) **(d)** Speaker's Bureau
(e) Advisory Board or Panel **(f)** Salary, Contractual Services **(g)** Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Hee-Kit Wong, MD	Singapore	DePuy Synthes (b); SpineGuard (e)
A. Noelle Larson, MD	USA	No Relationships

INVITED FACULTY – PRE-MEETING COURSE, HALF-DAY COURSES & LUNCHTIME SYMPOSIA (if not listed above)

Christopher P. Ames, MD	USA	Aesculap (g); Baxano Surgical (g); Biomet Spine (g); DePuy Synthes (b); Doctors Research Group (g); Fish & Richardson, P.C. (g); Medtronic (b); Stryker Spine (b,g); UCSF (f); Visualase (g)
Oheneba Boachie-Adjei, MD	USA	DePuy Synthes (a,d); K2M (a,b,d,e); Osteotech (a,b); TranS1 (a,b,d,g)
Michelle S. Caird, MD	USA	No Relationships
Robert M. Campbell, Jr., MD	USA	No Relationships
Aina J. Danielsson, MD, PhD	Sweden	No Relationships
Vedat Deviren, MD	USA	Guidepoint (b); NuVasive (b,g); Stryker Spine (b)
Mary Anne Douglas, RN, MS, CNOR	USA	No Relationships
Erin Dupree, MD, FACOG	USA	No Relationships
John B. Emans, MD	USA	DePuy Synthes (b,g); Journal of Childrens Orthopaedics (e); Medtronic (b)
Mark A. Erickson, MD	USA	Medtronic (a)
James M. Eule, MD	USA	No Relationships
Frances Farley, MD	USA	No Relationships
Robert W. Gaines, Jr., MD	USA	DePuy Synthes (g); K2M (g)
Adrian Gardner, BM, MRCS, FRCS (Tr&Orth)	United Kingdom	DePuy Synthes (e); Medtronic (a,e)
Stephen W. Harden, Captain, BS, ATP	USA	LifeWings (f)
Hamid Hassanzadeh, MD	USA	No Relationships
Daniel J. Hedequist, MD	USA	No Relationships
Robert Hensinger, MD	USA	Journal of Pediatric Orthopaedics (e)
Serena S. Hu, MD	USA	NuVasive (b); Medtronic (b)
Michelle Hoppes, RN, MS, AHRMQR, DFASHRM	USA	No Relationships
Charles E. Johnston, MD	USA	Medtronic (g); Elsevier (g); Medtronic (a); DePuy Synthes (d)
Michael P. Kelly, MD	USA	Advance Medical (f)
Tyler Koski, MD	USA	Globus Medical (b); MB Innovations (b); Medtronic (a,b); NuVasive (b); Spinewave (b); Transition Spine Solutions (e)
John P. Kostuik, MD	USA	K2M (f)
Lawrence G. Lenke, MD	USA	AOSpine (a); AOSpine North America (a); Axial Biotech (a); DePuy Synthes (a,b); Fox Family Foundation (a); K2M (b); Medtronic (b,g); Quality Medical Publishing (g); SRS (a)
John E. Lonstein, MD	USA	Biomet Spine (g)
David S. Marks, FRCS	United Kingdom	DePuy Synthes (g); K2M (d); Medtronic (b); Stryker Spine (d)
Michael J. Mendelow, MD	USA	Tangent (g)
Peter O. Newton, MD	USA	DePuy Synthes (a,b,g); ElectroCore (g); EOS Imaging (a)

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
(e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Hilali H. Noordeen, FRCS	United Kingdom	Baxter (b); Ellipse Technologies (b,e); K2M (a,b,e); KSpine (a,b,e); Stryker Spine (b)
Joseph H. Perra, MD	USA	No Relationships
Yong Qiu, MD	China	No Relationships
Brandon A. Ramo, MD	USA	No Relationships
Greg Redding, MD	USA	UpToDate (f)
Michael Ruf, MD	Germany	DePuy Synthes (b)
Richard M. Schwend, MD	USA	AAP (e); Medtronic (d); Miracle Feet (e); POSNA (e); Project Perfect World (e)
David L. Skaggs, MD, MMM	USA	Biomet (b,d); Growing Spine Foundation (e); Growing Spine Study Group (e); Medtronic (b,d,e,g); POSNA (a); SRS (a,e); Stryker (d); Wolters Kluwer Health - Lippincott Williams & Wilkins (g)
John T. Smith, MD	USA	Children's Spine Foundation (e); DePuy Synthes (b,g); Ellipse Technologies (f); Spine Guard (b)
Allistair G. Thompson, FRCS	United Kingdom	No Relationships
Vernon T. Tolo, MD	USA	The Journal of Bone and Joint Surgery (g); Wolters Kluwer (g)
Vidyadhar V. Upasani, MD	USA	No Relationships
Michael G. Vitale, MD, MPH	USA	Biomet Spine (b,g); DePuy Synthes (a); CWSDSG (e); CWSDRF (a); OMeGA (a); POSNA (a,e); Scoliosis Research Society(a); Stryker Spine (b)
Robb J. William	USA	IBJI (f); Inomed (g); Pin Point (g)
Zane Wyatt, PhD	USA	No Relationships
Reinhold D. Zeller, MD, FRCSC	Canada	Paradigm Spine (b); Spinevision (g)

PAPER AUTHORS (if not listed above)

Mark F. Abel, MD	USA	No Relationships
Kariman Abelin-Genevois, MD, MSc	France	No Relationships
Celeste Abjornson, PhD	USA	Alphatec (e); Bacterin (b); Centinel Spine (b); DePuy Synthes (a); Integra (a); Novabone (a); NuVasive (a); NuTech (a); Orthobond (a); RTI Surgical (b); Spine Wave (b)
Emre Acaroglu, MD	Turkey	AOSpine (e); Biomet Spine (d); Cotrel Foundation (b); DePuy Synthes (a); IncredX (g); Medtronic (b); Stryker Spine (a)
Ashok K. Agrahari, MSc, MPhil (THS), PhD	India	No Relationships
Nadav Ahituv	USA	No Relationships
Azeem Ahmad, BA, BS	USA	No Relationships
Henry Ahn, MD, PhD, FRCSC	Canada	No Relationships
Tsutomu Akazawa, MD	Japan	No Relationships
Behrooz A. Akbarnia, MD	USA	DePuy Synthes (a,g); Ellipse Technology (b); K2M (a,b,g); KSpine (b); NuVasive (a,b,g); OREF (a)
Harry Akoto, MD	Ghana	No Relationships
Motasem Al Maaieh	USA	No Relationships
Stephen Albanese, MD	USA	No Relationships
Akif Albayrak	Turkey	No Relationships
Angel Alberich-Bayarri	Spain	No Relationships
Raed M. Alobaidan, MBBS	USA	No Relationships
Julie L. Alvarez, MPH	USA	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Rodrigo A. Amaral	Brazil	NuVasive (b)
Terry D. Amaral, MD	USA	DePuy Synthes (a); Medtronic (a)
Robert J. Ames, BA	USA	No Relationships
KiChan An, MD, PhD	Republic of Korea	No Relationships
Neel Anand, MD	USA	Baxano Surgical (b,e,g); Co-Align (b); Globus Medical (e,g); Medtronic (b,g); NuVasive (g)
Mikkel Andersen, MD	Denmark	No Relationships
Melissa L. Anderson, MS	USA	No Relationships
Kei Ando, PhD	Japan	No Relationships
Lindsay Andras, MD	USA	No Relationships
Prokopis Annis, MD	USA	No Relationships
Luis Miguel Antón-Rodríguez, PhD	Spain	No Relationships
Kristin R. Archer, PhD, DPT	USA	No Relationships
Hideyuki Arima	Japan	No Relationships
Takashi Asazuma, MD, PhD	Japan	No Relationships
Yunus Atici	Turkey	No Relationships
Najmedden Attabib, MD, FRCSC	Canada	No Relationships
Jennifer Ayamga, BA, Mphil	Ghana	No Relationships
Saankritya Ayan, MD	USA	No Relationships
Camila B. R. De Mattos	USA	No Relationships
Juan Bago, MD	Spain	Biomet Spine (a); DePuy Synthes (a); K2M (a)
Chris S. Bailey, MD	Canada	Rick Hansen Institute (a)
Ravi S. Bains, MD	USA	NuVasive (g)
Christine R. Baldus, RN, MHS	USA	No Relationships
Eric Baldwin, MS	USA	No Relationships
Mehmet B. Balioglu, MD	Turkey	No Relationships
Sanka B. Bambarawana Liyanage, MBChB	New Zealand	No Relationships
Carlos Barrios, MD, PhD	Spain	No Relationships
Carrie E. Bartley, MA	USA	No Relationships
Tracey Bastrom, MA	USA	No Relationships
Edward Bayley, MRCS(Ed)	United Kingdom	No Relationships
Caleb Behrend, MD	USA	No Relationships
Kevin Bell, PhD	USA	No Relationships
Andy A. Beltran, MS	USA	No Relationships
Shi Benlong	China	No Relationships
James T. Bennett, MD	USA	No Relationships
Ernesto Bersusky, MD	Argentina	No Relationships
Shay Bess, MD	USA	Allosource (e); DePuy Synthes (a,b); K2M (b); Medtronic (a,b); Pioneer Spine (g)

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Randal R. Betz, MD	USA	Advanced Vertebral Solutions (g); DePuy Synthes (a,b,d,g); Chest Wall & Spine Deformity Study Group (e); Medtronic (b,g); Orthobond (g); Orthocon (b,g); SpineGuard (b,g); SpineZ (g); Zimmer Spine (b)
Ni Bi	China	No Relationships
Kristina Bianco, BA	USA	No Relationships
Odion Binitie	USA	No Relationships
Christof Birkenmaier, MD	Germany	No Relationships
Benjamin T. Bjerke-Kroll, MD, MS	USA	No Relationships
Kathy Blanke, RN	USA	No Relationships
Gerard Bollini	France	No Relationships
G�rard Bollini	France	No Relationships
Daniel Bonete, MD	Spain	No Relationships
Anthony J. Boniello, BS	USA	No Relationships
Stefano Boriani, MD	Italy	No Relationships
Patrick Bosch, MD	USA	Haemontics (a)
Antonio T. Breceovich	USA	Bacterin International (a); Integra LifeSciences (a); Vertical Spine (a)
Keith H. Bridwell, MD	USA	No Relationships
Rob C. Brink, BSc	Netherlands	No Relationships
Jerome Briot	France	No Relationships
Elsa J. Brochmann, PhD	USA	LANX/BioMed (g)
Darrel S. Brodke, MD	USA	Amedica (b,g); DePuy Synthes (b,g); Medtronic (g)
Jaysson T. Brooks, MD	USA	No Relationships
Robert W. Bruce, MD	USA	No Relationships
Jacob M. Buchowski, MD, MS	USA	CoreLink (b); Globus Medical (b,d,g); K2M (d); Lippincott Williams & Wilkins (a); Medtronic (b,d); OREF (a); Stryker Spine (b,d)
David B. Bumpass, MD	USA	No Relationships
Cody E. Bunger, MD	Denmark	No Relationships
Jes�s F. Burgos, PhD	Spain	No Relationships
Douglas C. Burton, MD	USA	DePuy Synthes (a,b,g)
Rob Burton, BMBS, MSc, BMedSci	United Kingdom	No Relationships
John Callaghan	USA	DePuy Synthes (b,g)
Frank P. Cammisa, MD	USA	Alphatec Spine (b,e,g); BI Members (g); Bonovo Orthopedics (g); Centinel Spine (b,e); DePuy Synthes (a,b,e); Healthpoint Capital Partners (b,e,g); Integra (a); IVY Healthcare Partners (b,e,g); K2M (g); Knee Creations (g); MMF Systems (g); Novabone (a); NuTech (a); NuVasive (a,b,e,g); Orthopaedic Investment Partners (g); Paradigm Spine (b,e,g); Pioneer Surgical Technology (g); Scient'x USA (g); Small Bone Innovations (g); Spinal Kinetics (b,e,g); Spinal Partners III (b,e); Venture Partners III (g); Vertebral Technologies (b,g); Viscogliosi Brothers (b,e,g)
Jessica Cao, BS	USA	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
(e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Brendan Caprio	USA	No Relationships
John Caridi, MD	USA	Stryker Spine (b); Zimmer Spine (b)
Allen L. Carl, MD	USA	K2M (e); KSpine (b,e,g)
Brandon B. Carlson, MD, MPH	USA	No Relationships
Leah Y. Carreon, MD, MSc	USA	AOSpine (a); Association for Collaborative Spine Research (g); Global Evidence Advisory Board Medtronic (e); Institutional Review Board University of Louisville (e); Norton Healthcare (a,f); NuVasive (a); OREF (a); Spine (e); The Spine Journal (e); University of Louisville Institutional Review Board (g)
Charlotte Carroll	USA	No Relationships
Emma V. Carter, MSc	United Kingdom	No Relationships
Jeff Cassidy	USA	No Relationships
Rene M. Castelein, MD, PhD	Netherlands	Alexandre Suerman MD/PhD Program (a); Medtronic (a,d)
Vincent Challier, MD	USA	No Relationships
Michael S. Chang, MD	USA	Globus Medical (b,d); Integra (b,d); Medicea (a); Medtronic (a,b,d); Stryker Spine (d)
Masaaki Chazono, MD, PhD	Japan	CSKen (g)
Leijie Chen	China	No Relationships
Yongsheng Chen, MBBS, MRCS	Singapore	No Relationships
Yuexin Chen, BS	USA	No Relationships
Jack C. Cheng, MD	Hong Kong	No Relationships
Thomas Cheriyan	USA	No Relationships
Kazuhiro Chiba, MD, PhD	Japan	No Relationships
Kyu-Jung Cho, MD	Republic of Korea	No Relationships
Robert H. Cho, MD	USA	DePuy Synthes (b); Medtronic (b)
Dean Chou, MD	USA	DePuy Synthes (b); Globus Medical (b); Medtronic (b); Orthofix (b)
Dinesh K. Choudhry, MD	USA	No Relationships
Elie Choufani	France	No Relationships
Steen B. Christensen, MD	Denmark	No Relationships
Sean Christie	Canada	Capital District Health Authority (a); Medtronic (a,b); Rick Hansen Institute (a)
Winnie C. Chu, FRCR, FHKAM, MD	China	No Relationships
Michelle J. Clarke, MD	USA	No Relationships
Nina Clovis	USA	No Relationships
Jeffrey D. Coe, MD	USA	Benvenue Medical (a); DePuy Synthes (b); Implantsium (g); Medtronic (a,b); NuTech (a); NuVasive (a,b); Phygen (g); SI Bone (b)
James Connolly	USA	No Relationships
P. Christopher Cook, MD	USA	No Relationships
Daniel Cooperman, MD	USA	No Relationships
Isabelle Courtois	France	No Relationships
Joseph Cowan, MB ChB, FRCP	United Kingdom	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Andrew K. Cree, MD	Australia	No Relationships
Matthew E. Cunningham, MD, PhD	USA	DePuy Synthes (b); J&J (b)
Mary R. Curtis, BSc	United Kingdom	No Relationships
Holt Cutler, BSE	USA	No Relationships
Albert D'heurle, MD	USA	No Relationships
Kirk W. Dabney, MD	USA	DePuy Synthes (b)
Scott D. Daffner, MD	USA	AOSpine (a); CSRS (a); DePuy Synthes (d)
Erika Daley, BS	USA	No Relationships
Debbie Y. Dang, MD, PhD	USA	No Relationships
Aygul Dankowski, PhD	USA	No Relationships
Gurudip Das, MS (Orth)	India	No Relationships
Michael D. Daubs, MD	USA	AOSpine North America (d); DePuy Synthes (b,g)
Darin J. Davidson	USA	No Relationships
Maria de la Iglesia-Vaya	Spain	No Relationships
Taylor E. Dear	Canada	No Relationships
Ujjwal K. Debnath, MS(Orth), FRCS, FRCS (Tr&Orth), DM (Orth)	India	No Relationships
Ozgur Dede, MD	USA	No Relationships
Mark B. Dekutoski, MD	USA	AO Foundation (a); BroadWater Associates (e); COManagment CORE Banner Hospitals (e); Mayo Medtronic Percutaneous Deformity (b,g); Mayo Office of Intellectual Properties (g); Medtronic (f); SPINENET AOfoundation (a); Synthes –Education (f)
Gokhan H. Demirkiran	Turkey	No Relationships
Satoru Demura	Japan	No Relationships
Satoru Demura, MD	Japan	No Relationships
Mihir J. Desai, MD	USA	No Relationships
Bassel G. Diebo, MD	USA	No Relationships
Josh Doan, MEng	USA	No Relationships
Lori A. Dolan, PhD	USA	No Relationships
Denis Dolotin	Russian Federation	No Relationships
Pedro Domenech, MD	Spain	No Relationships
Montse Domingo-Sabat	Spain	DePuy Synthes (a)
Julio Doménech, MD, PhD	Spain	No Relationships
Zachary A. Dooley, MS	USA	NuVasive (f,g)
Hassan Douis, MRCP, FRCR	United Kingdom	No Relationships
John S. Doyle, MD	USA	No Relationships
Marc Dreimann	Germany	No Relationships
Xavier Drevelle	France	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Brian M. Drew, MD	Canada	No Relationships
Jean Dubousset	France	No Relationships
Neil Duggal, MD, MSc, FRCSC, FACS	Canada	No Relationships
Blythe Durbin-Johnson, PhD	USA	No Relationships
Marcel F. Dvorak, MD, FRCSC	Canada	AOSpine (a,d); DePuy Synthes (a); Medtronic (a,b,d,e,g)
Aviva G. Dworkin, BS	USA	No Relationships
Eric Ebermeyer	France	No Relationships
Walter Eckalbar	USA	No Relationships
Matthew Ellison, MD	USA	No Relationships
Sherief Elsayed, FRCS (Tr&Orth)	United Kingdom	No Relationships
Ronald G. Emerson, MD	USA	Reach Bionics (b)
Sanford E. Emery, MD, MBA	USA	No Relationships
Meric Enercan, MD	Turkey	No Relationships
Kristin England, MD	USA	No Relationships
Thomas J. Errico, MD	USA	AOSpine (a); DePuy Synthes (g); Fastenetix (g); Fridolin Charitable Trust (a); K2M (b,d); NYUSoM (f); OMEGA (a); OREF (a); Paradigm Spine (a); SpineSearch (e)
Erden Erturer	Turkey	No Relationships
Erik Estivalezes, PhD	France	No Relationships
Daniele Fabris-Monterumici, MD	Italy	No Relationships
Kelly S. Falcone, MS	USA	No Relationships
Nader Fallah	Canada	No Relationships
John R. Faust, MD	USA	No Relationships
Michael G. Fehlings, MD, PhD	Canada	No Relationships
John A. Ferguson, FRACS	New Zealand	K2M (b); Ellipse Technologies (b)
Pedro M. Fernandes, Licenciature	Portugal	No Relationships
Luis Ferraris, MD	Germany	No Relationships
Emmanuelle Ferrero	USA	No Relationships
Antony Field	New Zealand	No Relationships
Heather A. Fillerup, BS	USA	No Relationships
Joel Finkelstein, MSc, MD, FRCSC	Canada	No Relationships
Charles G. Fisher, MD, MHSc, FRCSC	Canada	AO (a); DePuy Synthes (a); Medtronic (a,b,g); NuVasive (b); OREF (a)
John M. Flynn, MD	USA	AAOS (e); Biomet Spine (g); Pediatric Orthopaedic Society of North America (e); Orthopedics Today (e); Scoliosis Research Society (e); Walters-Kluwer Health - Lippincott Williams & Wilkins (g)
Azadeh F. Fotouhie	USA	No Relationships
Daryl R. Fourney, MD, FRCSC, FACS	Canada	Proven Care Pathways (g); AOSpine North America (a,d); Asubio Pharmaceuticals (a); Rick Hansen Foundation (a)
Ida Alejandra Francheri, MD	Argentina	No Relationships
Kai-Ming Fu, MD, PhD	USA	DePuy Synthes (b); Medtronic (b)

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Takahito Fujimori, MD, MSc	Japan	No Relationships
Jonathan E. Fuller, MD	USA	No Relationships
Haruki Funao, MD	USA	No Relationships
Toshimasa Futatsugi	Japan	No Relationships
Eduardo Galaretto, MD	Argentina	No Relationships
Aruna Ganju, MD	USA	No Relationships
George Gantsoudes, MD	USA	No Relationships
Xiaochong Gao	USA	No Relationships
Yubo Gao, PhD	USA	No Relationships
Gracian Garcia	Spain	No Relationships
Vicente García, MD	Spain	No Relationships
Marilyn L. Gates, MD	USA	No Relationships
Martine Gavaret, MD, PhD	France	No Relationships
Benjamin Geddes	USA	No Relationships
Michael C. Gerling, MD	USA	Stryker Spine (b)
Shawn R. Gilbert, MD	USA	No Relationships
Diana A. Glaser, PhD	USA	Alphatec (a); Biospace (a); DePuy Synthes (a); GSF (a); K2M (a); KCI (a); Naval Medical Center San Diego (a); POSNA (a)
Michael Glotzbecker, MD	USA	No Relationships
Ziya L. Gokaslan, MD	USA	AOSpine North America (a,g); DePuy Synthes (a); European Spine Journal (e); JNS Spine (e); Journal of Spinal Disorders (e); Journal of Surgical Oncology (e); K2M (a); Medtronic (a); Nature Review World Neurosurgery (e); NREF (a,e); Spinal Kinetics (g); Spine Journal (e); US Spine (e,g)
Bahadir H. Gokcen, MD	Turkey	No Relationships
Jeffrey A. Goldstein, MD	USA	Johnson and Johnson (g); Medtronic (b); NuVasive (b,g)
Derek Gordon, PhD	USA	No Relationships
Takahiro Goto, MD	Japan	No Relationships
Harm C. Graat, MD, PhD	Netherlands	No Relationships
Harsh Grewal, MD, FACS, FAAP	USA	No Relationships
Brian W. Grose, MD	USA	No Relationships
Seth A. Grossman, MD	USA	No Relationships
Pierre Guigui, MD	France	No Relationships
Jeffrey L. Gum, MD	USA	LifeSpine (b); OREF (a)
Kern H. Guppy, MD, PhD	USA	No Relationships
Kavita Gupta	USA	No Relationships
Sachin Gupta	USA	No Relationships
Javier Guzman, BS	USA	No Relationships
Samvel Gyurdzhyan	USA	No Relationships
Joong Won Ha	Republic of Korea	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Matthew A. Halanski, MD	USA	No Relationships
D. K. Hamilton, MD	USA	No Relationships
Azmi Hamzaoglu, MD	Turkey	Medtronic (b)
Sarah D. Hans, MD	USA	No Relationships
Dingjun Hao	China	No Relationships
Christina Hardesty, MD	USA	Medtronic (d)
Jessica Harris, MS, RD	USA	No Relationships
Nanjundappa S. Harshavardhana, MD, MS(Orth)	United Kingdom	No Relationships
Radek Hart, MD, PhD, FRCS	Czech Republic	No Relationships
Robert A. Hart, MD	USA	DePuy Synthes (a,b,g); Globus Medical (a); Medtronic (a,b); OREF (a); SeaSpine (g)
Saqib Hasan, MD	USA	No Relationships
Tomohiko Hasegawa, MD, PhD	Japan	No Relationships
Hiroshi Hashizume, MD, PhD	Japan	No Relationships
Nabil Hassan, MD	USA	No Relationships
Hiroyuki Hayashi	Japan	No Relationships
Tetsuo Hayashi, MD	Japan	No Relationships
Kimberly M. Hayes	USA	No Relationships
Robert F. Heary, MD	USA	DePuy Synthes (g); Thieme Medical Publishers (g); Zimmer Spine (g)
Douglas Hedden, MD	Canada	No Relationships
Ilkka Helenius, MD, PhD	Finland	Baxter International (a); Medtronic (a); Paediatric Research Foundation (a)
Axel Hempfing, MD	Germany	No Relationships
Jose A. Herrera-Soto, MD	USA	Biomet Spine (b,d,g); Spine Form (e)
John A. Herring, MD	USA	Elsevier (g); Medtronic (g)
Khalid Hesham, MD	USA	No Relationships
W. F. Hess, MD	USA	DePuy Synthes (b); K2M (a)
Alan S. Hilibrand, MD	USA	Aesculap (g); Amedics (g); Biomet Spine (g); Stryker Spine (g)
Douglas L. Hill, MBA	Canada	No Relationships
Suzanne J. Hilt, PNP	USA	No Relationships
Toru Hirano	Japan	No Relationships
Jayne R. Hiratzka, MD	USA	DePuy Synthes (d)
Steven M. Hollenbeck	USA	No Relationships
Bao Hong-da, PhD	China	No Relationships
Michio Hongo, MD	Japan	No Relationships
Roel J. Hoogendoorn, MD, PhD	Netherlands	No Relationships
Allard J. Hosman, MD, PhD	Netherlands	No Relationships
Naobumi Hosogane, MD	Japan	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Richard Hostin, MD	USA	DePuy Synthes (a,b); DJO (a); K2M (a); NuVasive (a); Seeger (a)
Takahiro Hozumi	Japan	No Relationships
Wellington Hsu, MD	USA	Baxter (a); Globus Medical (e); Lifenet (e); Medtronic (a,b); Pioneer Surgical (a,b,e); Spinesmith (b); Stryker Spine (b); Terumo (b); Zimmer Spine (b)
Man Hung, PhD	USA	No Relationships
R. John Hurlbert, MD, PhD, FRCSC, FACS	Canada	No Relationships
Steven W. Hwang, MD	USA	No Relationships
Stephanie Iantorno	USA	No Relationships
Shota Ikegami, PhD	Japan	No Relationships
Shiro Ikegawa, MD, PhD	Japan	No Relationships
Ryan M. Ilgenfritz, MD	USA	No Relationships
Brice Ilharreborde, MD	France	Implanet (b); Zimmer Spine (b)
Shiro Imagama, MD	Japan	No Relationships
Satoshi Inami	Japan	No Relationships
Yoshihiro Inui	Japan	No Relationships
Robert E. Isaacs, MD	USA	Baxano Medical (b); NuVasive (a,b); SafeWire (e); VilaSpine (g)
Yasuyuki Ishibashi	Japan	No Relationships
Naoki Ishiguro	Japan	No Relationships
Takayoshi Ishii	Japan	No Relationships
Yoshinori Ishikawa	Japan	No Relationships
Daniela Issa	Spain	K2M (a)
Taito Itabashi	Japan	No Relationships
Kenyu Ito	Japan	No Relationships
Manabu Ito, MD, PhD	Japan	AO Foundation (e); Hoya Pentax (a); Robert-Reid (a)
Zenya Ito	Japan	No Relationships
Hiroshi Iwasaki, MD	Japan	No Relationships
Roger P. Jackson, MD	USA	Aesculap (g); Amedica/US Spine (g); Biomet Spine (g); Medtronic (g); NuVasive (g); Renovis (g); Zimmer Spine (g)
Amit Jain, MD	USA	No Relationships
Steven James, MB, ChB, FRCR	United Kingdom	No Relationships
Volkmar Jansson	Germany	No Relationships
Jonathan K. Jennings, MD	USA	No Relationships
Dezsoe J. Jeszenszky, MD, PhD	Switzerland	DePuy Synthes (b,g)
Zhang Jianguo, MD	China	No Relationships
Michael G. Johnson	Canada	No Relationships
Jean-Luc Jouve, MD	France	Euros (b); Implanet (b)
Qiao Jun	China	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Muayad Kadhim, MD	USA	No Relationships
Sinan Kahraman	Turkey	No Relationships
Antony Kallur, MD	USA	No Relationships
Rishi M. Kanna, MS (Orth), MRCS	India	No Relationships
Deniz Kargin	Turkey	No Relationships
Isaac Karikari, MD	USA	No Relationships
Michael D. Kasten, MD	USA	Globus Medical (b,g); Medtronic (b); Stryker Spine (b)
Yuji Kasukawa	Japan	No Relationships
Hiroyuki Kato, MD, PhD	Japan	No Relationships
Satoshi Kato, MD	Japan	No Relationships
So Kato, MD	Japan	No Relationships
Chhavi Katyal, MD	USA	No Relationships
Kazuki Kawakami, BS	Japan	DePuy Synthes (b); Medtronic (b)
Noriaki Kawakami, MD, DMSc	Japan	Medtronic (b); DePuy Synthes (b)
Mehmet A. Kaygusuz, MD	Turkey	No Relationships
John W. Kempainen, MD	USA	No Relationships
Sam Keshen	Canada	No Relationships
Heli Keskinen, MD	Finland	No Relationships
Jeffrey Kessler, MD	USA	No Relationships
Joseph Khoury, MD	USA	No Relationships
Mesut Kilic, MD	Turkey	No Relationships
Hak-Sun Kim, MD	Republic of Korea	Medtronic (g)
JinHyok Kim	Republic of Korea	No Relationships
Sang D. Kim, MD, MS	USA	No Relationships
Yongjung J. Kim, MD	USA	No Relationships
Young-Tae Kim	Republic of Korea	No Relationships
Jeff S. Kimball, BS	USA	No Relationships
Skye King	USA	No Relationships
Shyam Kishan, MD	USA	DePuy Synthes (b); Globus Medical (b,g); K2M (a)
Kazuyoshi Kobayashi, MD	Japan	No Relationships
Sho Kobayashi, PhD	Japan	No Relationships
Tetsuya Kobayashi, MD, PhD	Japan	No Relationships
Remi Kohler	France	No Relationships
Heiko Koller, MD	Germany	No Relationships
Katsuki Kono	Japan	No Relationships
Branko Kopjar, MD, PhD, MS	USA	Cerapedics (b); MFG Spine (b); Salt Creek Medical (b); Smith and Nephew (b)
Katariina Korhonen	Finland	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Ikuyo Kou	Japan	No Relationships
Keio Spine Research Group	Japan	No Relationships
Daisuke Kudo	Japan	No Relationships
Udara Kularatane, MB, BChir, BE, PGC, FRCR	United Kingdom	No Relationships
Preethi M. Kulkarni, MD	USA	No Relationships
Gentaro Kumagai	Japan	No Relationships
Naresh S. Kumar, MBBS, FRCS, DM	Singapore	No Relationships
Shugo Kuraishi	Japan	No Relationships
Kenny Kwan	Hong Kong	No Relationships
Brian K. Kwon, MD, PhD, FRCCC	Canada	No Relationships
Cynthia LaBella, MD	USA	No Relationships
Renaud Lafage, MS	USA	No Relationships
Virginie Lafage, PhD	USA	DePuy Synthes (a,d); Globus Medical (d); ISSGF (a); K2M (d); Medtronic (b,d); Nemaris (g); NuVasive (d); SRS (a)
Michael O. LaGrone, MD	USA	Innovasis (b)
Sue Min Lai, PhD	USA	No Relationships
Tsz-ping Lam, MB, BS	China	No Relationships
Lifeng Lao, MD	China	No Relationships
Féthi Laouissat	France	No Relationships
Darryl Lau, MD	USA	No Relationships
Leok-Lim Lau	USA	No Relationships
William Lavelle, MD	USA	Amedica (a); DePuy Synthes (a); Medtronic (a); Stryker Spine (a)
Brandon Lawrence, MD	USA	AOSpine North America (d)
David E. Lazarus, MD	USA	No Relationships
David E. Lebel, MD, PhD	Israel	No Relationships
Charles Gerald T. Ledonio, MD	USA	Medtronic (a)
Byung Ho Lee, MD, PhD	Republic of Korea	No Relationships
Jung-Hee Lee, MD	Republic of Korea	No Relationships
Seung Yeol Lee, MD	Republic of Korea	No Relationships
Stella Lee, MD	USA	No Relationships
Jan Lehovskyy	United Kingdom	No Relationships
Julian J. Leong, MA, FRCS, PhD	United Kingdom	No Relationships
Noah D. Lewis	Canada	No Relationships
Stephen J. Lewis, MD	Canada	Medtronic (b); Stryker Spine (b)
Chenshuang Li	China	No Relationships
Tao Li	China	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Yawei Li, MD	China	No Relationships
Zheng Li	China	No Relationships
Barthelemy Liabaud, MD	USA	No Relationships
Breton Line, BSME	USA	ISSGF (b)
Shian Liu, BS	USA	No Relationships
Zhen Liu	China	No Relationships
Zhou Liu	China	No Relationships
Randall T. Loder, MD	USA	No Relationships
Douglas Londono, PhD	USA	No Relationships
Baron S. Lonner, MD	USA	AOSpine (a); DePuy Synthes (b,d,e,g); John and Marcella Fox Fund (a); K2M (d); OREF (a); Paradigm Spine (g); Setting Scoliosis Straight Foundation (a); Spine Search (e,g)
Edmond H. Lou, PhD	Canada	No Relationships
Scott J. Luhmann, MD	USA	Globus Medical (g); Lippincott (g); Medtronic (b,d); Orthofix (b); Stryker Spine (e,d)
Heikki Lukkarinen, MD	Finland	No Relationships
T. David Luo	USA	No Relationships
Kerstin Löfdahl-Hällerman, MD, PhD	Sweden	No Relationships
Jean-Marc Mac-Thiong, MD, PhD	Canada	DePuy Synthes (a); K2M (b); Medtronic (a); Spinologics (e,f,g)
Masafumi Machida, MD	Japan	No Relationships
Shugo Maeda	Japan	No Relationships
Rufai M. Mahmud, MD	Ghana	No Relationships
Stephen P. Maier, BA	USA	No Relationships
Sukanta Maitra	USA	No Relationships
Kamran Majid, MD	USA	No Relationships
Saihu Mao, MD	China	No Relationships
Bryan J. Marascalchi, BS	USA	No Relationships
Steven M. Mardjetko, MD, FAAP	USA	AAOS BOC (e); DePuy Synthes (b); Illinois Board of Orthopaedic Surgeons (e); SpineCraft (a,b,e,g)
Michelle C. Marks, PT, MA	USA	DePuy Synthes (a,b); SRS (a)
Luis Marti-Bonmati	Spain	No Relationships
Christopher T. Martin, MD	USA	Iowa Orthopaedic Society (a); Musculoskeletal Transplant Foundation (e); OREF (a); Orthopaedic Trauma Association (a)
Hiroko Matsumoto, MA	USA	Cerebral Palsy International Research Foundation (a); CSSG (a); POSNA (a)
Morio Matsumoto, MD	Japan	No Relationships
Tomohiro Matsumoto, MD, PhD	Japan	No Relationships
Yukihiro Matsuyama, MD	Japan	No Relationships
Michael Mayer, PhD	Germany	No Relationships
Keyvan Mazda, MD, MS, PhD	France	Zimmer Spine (g); Implanet (b)
Donna R. McAtee	USA	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Daren J. McCalla, MD	USA	No Relationships
Ian McCarthy, PhD	USA	No Relationships
Richard E. McCarthy, MD	USA	Medtronic (b,d); SRS (e)
Anna M. McClung, BSN, RN	USA	No Relationships
Amy L. McIntosh, MD	USA	No Relationships
Lisa McLeod, MD	USA	No Relationships
Anne McManus, RN	USA	No Relationships
Hossein Mehdian, MD, MS (Orth) FRCS(Ed)	United Kingdom	No Relationships
Charles T. Mehlman, DO, MPH	USA	Carolina Healthcare (g); Children (f); Michigan State University (d); National Institutes of Health (a); Oakstone (g)
Arne Mehrkens, MD	Switzerland	No Relationships
Oliver Meier, MD	Germany	No Relationships
Carolin Melcher, MD	Germany	No Relationships
Marco Mendoza, MD	USA	No Relationships
Sergio A. Mendoza-Lattes, MD	USA	Globus Medical (b)
Mariano E. Menendez, MD	USA	No Relationships
Emmanuel N. Menga, MD	USA	No Relationships
Addisu Mesfin, MD	USA	No Relationships
Mikhail Mikhailovsky, MD	Russian Federation	No Relationships
Freeman Miller, MD	USA	No Relationships
Nancy H. Miller, MS, MD	USA	No Relationships
Ryan Miller, MD	USA	No Relationships
Curtis A. Mina, MD	USA	No Relationships
Shohei Minami	Japan	No Relationships
Akihito Minamide, MD, PhD	Japan	No Relationships
Amirhossein Misaghi, MD	USA	No Relationships
Akiko Misawa, MD	Japan	No Relationships
Lance K. Mitsunaga, MD	USA	No Relationships
Atsushi Miyake	Japan	No Relationships
Naohisa Miyakoshi, MD	Japan	No Relationships
Firoz Miyajiri, MD, FRCS	Canada	DePuy Synthes (a,b)
Urvij Modhia, MBBS, MD	USA	No Relationships
Marina Moguelevitch, MD	USA	No Relationships
Anand Mohapatra, BS	USA	No Relationships
Scott R. Montgomery, MD	USA	No Relationships
Seong-Hwan Moon, MD, PhD	Republic of Korea	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
(e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Marc J. Moreau, MD	Canada	No Relationships
Jessica V. Morgan, BS	USA	No Relationships
Hiroshi Moridaira	Japan	No Relationships
Ryan D. Muchow, MD	USA	No Relationships
Keijiro Mukaiyama	Japan	No Relationships
Gregory M. Mundis, MD	USA	K2M (b,g); NuVasive (a,b,g); OREF (a)
Hideki Murakami	Japan	No Relationships
Akio Muramoto, MD	Japan	No Relationships
Samuel S. Murray, MD	USA	No Relationships
Ayhan Mutlu	Turkey	No Relationships
Karen S. Myung, MD, PhD	USA	No Relationships
Floreana A. Naef	USA	No Relationships
Yukihiro Nakagawa	Japan	No Relationships
Hiroaki Nakashima, MD	Japan	No Relationships
Sreeharsha V. Nandyala, BA	USA	No Relationships
Stefano Negrini, MD	Italy	Italian Scientific Spine Institute (e)
Geraldine I. Neiss, PhD	USA	No Relationships
Ian W. Nelson, MBBS, MCh (Orth), FRCS	United Kingdom	Medtronic (a)
Venu M. Nemani, MD, PhD	USA	No Relationships
Abhay Nene, MS	India	AOSpine India (e); Elly Lilly (e)
Brian J. Neuman, MD	USA	No Relationships
Matthew P. Newton Ede, MB, ChB, MRCS (Eng), FRCS (Tr&Orth)	United Kingdom	No Relationships
Bobby K. Ng, MD	Hong Kong	No Relationships
Ahtsham U. Niazi, FRCPC	Canada	No Relationships
Hideto Nishi, MD	Japan	No Relationships
Tristan Nishnianidze, MD, PhD	USA	No Relationships
Cameron Niswander	USA	No Relationships
Colin Nnadi, FRCS(Orth)	United Kingdom	No Relationships
Mariano A. Noel, MD	Argentina	Medtronic (f)
Ayato Nohara	Japan	No Relationships
Yutaka Nohara, MD	Japan	No Relationships
Vanessa Noonan, PhD, PT	Canada	Rick Hansen Institute (f)
Elizabeth P. Norheim, MD	USA	No Relationships
Vyacheslav Novikov, PhD	Russian Federation	No Relationships
Susana Núñez Pereira, MD, PhD	Germany	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Michael F. O'Brien, MD	USA	DePuy Synthes (a,b,g); DJO (a); K2M (a); NuVasive (a); Seeger (a)
Courtney M. O'Donnell, MD	USA	No Relationships
Kevin R. O'Neill, MD, MS	USA	No Relationships
Patrick O'Toole, MD	USA	No Relationships
Ibrahim Obeid	France	DuPuy Synthes (b); Medtronic (b)
Thierry Odent, MD, PhD	France	No Relationships
Yoji Ogura, MD	Japan	No Relationships
Tetsuya Ohara	Japan	No Relationships
Makoto Ohe, MD	Japan	No Relationships
Eijiro Okada, MD	Japan	No Relationships
John C. Olson, MS	USA	No Relationships
Atsushi Ono	Japan	No Relationships
Timothy S. Oswald, MD	USA	Medtronic (b)
Kyotaro Ota	Japan	No Relationships
Dror Ovadia, MD	Israel	No Relationships
Robert J. Owen, BS	USA	No Relationships
Gregory I. Pace, BA	USA	No Relationships
Eric Padegimas, MD	USA	No Relationships
Joshua M. Pahys, MD	USA	DePuy Synthes (b)
Zhaoxing Pan, PhD	USA	No Relationships
Kenneth J. Paonessa, MD	USA	K2M (a)
Jerome Paquet	Canada	No Relationships
Howard Y. Park, BA	USA	No Relationships
Alvaro Pascual.Leone	USA	No Relationships
Peter G. Passias, MD	USA	No Relationships
Alpesh A. Patel, MD	USA	Amedica (b,g); Biomet (b); Cervical Spine Research Society (e); Contemporary Spine Surgery (e); Cytonics (g); GE Healthcare (b); Indo-American Spine Alliance (e); Lumbar Spine Research Society (e); Nocimed (g); Stryker Spine (b); Zimmer Spine (b)
Nick Patel, BS	USA	No Relationships
Sujal Patel, MD	USA	No Relationships
Andrew J. Paterson, MD	USA	No Relationships
Justin C. Paul, MD, PhD	USA	No Relationships
Carl B. Paulino, MD	USA	No Relationships
Jeff Pawelek, BS	USA	No Relationships
Liz W. Paxton	USA	No Relationships
Murat Pekmezci, MD	USA	Stryker Spine (a)
Glenn J. Pelletier, MD	USA	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Ferran Pellise, MD	Spain	Biomet (b); DePuy Synthes (a,b); K2M (a)
Maria das Gracas C. Pereira, DVM, PhD	USA	No Relationships
Cesar Perez-Caballero	Spain	No Relationships
Sebastien Pesenti	France	No Relationships
Maty Petcharaporn, BS	USA	No Relationships
Kevin H. Phan, BS	USA	No Relationships
Lee Phillips	USA	No Relationships
Lucas Piantoni, MD	Argentina	No Relationships
Christian Pikhahn	Germany	No Relationships
Gabriel Piza Vallespir, MD, PhD	Spain	No Relationships
Howard M. Place, MD	USA	DePuy Synthes (f)
Connie Poe-Kochert, BSN	USA	No Relationships
Neron Popovski, MD	The Former Yugoslav Republic of Macedonia	No Relationships
Sina Pourtaheri, MD	USA	No Relationships
Themistocles S. Protopsaltis, MD	USA	Alphatec Spine (d); Globus Medical (b); K2M (d)
Blazej A. Pruszczynski	Poland	No Relationships
Andrew J. Pugely, MD	USA	No Relationships
Bangping Qian, MD	China	No Relationships
Xing Qiu, PhD	USA	No Relationships
Yong Qiu, MD	China	No Relationships
Nasir A. Quraishi, FRCS	United Kingdom	Alphatec (a); AOSpine (b); DePuy Synthes (a); Medtronic (a)
Kris E. Radcliff, MD	USA	DePuy Synthes (b,g); Globus Medical (b,g); Medtronic (b,g); Relieva Medical (g); Stryker Spine (g)
Mark D. Rahm, MD	USA	DePuy Synthes (e); K2M (a); SpineSmith (g)
Ra'Kerry K. Rahman, MD	USA	No Relationships
Saloni Raj	India	No Relationships
Nisha Raja-Rahman, MD	USA	No Relationships
Patricia L. Rumpy, MS, REPT, CNIM	USA	No Relationships
James V. Raso, MASc	Canada	Alberta Health Services (f)
Karl E. Rathjen, MD	USA	No Relationships
Bernard A. Rawlins, MD	USA	No Relationships
Wilson Z. Ray, MD	USA	DePuy Synthes (b)
FOCOS Research Associates	Ghana	No Relationships
Fredrick G. Reighard, MPH	USA	No Relationships
Rodrigo G. Remondino, MD	Argentina	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Yuan Ren, PhD	USA	No Relationships
Laurence D. Rhines, MD	USA	Globus (b); Stryker Spine (b)
Jeffrey A. Rihn, MD	USA	Pfizer (b)
Todd F. Ritzman, MD	USA	No Relationships
Carly S. Rivers, PhD	Canada	No Relationships
James W. Roach, MD	USA	No Relationships
Chessie Robinson, MA	USA	No Relationships
Kenneth J. Rogers, PhD	USA	No Relationships
Peter S. Rose, MD	USA	No Relationships
Thomas Ross, MS, RN	USA	No Relationships
Dominique A. Rothenfluh, MD, PhD	United Kingdom	No Relationships
Pierre Roussouly, MD	France	Kisco International (b); Medtronic (g); SMAIO (e)
David P. Roye, MD	USA	Children (g); CPIRF (a); POSNA (a); SICOT (e); Stryker Spine (b)
Monchai Ruangchainikom, MD	Thailand	No Relationships
Francisco J. S. Pérez-Grueso, MD	Spain	DePuy Synthes (a,b); K2M (a)
Meagan Sabatino, BA	USA	No Relationships
Karen Sacks, MSN	USA	No Relationships
Toshiki Saito	Japan	No Relationships
Tsuyoshi Sakuma, MD, PhD	Japan	No Relationships
Jerome Sales de Gauzy, PhD	France	Implanet (b)
Amer F. Samdani, MD	USA	DePuy Synthes (b); SpineGuard (b); Stryker Spine (b); Zimmer Spine (b)
Tunay Sanli, MA	Turkey	DePuy Synthes (a)
Ignacio Sanpera, MD, PhD	Spain	No Relationships
Eric J. Sarkissian, BS	USA	No Relationships
Vishal Sarwahi, MD	USA	DePuy Synthes (a,b); Medtronic (a,b)
Jason W. Savage, MD	USA	Stryker Spine (b)
Justin K. Scheer, BS	USA	No Relationships
Janneke J. Schimmel, MSc	Netherlands	No Relationships
Tom P. Schlösser, MD	Netherlands	Alexander Suerman MD/PhD Programme (a)
Jens A. Schmücker	Germany	No Relationships
Scott Schoenleber, MD	USA	No Relationships
Gregory D. Schroeder, MD	USA	No Relationships
Joshua E. Schroeder, MD	USA	No Relationships
Christian Schröder, Dipl-Ing	Germany	No Relationships
Beth A. Schueler, PhD	USA	No Relationships
Tobias L. Schulte, MD, PhD	Germany	No Relationships
Daniel M. Sciubba, MD	USA	DePuy Synthes (a,b); Globus Medical (b); Medtronic (b); NuVasive (b)

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support **(b)** Consultant **(c)** Stock/ Shareholder (self-managed) **(d)** Speaker's Bureau
(e) Advisory Board or Panel **(f)** Salary, Contractual Services **(g)** Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Trevor P. Scott, MD	USA	No Relationships
Mustafa F. Seckin	Turkey	No Relationships
Jeong Ho Seo	Republic of Korea	No Relationships
Rajiv K. Sethi, MD	USA	No Relationships
Christopher I. Shaffrey, MD	USA	AO (a); Biomet (b,g); Department of Defense (a); Globus (b); Medtronic (b,g); NACTN (a); NIH (a); NuVasive (b)
Claire Shannon, MD	USA	No Relationships
Shallu Sharma, MPT	Denmark	No Relationships
Swarkar Sharma, PhD	USA	No Relationships
William J. Shaughnessy, MD	USA	No Relationships
Jianxiong Shen, MD	China	No Relationships
Ajoy P. Shetty, MS (Orth)	India	No Relationships
Zhiyue Shi	China	No Relationships
Yo Shiba, MD	Japan	No Relationships
Yoichi Shimada, MD	Japan	No Relationships
Masayuki Shimizu	Japan	No Relationships
Dong-Eun Shin, PhD	Republic of Korea	No Relationships
Ryuichi Shinjo, MD	Japan	No Relationships
Harry L. Shufflebarger, MD	USA	DePuy Synthes (a,b,e,g)
Brenda A. Sides, MA	USA	No Relationships
Clément Silvestre	France	No Relationships
Ane Simony, MD	Denmark	No Relationships
Sarina Sinclair, PhD	USA	Elute (f)
Lewis P. Singer, MD	USA	No Relationships
Anuj Singla, MD	USA	No Relationships
Wafa Skalli, PhD	France	No Relationships
Richard L. Skolasky, ScD	USA	No Relationships
Branko Skovrlj, MD	USA	No Relationships
Brian D. Snyder, MD, PhD	USA	No Relationships
Alex Soroceanu, MD, CM, MPH, FRCSC	USA	No Relationships
Artem Sorokin, PhD	Russian Federation	No Relationships
Steven Sparagana, MD	USA	Novartis (a,d); Upsher-Smith Laboratories (e)
William R. Spiker, MD	USA	No Relationships
Jonathan Spilsbury, FRCS	United Kingdom	No Relationships
Rajeshwar N. Srivastava, MD	India	No Relationships
Anthony A. Stans, MD	USA	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Oliver M. Stokes, MBBS, MSc, FRCS (Tr & Orth)	United Kingdom	No Relationships
Wyndam M. Strodbeck, MD	USA	No Relationships
Children's Spine Study Group	USA	DePuy Synthes (a)
European Spine Study Group	Spain	DePuy Synthes (a)
Growing Spine Study Group	USA	Growing Spine Foundation (a)
Harms Study Group	USA	DePuy Synthes (a); EOS Imaging (a); OREF (a); SRS (a)
International Spine Study Group	USA	DePuy Synthes (a); Medtronic (a); Sofamor Danek (a)
Hideki Sudo	Japan	No Relationships
Etan P. Sugarman, MD	USA	No Relationships
Ryo Sugawara	Japan	No Relationships
Patrick A. Sugrue, MD	USA	No Relationships
Xu Sun, MD, PhD	China	No Relationships
Yong Sun	China	No Relationships
Isabelle Suprano	France	No Relationships
Teppei Suzuki	Japan	No Relationships
Yoshitaka Suzuki	Japan	No Relationships
Fred A. Sweet, MD	USA	No Relationships
Pascal Swider, PhD	France	No Relationships
Hasani W. Swindell, BS	USA	No Relationships
Temel Tacal, MD	Turkey	No Relationships
Atsushi Takahashi	Japan	No Relationships
Jun Takahashi, MD	Japan	No Relationships
Shinji Takahashi, MD, PhD	Japan	No Relationships
Yohei Takahashi	Japan	No Relationships
Katsushi Takeshita, MD	Japan	DePuy Synthes (b); Medtronic (b)
Daisaku Takeuchi	Japan	No Relationships
Kosuke Takimura, MD	Japan	No Relationships
Ufuk Talu, MD	Turkey	No Relationships
Arvydas A. Tamkus, MD, PhD, DABNM	USA	No Relationships
Jonathan Tan, MBBS, MRCS	Singapore	No Relationships
Takaaki Tanaka, MD	Japan	No Relationships
Toshihiro Tanaka	Japan	No Relationships
Hiroshi Taneichi, MD	Japan	No Relationships
Hui ren Tao, MD, PhD	China	No Relationships
Ryoji Tauchi, MD, PhD	Japan	No Relationships
Carlos A. Tello, MD	Argentina	Biomet (b)

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

- (a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Alexander A. Theologis, MD	USA	No Relationships
Senthilnathan Thirugnanasambandam, MD	United Arab Emirates	No Relationships
George H. Thompson, MD	USA	Journal of Pediatric Orthopaedics (f); NuVasive (f); OrthoPediatrics (b); SCIOT (e); Shrine Medical Advisory Board (e); SpineForm (b)
Beverly Thornhill, MD	USA	No Relationships
Haijun Tian	China	No Relationships
Daisuke Togawa, MD, PhD	Japan	No Relationships
Antoine G. Tohmeh, MD	USA	NuVasive (a,b,g); SOLAS (e)
Courtney Toombs, BS	USA	No Relationships
Jose M. Tormos, MD, PhD	Spain	No Relationships
Yoshiaki Toyama	Japan	No Relationships
Yoshiaki Toyama	Japan	No Relationships
Dong-Phuong Tran, MS	USA	No Relationships
Per D. Trobisch, MD	Germany	DePuy Synthes (b); Medtronic (d)
Evan P. Trupia, BS	USA	No Relationships
Eve C. Tsai, MD, PhD	Canada	No Relationships
Hiroyuki Tsuchiya	Japan	No Relationships
Taichi Tsuji, MD	Japan	No Relationships
Shunji Tsutsui, MD, PhD	Japan	No Relationships
Alexander W. Turner, PhD	USA	NuVasive (f)
Chad M. Turner, MD	USA	No Relationships
Marcin Tyrakowski, MD, PhD	Poland	No Relationships
Robert G. Tysklind, BS	USA	No Relationships
Junichi Ukai	Japan	No Relationships
Onur Levent Ulusoy	Turkey	No Relationships
Koki Uno, MD, PhD	Japan	DePuy Synthes (d); K2M(d)
Alexander R. Vaccaro, MD, PhD	USA	Advanced Spinal Intellectual Properties (c); Aesculap (g); AOSpine (e); Association of Collaborative Spine Research (e); Biomet Spine (g); Bonovo Orthopaedics (c); Cerapedics (a); Computational Biodynamics (c); Cross Current (c); Cytonics (c); DePuy Synthes (g); Electrocore(c); Flagship Surgical (c); FlowPharma (c); Gamma Spine (c); Gerson Lehrman Group (b); Globus Medical (c,g); Guidepoint Global (b); In Vivo (c); Innovative Surgical Design (b,c,e); K2M(c); Location Based Intelligence (c); Medacorp (b); Medtronic (g); NeuCore (c); NuVasive (a,g); Paradigm Spine (c); Progressive Spinal Technologies (c); Replication Medica (c); Rothman Institute and Related (c); R.S.I. (c); Small Bone Innovations (c); Spine Medica(c); Spinicity (c); Spinology (c); Stout Medical (b,c); Stryker Spine (a,g); Syndicom (c)
Lotte Van Hessem, MD	Netherlands	No Relationships
Marijn van Stralen, PhD	Netherlands	No Relationships
Maria A. Vanushkina, BS	USA	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

Peter P. Varga	Hungary	No Relationships
Alexandr Vasyura	Russian Federation	No Relationships
Claudio Vergari, PhD	France	No Relationships
Kushagra Verma, MD, MS	USA	No Relationships
Satyendra Verma, PhD	USA	No Relationships
Vivek Verma, MD	USA	No Relationships
Alejo Vernengo-Lezica, MD	Argentina	No Relationships
Joseph M. Verska, MD	USA	No Relationships
Alba Vila-Casademunt	Spain	DePuy Synthes (a)
Koen L. Vincken, PhD	Netherlands	No Relationships
Jean-Marc Vital, MD, PhD	France	No Relationships
Kanichiro Wada	Japan	No Relationships
Theodore A. Wagner, MD	USA	DePuy Synthes (a,g); K2M (a)
Khin L. Wai, MBBS, MSc	Singapore	No Relationships
Cheng Wang	China	No Relationships
Jeffrey C. Wang, MD	USA	Aesculap (g); Alphatech (g); Amedica (g); Biomet (g); DePuy Synthes (g); Osprey (g); Seaspine (g); Stryker Spine (g)
Yan Wang, MD	China	No Relationships
Yingsong Wang, MD	China	No Relationships
Matthew R. Wanner, MD	USA	No Relationships
Kota Watanabe, MD, PhD	Japan	No Relationships
Bernd Wegener, MD	Germany	No Relationships
Stuart L. Weinstein, MD	USA	No Relationships
Karen J. Wernli, PhD	USA	No Relationships
Pumibal Wetpiriyakul, MD	Thailand	No Relationships
Shlomo Wientroub, MD	Israel	No Relationships
Jennifer A. Winkler, BS	USA	No Relationships
Carol Wise, PhD	USA	No Relationships
Sarah Wolff, BSN	USA	No Relationships
Regina P. Woon, MPH	USA	No Relationships
Bettye Wright, RN, PA	USA	No Relationships
Margaret L. Wright, BS	USA	No Relationships
Irene Wulff, MD	Ghana	No Relationships
En Xie, MD, PhD	China	No Relationships
Jingming Xie	China	No Relationships
Xuhong Xue, MD	China	No Relationships

IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

AUTHOR DISCLOSURES

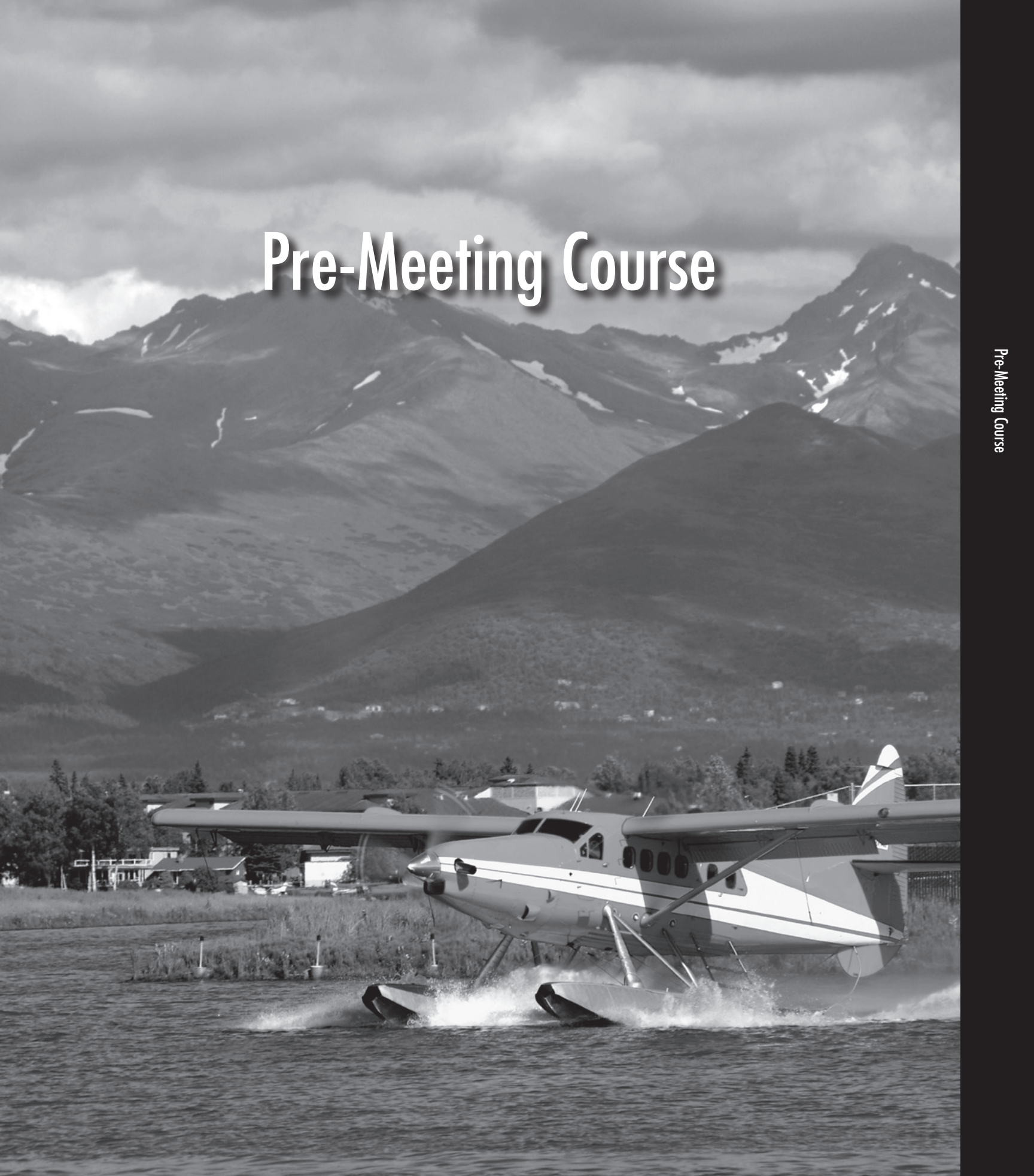
Mitsuru Yagi, MD, PhD	Japan	K2M (a)
Hiroshi Yamada, MD, PhD	Japan	No Relationships
Toru Yamaguchi, MD	Japan	No Relationships
Kiyofumi Yamakawa	Japan	No Relationships
Takuya Yamamoto	Japan	No Relationships
Yu Yamato	Japan	No Relationships
Ken Yamazaki, MD	Japan	No Relationships
Haruhisa Yanagida, MD	Japan	No Relationships
Justin S. Yang, MD	USA	No Relationships
Sun Yang, BA	USA	No Relationships
Crista Yarrell	New Zealand	No Relationships
Tatsuya Yasuda	Japan	No Relationships
Burt Yaszay, MD	USA	DePuy Synthes (a,b,d); K2M (a,g); NuVasive (b); OrthoPediatrics (g)
Michael J. Yaszemski, MD, PhD	USA	Medtronic (b)
Can H. Yildirim, MD	Turkey	No Relationships
Noriaki Yokogawa	Japan	No Relationships
Daisuke Yoneoka, MS	Japan	No Relationships
Ikuho Yonezawa, MD, PhD	Japan	No Relationships
Petya Yorgova, MS	USA	No Relationships
Munehito Yoshida, MD	Japan	No Relationships
Hiroyuki Yoshihara, MD, PhD	USA	No Relationships
Katsuhito Yoshioka, MD	Japan	No Relationships
Katsuhito Yoshioka, MD	Japan	No Relationships
Aye Sandar Zaw, MBBS, MPH	Singapore	No Relationships
Zhu Ze-zhang	China	No Relationships
Lukas P. Zebala, MD	USA	Amedica (b); AOSpine (a); Broadwater (d); DePuy Synthes (a,d); Ulrich Medical (b)
Juliane Zenner, MD	Germany	No Relationships
Wei Zhang	USA	No Relationships
Ying Zhang	China	No Relationships
Yonggang Zhang, PhD	China	No Relationships
Ke-Wei Zhao, PhD	USA	No Relationships
Zhi Zhao	China	No Relationships
GuoQuan Zheng	China	No Relationships
Feng Zhu	China	No Relationships
Daniel Zuchelli, BS	USA	No Relationships

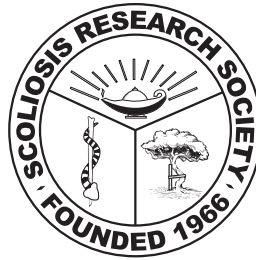
IF NOTED, THE RELATIONSHIPS DISCLOSED ARE AS FOLLOWS:

(a) Grants/ Research Support (b) Consultant (c) Stock/ Shareholder (self-managed) (d) Speaker's Bureau
 (e) Advisory Board or Panel (f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

Pre-Meeting Course

Pre-Meeting Course





The Scoliosis Research Society gratefully acknowledges
Biomet, DePuy Synthes, Medtronic, NuVasive for their
support of the Pre-Meeting Course.



PRE-MEETING COURSE

LIFELONG LEARNING IN SPINAL DEFORMITY: WHAT I HAVE LEARNED, WHAT I DO AND HOW I TEACH

Scoliosis Research Society • Pre-Meeting Course

Wednesday, September 10, 2014

7:45 AM – 4:30 PM

Dena'ina Convention Center

Anchorage, Alaska, USA

Course Chair:

Lori A. Karol, MD

2013-2014 Education Committee

Jahangir K. Asghar, MD

Sigurd H. Berven – Chair Elect

John R. Dimar, II, MD – Past Chair

Nicholas D. Fletcher, MD

John C. France, MD

Daniel W. Green, MD, MS, FACS

Marinus de Kleuver, MD, PhD

Eric O. Klineberg, MD

Nathan H. Lebowhl, MD

Jean-Christophe A. Leveque, MD

Jwalant S. Mehta, FRCS (Orth)

Praveen Mummaneni, MD

Chris J. Neal, MD

Elias C. Papadopoulos, MD

Miguel H. Puigdevall, MD

S. Rajasekaran, MD, FRCS, Mch, PhD

Scott S. Russo, MD

Maria Cristina Sacramento-Dominguez, MD, PhD

James O. Sanders, MD

Frank J. Schwab, MD

Kit M. Song, MD, MHA

Mark Weidenbaum, MD

Course Overview

This interactive course, presented by internationally renowned faculty, through symposia and case examples, will address principles of improvement and techniques for optimizing outcomes and safety for pediatric and adult scoliosis deformity patients. There will be an emphasis on different modalities of education in the treatment of severe spinal deformity, minimization of risks and avoidance of complications. The course will consist of invited lectures, debates, case presentations and audience discussion.

Course Objectives and Outcomes

Upon completion of this course, participants should be able to:

- 1) Improve preoperative planning for complex spinal surgeries in both adults and children in order to improve outcomes;
- 2) Assess and use the outcome of pooled complication data (SRS M&M database) to identify and address risk factors in simple spinal fusion and in complex spinal surgeries that include osteotomies;
- 3) Recognize the potential benefits of intraoperative radiographic navigation in complex spinal surgery and use it when appropriate to provide an additional level of safety in operative settings;
- 4) Implement strategies to minimize and/or treat long-term effects of spinal deformity surgery during adolescence.
- 5) Consider pulmonary and orthopaedic risks in patients with non-operated severe scoliosis in young adulthood when discussing treatment options with patients.

Target Audience

Presentations at the Annual Meeting & Course will have value for physicians and allied health personnel who treat spinal deformities at all levels and in all ages of patients. Medical students, residents, fellows and researchers with an interest in spinal deformities will also benefit from the materials presented.

Continuing Medical Education (CME) Accreditation

This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education (ACCME) through the sponsorship of the Scoliosis Research Society (SRS). SRS is accredited by the ACCME to provide continuing medical education for physicians. SRS designates this live activity for a maximum of 8.25 *AMA PRA category 1 Credit(s)*[™]. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Disclosure of Conflict of Interest

It is the policy of SRS to insure balance, independence, objectivity and scientific rigor in all of their educational activities. In accordance with this policy, SRS identifies conflicts of interest with instructors, content managers and other individuals who are in a position to control the content of an activity. Conflicts are resolved by SRS to ensure that all scientific research referred to, reported, or used in a CME activity conforms to the generally accepted standards of experimental design, data collection and analysis. Complete faculty disclosures are included in Conflict of Interest Disclosures section of this book.

PRE-MEETING COURSE

CME Certificates

CME Certificates will be available to pre-registered delegates immediately upon the close of the meeting at www.srs.org/professionals/meetings/am14.

Delegates should log onto the website listed above and enter their last name and the ID# listed on your badge. The system will then ask delegates to indicate which sessions they attended, and then will generate a PDF certificate which may be printed or saved. Session attendance information is saved in the database, and certificates may be accessed again, in the event the certificate is lost or another copy is required. Delegates who registered onsite will be able to access their certificates after October 1, 2014.

Please note that only the certificate of attendance will be emailed from the meeting; not CME certificates. The online certificate program is the only source for this documentation. If you have any questions, please visit the registration desk, or email the SRS office at meetings@srs.org.

FDA Statement

All drugs and medical devices used in the United States are administered in accordance with Food and Drug Administration (FDA) regulations. These regulations vary depending on the risks associated with the drug or medical device, the similarity of the drug or medical device to products already on the market, and the quality and scope of clinical data available. Some drugs and medical devices demonstrated in Scoliosis Research Society meetings or described in Scoliosis Research Society print publications have FDA clearance for use for specific purposes or for use only in restricted research settings. The FDA has stated that it is the responsibility of the physician to determine the FDA status of each drug or device he or she wishes to use in clinical practice, and to use the products with appropriate patient consent and in compliance with applicable law.

Disclaimer

The material presented at the SRS Annual Meeting & Course has been made available by the Scoliosis Research Society for educational purposes only. This material is not intended to represent the only, nor necessarily best, method or procedure appropriate for the medical situations discussed, but rather is intended to present an approach, view, statement or opinion of the presenter which may be helpful to others who face similar situations.

SRS disclaims any and all liability for injury or other damages resulting to any individuals attending a session for all claims which may arise out of the use of the techniques demonstrated there in by such individuals, whether these claims shall be asserted by a physician or other party

The 2014 Pre-Meeting Course is supported, in part, by grants from Biomet, DePuy Synthes, Medtronic, NuVasive.



PRE-MEETING COURSE



Audience Response

This course will include an audience response component. Audience response questions can be found in this course book and can be answered using the "Polls & Feedback" module of the Mobile Application. Click on the appropriate session to access the questions for that particular session. A live feed of audience response will be shown at the conclusion of each session.

Mobile Application

A mobile and online app will be available to all delegates during the 49th Annual Meeting & Course. The app is designed to provide all the information about the Annual Meeting & Course and Anchorage in one convenient location and can be accessed from any smart phone or computer with an internet connection. To download the app visit, <http://eventmobi.com/srsam14> or scan the QR code above with your smart phone

How to Use a QR Code/ Download the App

Smart phone cameras are able to scan QR Codes, or Quick Response Codes, to instantly link you to a specific image or URL. To use a QR Code all you need is an app that allows you to scan using the camera built into your phone. To access the SRS Annual Meeting App Homepage directly using the QR code, follow these directions.

1. Your smart phone needs to have a QR scanner application installed.
 - For Blackberry download: The QR Code Scanner Pro from the Blackberry App Store OR there is a QR Code Scanner built in to the Blackberry Messenger.
 - For iPhone download: Scan. This app can be found in the app store by searching the word scan. The app is the property of QR Code City, LLC.
2. Once the app is downloaded you are ready to scan the QR code. Place the QR code in the middle of the brackets so that it is centered and as large as the brackets.
3. On the iPhone once the QR code is centered it will automatically scan and load the webpage linked to the QR code
4. On the Blackberry-
 - Blackberry Messenger: Click into Blackberry Messenger and scroll down to find the option that says "scan a group barcode." The app will then give you a short tutorial how to scan your code.
 - QR Code Scanner Pro: Open the app and click the scan option. Once you have your code centered and as large as the brackets select "click to scan." The app will then pull up the URL.
5. On the iPhone: You can click on the arrow in the bottom right-hand corner to open the webpage in safari. You can also navigate the app while you are still in the Scan App.
6. On the Blackberry: Once you scan the code you will be able to navigate the entire app. To permanently save the app click on your blackberry button and select save page. A message will prompt you to save to message list-click ok. The app will save to your email. Anytime you want to revisit the app, click on the message in your email and you will automatically be linked back to the app

PRE-MEETING COURSE

MORNING SESSION I

What We Know About Severe Spine Deformity and How We Teach It

September 10, 2014

Room: Idlughet Hall 1&2

Moderators: *Sigurd H. Berven, MD & Lori A. Karol, MD*

- 7:45 – 7:50 AM **Introduction**
Steven D. Glassman, MD
- 7:50 – 7:55 AM **Spine Deformity in Alaska**
James M. Eule, MD
- 7:55 – 8:00 AM **Introduction to Automated Response System (ARS): Complex Spine Surgery for Scoliosis in the Adult and Child**
Lori A. Karol, MD
- 8:00 – 8:08 AM **Learning from the Past: Complex Scoliosis Surgery in the Adult— Learning From Evidence Based Medicine**
Nathan H. Lebowhl, MD
- 8:08 – 8:16 AM **Learning from the Past: Complex Scoliosis Surgery in the Pediatric Patient— Evidence Based Medicine**
James O. Sanders, MD
- 8:16 – 8:24 AM **Complex Scoliosis Surgery: Learning from the SRS M&M Database**
Justin S. Smith, MD, PhD
- 8:24 – 8:34 AM **Discussion**
- 8:34 – 8:42 AM **Learning From the Experience of Experts: Pre-Operative Planning in Pediatric Severe Deformity (Primary and/or Revision)**
John P. Dormans, MD
- 8:42 – 8:50 AM **Pre-Operative Planning in Adult Severe Deformity (Primary and/or Revision)**
Frank J. Schwab, MD
- 8:50 – 8:58 AM **Intraoperative Imaging and Navigation in Complex Deformity and Revision Surgery: How Does it Help Us Teach and Learn?**
David W. Polly Jr., MD
- 8:58 – 9:06 AM **Intraoperative Pearls in Severe Pediatric Spine Deformity Surgery without Navigation**
Daniel J. Sucato, MD, MS
- 9:06 – 9:16 AM **Discussion**
- 9:16 – 9:22 AM **Teaching How to do Complex Spine Surgery: The US Model**
Munish Chandra Gupta, MD
- 9:22 – 9:28 AM **Teaching How to do Complex Spine Surgery: The Canadian Model**
Reinhold D. Zeller, MD, FRCSC
- 9:28 – 9:34 AM **Teaching How to do Complex Spine Surgery: The European Model**
Henry F. H. Halm, MD
- 9:34 – 9:40 AM **Teaching Complex Spine Surgery in Patients with Intraspinial Pathology**
Tyler Koski, MD
- 9:40 – 9:50 AM **Discussion**
- 9:50 – 10:10 AM **Panel: How to “Survive” the Learning Curve**
Moderator: *Vernon T. Tolo, MD*
Panel: *Kenneth MC Cheung, MD; Mark A. Erickson, MD; Steven D. Glassman, MD; Serena S. Hu, MD; S. Rajasekaran, MD, PhD; Scott S. Russo, Jr., MD*
- 10:10 – 10:25 AM **Break**

PRE-MEETING COURSE

MORNING SESSION II

Complex Scoliosis Surgery: What Pediatric Spine Surgeons Can Learn from Adult Deformity Surgeons and What Adult Surgeons Can Learn from Those who Treat Children

Room: Idlughet Hall 1&2

Moderators: *B. Stephen Richards, III, MD & Maria Cristina Sacramento-Dominguez, MD, PhD*

- 10:25– 10:33 AM **The Neglected Severe Curve in the Adolescent**
Richard M. Schwend, MD
- 10:33 – 10:41 AM **The Long Term Adult Sequellae of Residual Deformity in the Operated Adolescent**
Oheneba Boachie-Adjei, MD
- 10:41 – 10:49 AM **Severe Deformity in Adolescence: What are the Pulmonary Implications?**
Gregory Redding, MD
- 10:49 – 10:57 AM **The Adult Sequellae of Severe Scoliosis in Adolescence**
Aina Danielsson, MD, PhD
- 10:57 – 11:03 AM **Discussion**
- 11:03 – 11:11 AM **VCR in Children and Adolescence: Learning Techniques Used First in Adults**
Paul D. Sponseller, MD, MBA
- 11:11 – 11:19 AM **Pseudarthrosis in Young Adulthood following Complex Spinal Surgery for Severe Scoliosis: Fact or Fiction**
Michael Ruf, MD
- 11:19 – 11:27 AM **To Fuse or Not to Fuse? Balanced Curves in Late Adolescence**
Mark Weidenbaum, MD
- 11:27 – 11:33 AM **Discussion**
- 11:33 – 11:46 AM **Debate: Distal Level Preservation in Adolescents with Severe Curves versus Less Residual Deformity**
Moderator: *B. Stephen Richards, III, MD*
Preserve Motion and Accept Residual Deformity: *Joseph H. Perra, MD*
Less Residual Deformity Even if One More Fused Level: *Matthew E. Oetgen, MD*
- 11:46 – 11:55 AM **Discussion**
-
- 12:10 – 1:10 PM **Lunchtime Symposia**
- Are You Ready for ICD-10**
Room: Tikahtnu AB
- Ethical Dilemmas in Spine Surgery**
Room: Idlughet 1/2
- Global Outreach Committee Update**
Room: Tikahtnu CF

AFTERNOON SESSION I

Learning from Our Complications: The Complication I Have Learned the Most from in Complex Scoli Deformity and What it Can Teach You

Room: Idlughet Hall 1&2

Moderators: *Behrooz A. Akbarnia, MD & Karl E. Rathjen, MD*

- 1:20 – 1:27 PM **Intraoperative Loss of Signals**
Kamal N. Ibrahim, MD, FRCS(C), MA
- 1:27 – 1:34 PM **Pseudarthrosis**
Ahmet Alanay, MD
- 1:34 – 1:41 PM **Balance Problems after Posterior Spinal Fusion**
Laurel C. Blakemore, MD

PRE-MEETING COURSE

- 1:41 – 1:48 PM **The “Domino Effect” in the Treatment of the Rheumatoid Spine: Crisis Management**
John R. Dimar, II, MD
- 1:48 – 1:55 PM **Junctional Kyphosis**
Christopher I. Shaffrey, MD
- 1:55 – 2:05 PM **Discussion**
- 2:05 – 2:12 PM **Surgical Simulation: What is Available in 2014 and How Can it Help Us Learn?**
Stefan Parent, MD, PhD
- 2:12 – 2:21 PM **Quality, Safety and Value: The Adult Spine Surgery Initiatives and What Can We Learn**
Sigurd H. Berven, MD
- 2:21 – 2:30 PM **Quality, Safety and Value: The Pediatric Spine Surgery Initiatives and What We Learn**
Michael G. Vitale, MD, MPH
- 2:30 – 2:40 PM **Discussion**

AFTERNOON SESSION II

How We Learn: Mentors, Mentees and Reverse Mentoring

Room: Idlughet Hall 1&2

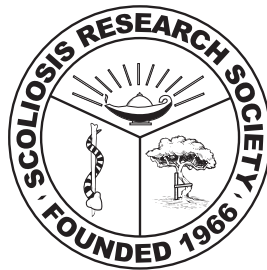
Moderators: *Kit M. Song, MD, MHA & Muharrem Yazici, MD*

- 2:40 – 2:54 PM **Case TBD**
Moderator: *Adrian C. Gardner, FRCS*
David S. Marks, FRCS; Allistair Graham Thompson, FRCS
- 2:55 – 3:09 PM **Lordoscoliosis: Restoration of Sagittal Plane**
Moderator: *Brandon A. Ramo, MD*
Charles E. Johnston, MD; Peter O. Newton, MD
- 3:10 – 3:24 PM **Junctional Kyphosis: Prevention and Treatment**
Moderator: *Hamid Hassanzadeh, MD*
Khaled Kebaish, MD; John P. Kostuik, MD
- 3:25 – 3:32 PM **Discussion**
- 3:33 – 3:47 PM **Early Onset Scoliosis (EOS) Controversy: When to Implement Growth Friendly Surgery?**
Moderator: *Vidyadhar V. Upasani, MD*
John B. Emans, MD; Daniel J. Hedequist, MD
- 3:48 – 4:02 PM **ASF/PSF Versus Vertebral Column Resection: Indications**
Moderator: *Michael P. Kelly, MD*
Jacob M. Buchowski, MD, MS; Lawrence G. Lenke, MD
- 4:03 – 4:17 PM **Modern Treatment in Congenital Cervicothoracic Scoliosis**
Moderator: *Michelle S. Caird, MD*
Frances A. Farley, MD; Robert N. Hensinger, MD
- 4:18 – 4:25 PM **Discussion**
- 4:25 – 4:30 PM **ARS and Cases; Closing remarks**
Lori A. Karol, MD

Case Presentation Sessions Begin at 4:45 PM

PRE-MEETING COURSE

MORNING SESSION I WHAT WE KNOW ABOUT SEVERE SPINE DEFORMITY AND HOW WE TEACH IT



Moderators:

Sigurd H. Berven, MD & Lori A. Karol, MD

Faculty:

Kenneth M. Cheung, MD; John P. Dormans, MD; Mark A. Erickson, MD; James M. Eule, MD; Steven D. Glassman, MD; Serena Hu, MD; Lori A. Karol, MD; Tyler Koski, MD; Nathan H. Lebowhl, MD; Lawrence G. Lenke, MD; David S. Marks, FRCS; David W. Polly, Jr., MD; S. Rajasekaran, MD, PhD; Scott S. Russo, MD; James O. Sanders, MD; Frank J. Schwab, MD; Justin S. Smith, MD, PhD; Daniel J. Sucato, MD, MS; Reinhard D. Zeller, MD, FRCSC

PRE-MEETING COURSE

Learning from the Past: Complex Scoliosis Surgery in the Adult: Learning from Evidence Based Medicine

Nathan H. Lebowhl MD

Chief, Spinal Deformity Surgery

University of Miami Spine Institute

Miller School of Medicine

Miami, Florida, USA

The development and validation of disease specific outcome instruments and the establishment of multicenter databases with large patient populations has allowed investigators to answer important questions about surgical management of adult scoliosis. Evaluation of surgical outcomes in the early era of spinal instrumentation led to the conclusion that surgery for adult patients with scoliosis was fraught with risk, and had minimal benefit. In the 1990's, publications by Dickson and Albert provided more optimism about the benefits of surgery, but had limitations due to the size of the study populations and the lack of a disease specific evaluation instrument. The development of the SRS-22 outcomes questionnaire and its subsequent validation as an effective instrument for the evaluation of outcomes in adult deformity patients, combined with the establishment of multicenter databases were the key developments which have enabled our current understanding of surgical management.

Thanks to the work first presented by Glassman, and then validated by many other authors, a paradigm shift has occurred in the approach to the adult deformity patient. He was the first to show that coronal deformity in adult patients was much less important than sagittal imbalance in those patients. This is in spite of the condition being defined as a coronal deformity. Because of the large study populations, the data has strong statistical significance. The results have been reinforced by many authors, whether looking at the alignment after treatment, or whether sagittal imbalance was part of the indication for surgical treatment. Correction of pre-op coronal imbalance and magnitude of correction of coronal deformity do not correlate with good outcome, but if sagittal imbalance exists pre-operatively and is corrected, a good outcome can be anticipated.

Further evaluation of the radiographic measurements of these surgical populations has defined the role of the pelvis as a platform for the spine, and has led to a better understanding of the role of pelvic shape and position. The importance of pelvic tilt, and of the match between pelvic incidence and lumbar lordosis has been well defined and statistically proven.

Nonoperative care has been shown to be ineffective, and in contrast to Nachemson's recommendations that "all types of conservative care must be tried before discussing an operation" operative management is the treatment of choice for appropriately selected patients. Even in the elderly patient, who has a higher risk of complication from surgery, surgical management has been shown to have significant benefit; in fact relatively more improvement from surgery has been shown in the older age group.

- 1) Nachemson A., Adult scoliosis and back pain. Spine 1979 Nov-Dec;4(6):513-7.
- 2) Sponseller PD, Cohen MS, Nachemson AL, Hall JE, Wohl ME. Results of surgical treatment of adults with idiopathic scoliosis. J Bone Joint Surg Am. 1987 Jun;69(5):667-75.

- 3) Dickson JH, Mirkovic S, Noble PC, Nalty T, Erwin WD. Results of operative treatment of idiopathic scoliosis in adults. J Bone Joint Surg Am. 1995 Apr;77(4):513-23.
- 4) Albert TJ, Purtill J, Mesa J, McIntosh T, Balderston RA., Health outcome assessment before and after adult deformity surgery. A prospective study. Spine 1995 Sep 15;20(18):2002-4
- 5) Berven SI, Deviren V, Demir-Deviren S, Hu SS, Bradford DS., Studies in the modified Scoliosis Research Society Outcomes Instrument in adults: validation, reliability, and discriminatory capacity. Spine 2003 Sep 15;28(18):2164-9
- 6) Bridwell KH1, Cats-Baril W, et al. The validity of the SRS-22 instrument in an adult spinal deformity population compared with the Oswestry and SF-12: a study of response distribution, concurrent validity, internal consistency, and reliability. Spine 2005 Feb 15;30(4):455-61.
- 7) Glassman SD, Berven S, Bridwell K, Horton W, Dimar JR. Correlation of radiographic parameters and clinical symptoms in adult scoliosis. Spine 2005 Mar 15;30(6):682-8.
- 8) Daubs MD, Lenke LG, Bridwell KH, Kim YJ, Hung M, Cheh G, Koester LA. Does correction of preoperative coronal imbalance make a difference in outcomes of adult patients with deformity? Spine 2013 Mar 15;38(6):476-83.
- 9) Lafage V, Schwab F, Patel A, Hawkinson N, Farcy JP. Pelvic tilt and truncanl inclination: two key radiographic parameters in the setting of adults with spinal deformity. Spine 2009 Aug 1;34(17):E599
- 10) Schwab FJ, Blondel B, Bess S, et al. Radiographical spinopelvic parameters and disability in the setting of adult spinal deformity: a prospective multicenter analysis. Spine 2013 Jun 1;38(13):E803-12.
- 11) Bridwell KH, Glassman S, Horton W, et al. Does treatment (nonoperative and operative) improve the two-year quality of life in patients with adult symptomatic lumbar scoliosis: a prospective multicenter evidence-based medicine study. Spine 2009 Sep 15;34(20):2171-8.
- 12) Smith JS, Shaffrey CI, Glassman SD, et al. Risk-benefit assessment of surgery for adult scoliosis: an analysis based on patient age. Spine 2011 May 1;36(10):817-24.

Notes:

PRE-MEETING COURSE

Learning from the Past: Complex Scoliosis Surgery in the Pediatric

Patient: Evidence Based Medicine

James O. Sanders, MD

Professor of Orthopaedics and Pediatrics

University of Rochester

Dept. of Orthopaedics & Rehabilitation

Rochester, New York, USA

1. What is “complex scoliosis surgery”
 - a. Any surgery I do?
 - b. Instrumented fusions in the very young?
 - c. Large curves?
 - d. Revision surgery?
 - e. Osteotomies?
 - f. VCR’s?
 - g. Growing instrumentation?
 - h. Normal surgery in complex patients?

What type of evidence base do we need for each of these? I suggest three questions worth investigating:

1. Is the surgery better than the natural history?
2. Is the surgery better than a reasonable alternative?
3. Are the harms worth the risks?

Is the surgery better than the natural history?

What does the evidence say?

EBM relies upon comparative studies. To say a treatment is better than the natural history requires either:

- a. A study comparing outcomes of a treatment to the natural history, or
- b. A well-known natural history and a very large treatment effect

So what literature exists for each of these meeting these criteria?:

1. Early onset scoliosis: no comparative studies of outcomes
2. Moderate AIS: short run, improved SRS scores — mostly appearance but only preop to postop comparisons. Not compared to natural history.
3. Large AIS — 2 year improvement in PFTs, but only preop to postop comparisons, not compared to natural history
4. Congenital scoliosis: no comparative studies of outcomes
5. Congenital kyphosis: no comparative studies of outcomes
6. Syndromic scoliosis: no comparative studies of outcomes
7. Myelomeningocele — evidence against surgery improving QOL
8. Non-CP neuromuscular scoliosis: no comparative studies of outcomes
9. Cerebral palsy: no comparative studies of outcomes

Which of these have a very well-known natural history and very large treatment effect? EOS, AIS, and congenital kyphosis are the most likely, but we do not know if the size of the treatment effect.

So, are we doing surgery without evidence?

Hardly:

1. There is no question that scoliosis surgery makes the spine straighter
2. Patients who are displeased with their appearance are much more pleased postoperatively
3. Parents express satisfaction with the sitting balance and comfort in children with neuromuscular scoliosis
4. Patients with poor pulmonary function improve their pulmonary function with some AIS patients but it is less clear with other disorders.
5. Spinal Deformity Surgery has substantial challenges in creating evidence to truly demonstrate that a treatment is better than the natural history. This is potentially problematic when reimbursements are under scrutiny.

Is the surgery better than a reasonable alternative?

1. Growing instrumentation compared to bracing or casting — limited evidence in the short run for casting
2. Instrumented fusion compared to growing instrumentation — no comparative studies
3. Pedicle screws to hooks or wires — studies show more correction with screws but no difference in functional outcomes
4. Intraoperative traction to anterior/posterior surgery
5. Pedicle screws to anterior/posterior surgery
6. Ponte’s with instrumentation compared to instrumentation — Halanski MA, Cassidy JA. significantly higher blood loss and operative time associated with the use of routine posterior osteotomies in the thoracic spine without a significant improvement in coronal or sagittal correction.
7. VCR compared to halo traction or anterior/posterior surgery — no comparative studies
8. Temporary distraction compared to halo traction — no comparative studies

Are the harms worth the risks?

1. Infection in neuromuscular scoliosis — Sharma, et al.
2. Infection and paraplegia with VCR — Helenius, et al

Where does this leave us?

1. We have no comparative studies of the natural history of disorders compared to their surgical treatment.
2. We have very few comparative studies of treatments compared to other treatments.
3. Our surgical procedures carry high risk.
4. Shared decision making can help.
5. We are likely to be under increasing pressure to demonstrate that our procedures provide value.
6. Our field is ripe for comparative effectiveness research
7. Risk versus benefit and risk versus cost ultimately become personal and societal choices.

PRE-MEETING COURSE

Notes:

Complex Scoliosis Surgery: Learning From the SRS M&M Database

Justin S. Smith, MD, PhD

Associate Professor of Neurosurgery

University of Virginia

PO Box 800212

Charlottesville, VA 22908

Phone: 434-243-9331

Fax: 434-243-1758

jss7f@virginia.edu

Key Points

1. Assessment of M&M and why it is important.

- All surgical procedures have inherent risks of complications.
- Assessment of complications is important for patient counseling, quality improvement, and medico-legal issues.
- There are few modern series that have documented complication rates for spine procedures and most of these are based on relatively small series or single-surgeon or single-institution experiences.
- Since founded in 1966, the SRS has been committed to research and education in the field of spinal deformities.
- Collection of M&M has been a unique tool of the society that has historically been used to provide information to members on complication rates and trends associated with procedures performed.
- Collection and submission of de-identified M&M data are distinguishing aspects of membership in the SRS.
- Mechanism for collection of SRS M&M data has evolved from a card system using machine notching to an on-line data entry system.

2. Peer-reviewed publications resulting from SRS M&M data.¹⁻²¹

- The first publication was from MacEwen et al in 1975.¹⁰ This first analysis focused on acute neurological complications in 7,885 scoliosis cases performed by the membership between 1965 and 1971. They reported a 0.72% neurologic complication rate and noted that patients with the diagnoses of kyphosis and congenital scoliosis were at increased risk of complications, especially neurologic complications.
- No subsequent reports from the SRS M&M database were published in peer-reviewed literature until Coe et al published in 2006 an assessment

of complications in 6,716 patients submitted by the membership between 2001 and 2004 who underwent spinal fusion and instrumentation for adolescent idiopathic scoliosis.¹ This study reported an overall complication rate of 5.7% with no significant differences in complication rates between posterior and anterior spinal fusion procedures. They did note that the rate of complications for combined anterior-posterior procedures was twice as high as the rates for posterior-only or anterior-only procedures.

- Also based on cases submitted by the membership between 2001 and 2004, Coe et al assessed complication rates for spinal fusion for 683 Scheuermann's kyphosis cases.² They reported a significantly higher complication rate in adults compared with pediatric patients and noted that the overall rate of complications was not significantly different between posterior spinal fusion and same-day combined anterior-posterior procedures.
- Although there were only 3 peer-reviewed publications from the SRS M&M data over the first ~40 years of the society, over the last 4 years there have been an additional 18 peer-reviewed publications that cover a broad range of topics:
 - Common procedures M&M validation study¹⁵
 - Degenerative spondylolisthesis M&M¹²
 - Degenerative lumbar stenosis M&M⁶
 - Infection rates in spine surgery¹⁸
 - New neurological deficits in spine surgery⁷
 - Complications associated with the use of BMP for spine fusion²⁰
 - Pediatric scoliosis M&M¹¹
 - Adult scoliosis M&M¹³
 - Pediatric spondylolisthesis M&M⁵
 - Unintended durotomy in spine surgery¹⁹
 - Fixed sagittal deformity M&M¹⁶
 - Pediatric spinal surgery M&M³
 - Correlation of ASA grade and M&M⁴
 - High-grade spondylolisthesis M&M⁸
 - Mortality in spine surgery¹⁷
 - Overall trends: "new" versus "old" data collection system⁹
 - Spine fracture surgery M&M²¹
 - Mortality: "old" versus "new" collection systems¹⁴
 - Following are high-lights of findings from a selected subset of publications from the SRS M&M database.

3. **Validation of the SRS M&M Database:** Smith JS, *et al.* Complication rates of three common spine procedures and rates of thromboembolism following spine surgery based on 108,419 procedures. *Spine* 35(24):2140-9, 2010.¹⁵

- SRS M&M database between the years 2004 and 2007 included all spine procedures performed- not just deformity cases. Complications for three common procedures (lumbar microdiscectomy, ACDF, and decompression for lumbar stenosis) were assessed and compared with corresponding complication rates reported in the literature as a means of validating the reliability of the database.
- The overall major complication rates for these common procedures were

PRE-MEETING COURSE

very comparable to those in previously reported smaller series, which supports the validity of the database for study of less common spinal disorders, including spinal deformity.

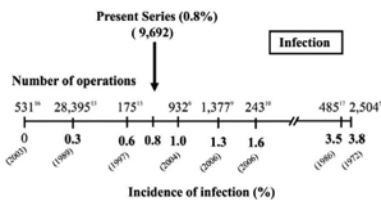


Figure 3. Comparison of the rate of wound infection associated with lumbar discectomy in the present series with rates from previously reported series. Numbers above the horizontal line indicate the number of procedures in each study, and numbers below the horizontal line indicate the percent of wound infections reported in each study.

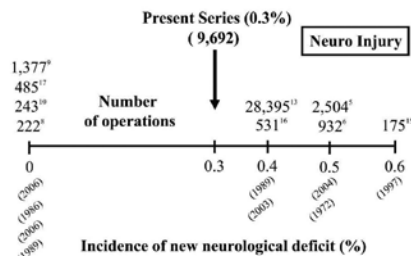
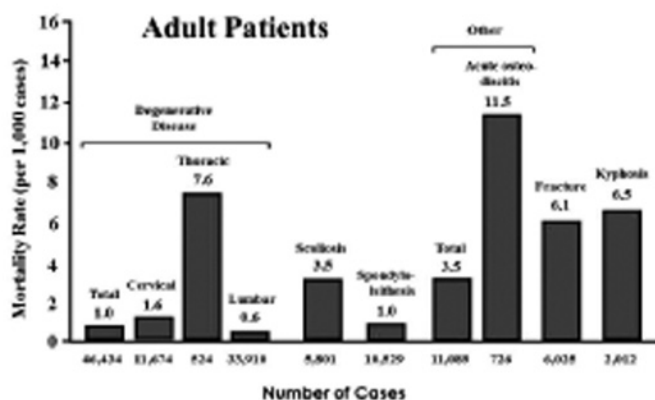


Figure 4. Comparison of the rate of new neurologic deficit associated with lumbar discectomy in the present series with rates from previously reported series. Numbers above the horizontal line indicate the number of procedures in each study, and numbers below the horizontal line indicate the percent of new neurologic deficits reported in each study.

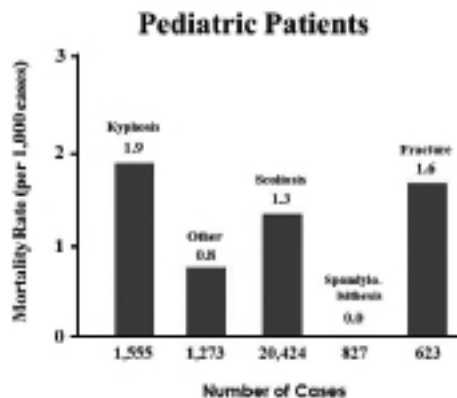
4. Rates of mortality in spine surgery: Smith JS, *et al.* Rates and causes of mortality associated with spine surgery based on 108,419 procedures: A review of the Scoliosis Research Society morbidity and mortality database. *Spine* 37(23):1975-82, 2012. *Spine* 35(24):2140-9, 2010.¹⁷

- Broad range in mortality rates based on diagnosis and adult versus pediatric
- Most common causes of mortality: respiratory/pulmonary, cardiac, sepsis, stroke, and intra-op blood loss
- Increased mortality risk with greater age, higher ASA score, and more complex procedures

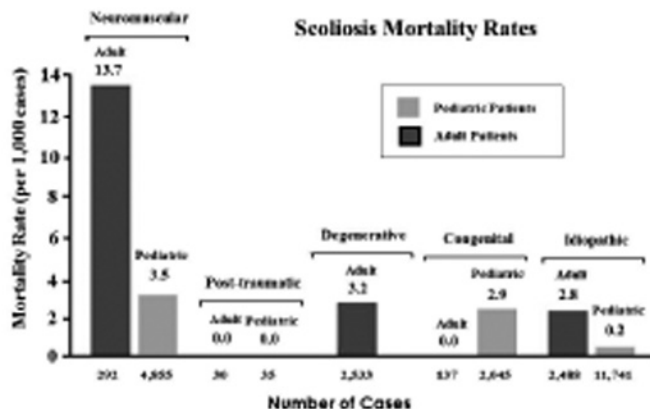
Mortality Rate Based on Primary Diagnosis



Mortality Rate Based on Primary Diagnosis



Mortality Rate Based on Subtype of Scoliosis



Mortality for Selected Surgical Procedures

Procedure	Deaths per 1,000 Patients
Liposuction	1 ¹
Pediatric Scoliosis	1.3
Carotid Endarterectomy	1.5-1.7 ²
Adult Scoliosis	3.5
Elective AAA Repair	3.9-6.5 ³
Arthroplasties	7 ¹
CABG	45-56 ²
Pancreatic Resection for Cancer	38-163 ³
Esophagectomy For Cancer	84-203 ³

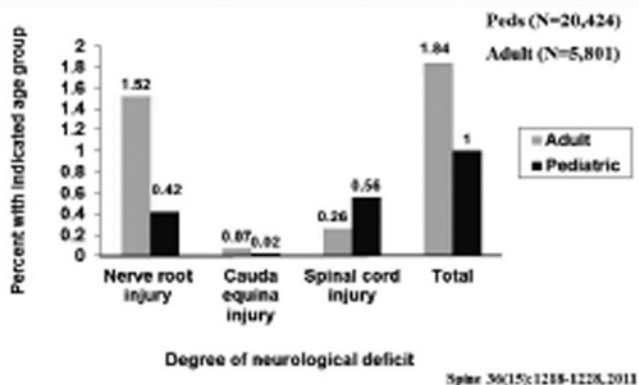
¹ *Ann Surg* 2005;141:733-43
² *NEJM* 2002;346:1128-37
³ *JAMA* 2011;305:2027-38

PRE-MEETING COURSE

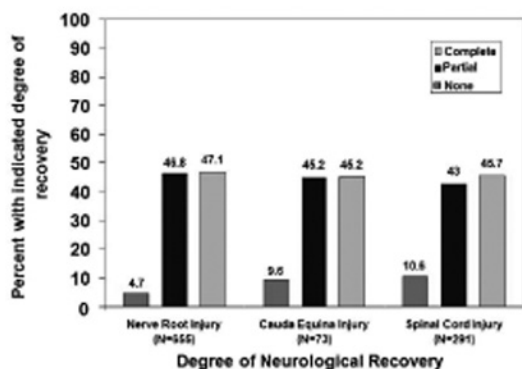
4. Rates of new neurological deficit in spine surgery: Hamilton DK, *et al.* Rates of new neurological deficit associated with spine surgery based on 108,419 procedures: a report of the Scoliosis Research Society Morbidity and Mortality Committee. *Spine* 36(15):1218-28, 2011.⁷

- Rates of new neurological deficits varied by diagnosis and by pedi versus adult
- Sensitivity and specificity of combined SSEP and EMG monitoring for new nerve root deficit were 0.13 and 0.99, respectively.
- Sensitivity and specificity of combined SSEP and MEP monitoring for new spinal cord deficit were 0.43 and 0.98, respectively.
- Vast majority of deficits at least partially recovered.

Neurological Injury Based on Primary Diagnosis: Scoliosis



Recovery Rates of 1,019 New Neurological Deficits Associated with Spinal Surgery

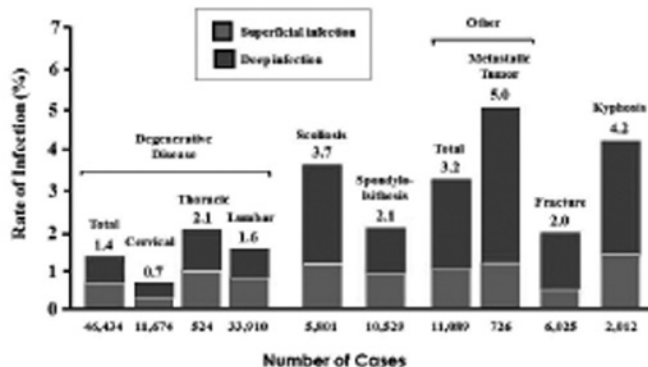


4. Rates of infection in spine surgery: Smith JS, *et al.* Rates of infection after spine surgery based on 108,419 procedures: a report of the Scoliosis Research Society Morbidity and Mortality Committee. *Spine* 36(7):556-63, 2011.¹⁸

- Overall superficial and deep wound infection rates were 0.8% and 1.3%, respectively.
- Wound infection rates were lowest for procedures performed for degenerative spine disease and highest for spinal deformity.
- For adult and pediatric patients, NM scoliosis had highest rates of deep wound infection.

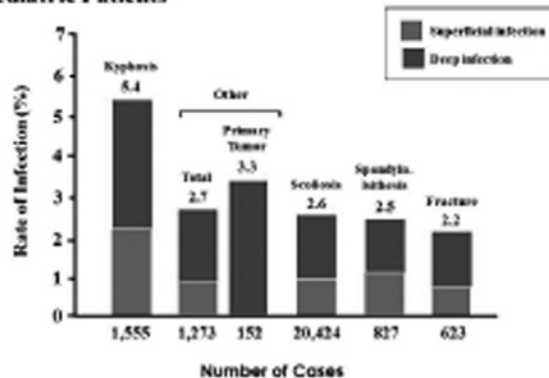
Rate of Infection Based on Primary Diagnosis

Adult Patients



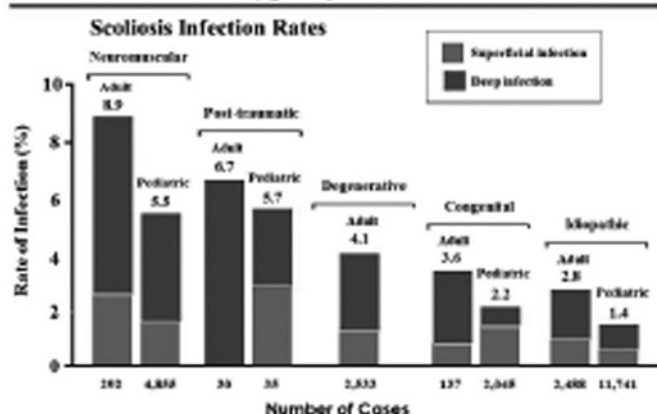
Rate of Infection Based on Primary Diagnosis

Pediatric Patients



PRE-MEETING COURSE

Rate of Infection Based on Subtype of Scoliosis



5. **BMP use in spine surgery:** Williams BJ, *et al.* Does bone morphogenetic protein increase the incidence of perioperative complications in spinal fusion? *Spine* 36(20):1685-91, 2011.²⁰

- BMP was used in 21% of the 55,862 spinal fusions in the series.
- BMP was more commonly used in older patients and in revision procedures.
- Vast majority of BMP use was off-label.
- BMP use with anterior cervical fusion was associated with an increased incidence of complications.
- Use of BMP was not associated with more complications in thoracolumbar and posterior cervical fusions.

Complication	Fusion Without BMP (No. [%])	Fusion With BMP (No. [%])	P*	
Respiratory critical and low analysis	Overall	380 (0.6)	862 (0.5)	0.5
	Wound infection	96 (0.1)	26 (0.0)	0.8
	Intraop. hemorrhage	65 (0.1)	21 (0.0)	0.3
Respiratory critical	Overall	1 (0.0)	38 (0.0)	<0.001
	Wound infection	1 (0.0)	1 (0.0)	<0.001
	Total transfusions	1 (0.0)	3 (0.0)	0.3

*P < 0.05 considered significant.
BMP indicates bone morphogenetic protein.

6. **Pediatric scoliosis M&M:** Reames DL, *et al.* Complications in the surgical treatment of 19,360 cases of pediatric scoliosis. *Spine* 36(18):1484-91, 2011.²⁰

- Largest series of pediatric scoliosis reported: 11,227 idiopathic, 4,657 neuromuscular, and 2,012 congenital
- Based on 19,360 cases, overall complication rate was 10.2% and overall mortality was 0.13%.
- Highest complication rates were with NM and congenital scoliosis.
- Higher rates of complications with revision versus primary cases.
- Compared with pedicle screw-only and hook-only constructs, wire-only and anterior screw-only constructs were associated with significantly higher rates of new neurological deficits.
- Most common causes of mortality were respiratory failure/aspiration, sepsis, and intra-op hemorrhage, suggesting areas for improvement of safety of care.

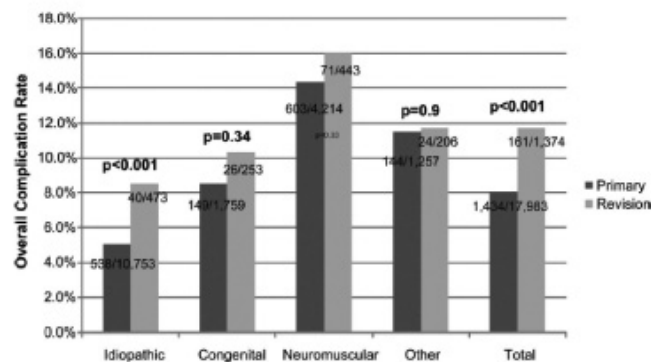


TABLE 4. New Neurological Deficits Associated With the Surgical Treatment of Pediatric Scoliosis, Stratified Based on Type of Instrumentation Used

	Total	New Neurological Deficits*†‡ N (%)	Nerve Root Deficit	Cauda Equina Deficit	Spinal Cord Deficit (Partial)	Spinal Cord Deficit (Complete)
Lumbar pedicle screws only	309	2 (0.6)	2*	0	0	0
Thoracic pedicle screws only	1066	5 (0.5)	2*	0	3*	0
Thoracic and/or lumbar pedicle screws only	4672	34 (0.7)	10*, 5†	1*	11*, 5†	1*, 1†
Anterior screws only	1019	21 (2)	7*, 4†	0	4*, 3†	1†
Posterior hooks only	1021	4 (0.4)	3†	0	1*	0
Posterior wires only	415	7 (1.7)	2*	0	1*, 2†	1*, 1†

*Complete recovery.
†Partial recovery.
‡No recovery.
§Pedicle screw-only constructs (thoracic and/or lumbar) had a significantly lower rate of new neurological deficits compared with anterior screw constructs (P < 0.001) and posterior wire-only constructs (P < 0.001). Pedicle screw-only constructs (thoracic and/or lumbar) had a statistically similar rate of new neurological deficits compared with hook-only constructs (P = 0.3).
¶Two new deficits not further specified.

TABLE 2. Mortality Associated With the Surgical Treatment of Scoliosis in 19,360 Pediatric Patients

	Total N (%)	Idiopathic 11,227	Congenital 2012	Neuromuscular 4657	Other 1464
Total	26 (0.13%)	2 (0.02%)	6 (0.30%)	16 (0.34%)	2 (0.14%)
Respiratory failure or aspiration	8		3	4	1
Sepsis	4				
Pneumonia	3	1		2	
Bowel perforation	1			1	
Intraoperative hemorrhage	4		1	3	
Cardiac failure	2	1		1	
Pulmonary embolus	1			1	
TRALI	1		1		
Brainstem herniation	1		1		
Brainstem infarct	1			1	
Fluid overload	1			1	
Unknown	3			2	1

TRALI indicates transfusion-related acute lung injury.

Summary Points

- SRS M&M data have been used to produce numerous clinically useful reports.
- Current data collection focuses only on deformity cases and specific events: death, paralysis, vision loss.
- Simplified data collection process, in conjunction with specific complication-focused modules, will allow even more detailed complication assessments.

References

1. Coe JD, Arlet V, Donaldson W, Berven S, Hanson DS, Mudiyan R, *et al.*: Complications in spinal fusion for adolescent idiopathic scoliosis in the new millennium. A report of the Scoliosis Research Society Morbidity and Mortality Committee. *Spine (Phila Pa 1976)* 31:345-349, 2006
2. Coe JD, Smith JS, Berven S, Arlet V, Donaldson W, Hanson D, *et al.*: Complications of spinal fusion for scheuermann kyphosis: a report of the scoliosis research society morbidity and mortality committee. *Spine (Phila Pa 1976)* 35:99-103, 2010

PRE-MEETING COURSE

3. Fu KM, Smith JS, Polly DW, Ames CP, Berven SH, Perra JH, et al: Morbidity and mortality associated with spinal surgery in children: a review of the Scoliosis Research Society morbidity and mortality database. *J Neurosurg Pediatr* 7:37-41, 2011
4. Fu KM, Smith JS, Polly DW, Jr., Ames CP, Berven SH, Perra JH, et al: Correlation of higher preoperative American Society of Anesthesiology grade and increased morbidity and mortality rates in patients undergoing spine surgery. *J Neurosurg Spine* 14:470-474, 2011
5. Fu KM, Smith JS, Polly DW, Jr., Perra JH, Sansur CA, Berven SH, et al: Morbidity and mortality in the surgical treatment of six hundred five pediatric patients with isthmic or dysplastic spondylolisthesis. *Spine (Phila Pa 1976)* 36:308-312, 2011
6. Fu KM, Smith JS, Polly DW, Jr., Perra JH, Sansur CA, Berven SH, et al: Morbidity and mortality in the surgical treatment of 10,329 adults with degenerative lumbar stenosis. *J Neurosurg Spine* 12:443-446, 2010
7. Hamilton DK, Smith JS, Sansur CA, Glassman SD, Ames CP, Berven SH, et al: Rates of new neurological deficit associated with spine surgery based on 108,419 procedures: a report of the scoliosis research society morbidity and mortality committee. *Spine (Phila Pa 1976)* 36:1218-1228, 2011
8. Kasiwal MK, Smith JS, Shaffrey CI, Saulle D, Lenke LG, Polly DW, Jr., et al: Short-term complications associated with surgery for high-grade spondylolisthesis in adults and pediatric patients: a report from the scoliosis research society morbidity and mortality database. *Neurosurgery* 71:109-116, 2012
9. Knapp DR, Goytan MJ, Noordeen KK, Smith JS, Broadstone PA, Berven SH, et al: Assessment of morbidity and mortality collection data 2009. *Spine Deformity* 1:179-184, 2013
10. MacEwen GD, Bunnell WP, Sriram K: Acute neurological complications in the treatment of scoliosis. A report of the Scoliosis Research Society. *J Bone Joint Surg Am* 57:404-408, 1975
11. Reames DL, Smith JS, Fu KM, Polly DW, Jr., Ames CP, Berven SH, et al: Complications in the surgical treatment of 19,360 cases of pediatric scoliosis: a review of the Scoliosis Research Society Morbidity and Mortality database. *Spine (Phila Pa 1976)* 36:1484-1491, 2011
12. Sansur CA, Reames DL, Smith JS, Hamilton DK, Berven SH, Broadstone PA, et al: Morbidity and mortality in the surgical treatment of 10,242 adults with spondylolisthesis. *J Neurosurg Spine* 13:589-593, 2010
13. Sansur CA, Smith JS, Coe JD, Glassman SD, Berven SH, Polly DW, Jr., et al: Scoliosis research society morbidity and mortality of adult scoliosis surgery. *Spine (Phila Pa 1976)* 36:E593-597, 2011
14. Shaffrey E, Smith JS, Lenke LG, Polly DW, Jr., Chen CJ, Coe JD, et al: Defining rates and causes of mortality associated with spine surgery: comparison of 2 data collection approaches through the Scoliosis Research Society. *Spine (Phila Pa 1976)* 39:579-586, 2014
15. Smith JS, Fu KM, Polly DW, Jr., Sansur CA, Berven SH, Broadstone PA, et al: Complication rates of three common spine procedures and rates of thromboembolism following spine surgery based on 108,419 procedures: a report from the Scoliosis Research Society Morbidity and Mortality Committee. *Spine (Phila Pa 1976)* 35:2140-2149, 2010
16. Smith JS, Sansur CA, Donaldson WF, 3rd, Perra JH, Mudiyan R, Choma TJ, et al: Short-term morbidity and mortality associated with correction of thoracolumbar fixed sagittal plane deformity: a report from the Scoliosis Research Society Morbidity and Mortality Committee. *Spine (Phila Pa 1976)* 36:958-964, 2011
17. Smith JS, Saulle D, Chen CJ, Lenke LG, Polly DW, Jr., Kasiwal MK, et al: Rates and causes of mortality associated with spine surgery based on 108,419 procedures: a review of the Scoliosis Research Society Morbidity and Mortality Database. *Spine (Phila Pa 1976)* 37:1975-1982, 2012
18. Smith JS, Shaffrey CI, Sansur CA, Berven SH, Fu KM, Broadstone PA, et al: Rates of infection after spine surgery based on 108,419 procedures: a report from the Scoliosis Research Society Morbidity and Mortality Committee. *Spine (Phila Pa 1976)* 36:556-563, 2011
19. Williams BJ, Sansur CA, Smith JS, Berven SH, Broadstone PA, Choma TJ, et al: Incidence of unintended durotomy in spine surgery based on 108,478 cases. *Neurosurgery* 68:117-123; discussion 123-114, 2011
20. Williams BJ, Smith JS, Fu KM, Hamilton DK, Polly DW, Jr., Ames CP, et al: Does bone morphogenetic protein increase the incidence of perioperative complications in spinal fusion? A comparison of 55,862 cases of spinal fusion with and without bone morphogenetic protein. *Spine (Phila Pa 1976)* 36:1685-1691, 2011
21. Williams BJ, Smith JS, Saulle D, Ames CP, Lenke LG, Broadstone PA, et al: Complications associated with surgical treatment of traumatic spinal fractures: a review of the scoliosis research society morbidity and mortality database. *World Neurosurg* 81:818-824, 2014

Notes:

PRE-MEETING COURSE

Learning from the Experience of Experts: Pre-Operative Planning in Pediatric Severe Deformity (Primary and/or Revision)

John P. Dormans MD

Chief of Orthopaedic Surgery

The Children's Hospital of Philadelphia

Professor of Orthopaedic Surgery

The University of Pennsylvania School of Medicine

Philadelphia, Pennsylvania, USA

- 1) "Severe deformity" is not AIS:
 - a) Spinal deformity, usually following early onset scoliosis, that, besides its severe clinical and radiographic picture, is also most commonly associated with poor pulmonary function due to chest wall deformity.
 - b) Increased neurological deficits: Significantly higher with kyphosis, more so congenital [1, 2]
 - c) Increased blood loss: "Severe deformity" associated with connective tissue disorders [3-5]
 - d) Pulmonary issues: Stiff chest wall with decreased compliance and poor lung capacity
 - e) Prolonged postoperative recovery given comorbidities/underlying diagnosis
- 2) Preoperative multidisciplinary evaluation
 - a) Multidisciplinary approach:
 - Genetic Evaluation
 - Urology: Kidney US-association with congenital scoliosis
 - Pulmonology: PFTs-Dynamic lung MRI-May need sleep study for apnea assessment
 - Anesthesiology: Assessment of trajectory and path of trachea. Difficult intubation and maintenance of airway.
 - Nutrition: May require nutritional supplements or feeding tubes to improve the nutritional status preoperatively. Detail to albumin/protein levels and lymphocyte count to ensure proper postoperative healing capabilities.
 - Cardiology/Neurology: Depending on underlying diagnosis
 - Labwork: CBC, PT/PTT, LFTs if needed, 2+ units typed and crossed(+cell saver)
 - b) NSQIP (National Surgical Quality Improvement Program) Spine Fusion Pilot Project:
 - Multi-institutional- Review of 1960 patients nationwide to date— data on readmission, return to OR, wound occurrences, and health care associated infections.
 - To examine the outcomes and variability related to posterior spinal fusions performed in pediatric orthopaedic surgery for spinal deformity
 - To identify patient variables and practice patterns that lead to variation in the care of children with spinal deformity.
 - c) Predefined care pathways/protocol-based approach [6, 7]:
 - Northwestern protocol-2010 [7]:
 - (1) Dedicated anesthesiologist reviews the surgeon's and hospitalist's medical workup and laboratory results, and prepares recommendations for the multidisciplinary spine conference.
 - (2) Specific and detailed "intraoperative communication guidelines" and "transfusion therapy management protocol"
 - Virginia Mason Medical Center - University of Washington: "Major Spine Level 3 Pathway Protocol" - 2014 [6]:
 - (1) Live multidisciplinary preoperative conference
 - (2) Dual attending surgeons in the operating room
 - (3) Intraoperative protocol for the management of coagulopathy: blood-tracking board and laboratory tracking board
 - (4) Detailed pre-, intra-, and post-operative checklist documentation
 - c) Imaging:
 - MRI: important and mandatory for all "severe deformity" patients: stenosis/cord signal changes due to deformity. Avoid surprises of syrinx/Chiari malformations
 - CT: additional to MRI for revisions (hardware artifact with MRI/ assess pseudoarthrosis) and congenital curves (3-D reconstruction helpful in understanding complex anatomy, planning osteotomies)
 - Bending/traction films: Very helpful in assessing flexibility-> planning for spine mobilization.
 - Patients with syndromic conditions: Don't forget the associations! Always AP/LAT and Flex/Ex C-spine radiographs to assess for instability.
- 3) Surgical Planning
 - a) Bracing is an option in children with significant growth potential?
 - Never an alternative to surgery
 - Helpful after early prophylactic surgery to prevent progression of secondary structural curves
 - b) Single (neurosurgical or orthopedic) versus combined operative team: better clinical outcome (blood loss, surgical time, post-operative infections) with dual attending surgeon model [8, 9] — teaching hospitals?
 - c) Optimizing surgical preparation: Incomplete or unavailable instrumentation, issues with implant sterilization, and surgeon preparation: all affect surgical outcomes!
 - d) Preop Traction [10, 11]:
 - PROS: Increases flexibility of spine AND chest wall->improves pulmonary function
 - CONS: cost/need for hospitalization
 - Contraindicated in congenital kyphosis, previous spinal tumor resections and when neurological deficits are present.
 - My bias: Can avoid with meticulous osteotomies for spine/chest mobilization

PRE-MEETING COURSE

- e) Spine mobilization always necessary in severe deformity. Ponte osteotomies/Smith-Peterson osteotomies (SPO)/Pedicle subtraction osteotomies (PSOs)/Vertebral column resections (VCRs). Chest wall mobilization not always necessary
- No substitute for experience (Courses with cadaver training, w/w another, gradual progression with experience):
Ponte-SPOs
Lumbar Hemivertebrae (front/back -> posterior only)
Upper hemivertebrae
PSO (lumbar – rare in pediatric spinal deformity – mostly revision)
VCR (Neuromuscular 1st, Lumbar)
- f) Thromboelastography [12, 13]:
- Role in severe spinal deformity for assessment and early detection of replacement needs?
- g) Intraop imaging:
- My bias: O-arm for post-hoc confirmation of pedicle screw placement (33% reposition one screw, 33% reposition 2 screws, 33% reposition none)
- h) Intraoperative Neurophysiological Monitoring (IONM): Critical for severe deformity-Trained dedicated team in OR-Direct communication between teams.
- Have a plan in case of loss of IONM before going into surgery:
Technical Problems (leads positioning, interference)
Check/Raise blood pressure
Release correction, especially distraction
Adjust instrumentation
Consider wake-up test
If TRUE complete loss of TcMEPs: remove instrumentation and come back another
- 4) Surgical options for the growing pediatric spinal deformity:
- a) Growing Rods[14]:
- Primary intervention for early onset scoliosis
 - Law of diminishing returns but best results with routinely 6-month interval lengthening
 - Maturity? Remove and fuse/Remove and don't fuse/Leave growing rods?
- b) VEPTR:
- Spine-to-rib construct with second rib-to-rib construct (most commonly)
 - Best option for true rib/chest wall anomalies
- c) Convex Hemiepiphysodesis: Epiphysiodesis on the convex side of the deformity with or without instrumentation [15, 16] : 50% improvement-40% no change-10% continued progression
- < age 5
 - NOT in cervical spine involvement, myelomeningocele, unilateral unsegmented bar
 - Curves less than 70 degrees
- NOT with associated kyphosis because of exacerbation of kyphosis due to anterior convex growth arrest
- d) Rib-to-pelvis/ NM constructs:
- Early onset and progressive “collapsing” neuromuscular curves
- 5) Revision Surgery
- a) Not a thing of the past! [17, 18]
- Hardware Failure
 - Pseudoarthrosis
 - Crankshaft phenomenon
 - Proximal Junctional Kyphosis
 - Infection
 - Rate of reoperation:
7.5% for AIS [17]
53% after hemivertebrae resection [19]
20% in cerebral palsy [20]
- b) Meticulous preoperative planning:
- Focal vs global correction?
 - Replacement vs connecting on to the existing instrumentation?
- 6) Conclusion
- a) Correct diagnosis/ know natural history:
- AIS vs Congenital vs Neuromuscular
 - Scoliosis vs Kyphosis
- b) Know you options; “Buy time” in very young
- c) Learning curve/ No substitute for experience
- d) The future: Comprehensive protocols, dual experienced surgeons, intraop blood products
- e) Highest quality monitoring and anesthesia are key

References

- [1, 14-16, 21-23]
1. Sankar, W.N., et al., *Neurologic risk in growing rod spine surgery in early onset scoliosis: is neuromonitoring necessary for all cases?* Spine (Phila Pa 1976), 2009. 34(18): p. 1952-5.
 2. Vitale, M.G., et al., *Risk factors for spinal cord injury during surgery for spinal deformity.* J Bone Joint Surg Am, 2010. 92(1): p. 64-71.
 3. Rabenhorst, B.M., S. Garg, and J.A. Herring, *Posterior spinal fusion in patients with Ehlers-Danlos syndrome: a report of six cases.* J Child Orthop, 2012. 6(2): p. 131-6.
 4. Erkula, G., et al., *Musculoskeletal findings of Loeys-Dietz syndrome.* J Bone Joint Surg Am, 2010. 92(9): p. 1876-83.
 5. Gjolaj, J.P., et al., *Spinal deformity correction in Marfan syndrome versus adolescent idiopathic scoliosis: learning from the differences.* Spine (Phila Pa 1976), 2012. 37(18): p. 1558-65.
 6. Sethi, R.K., et al., *The Seattle Spine Team Approach to Adult Deformity Surgery: A Systems-Based Approach to Perioperative Care and Subsequent Reduction in Perioperative Complication Rates.* Spine Deformity, 2014. 2(2): p. 95-103.

PRE-MEETING COURSE

7. Halpin, R.J., et al., *Standardizing care for high-risk patients in spine surgery: the Northwestern high-risk spine protocol*. Spine (Phila Pa 1976), 2010. 35(25): p. 2232-8.
8. Blam, O.G., et al., *Risk factors for surgical site infection in the patient with spinal injury*. Spine (Phila Pa 1976), 2003. 28(13): p. 1475-80.
9. Ames, C.P., et al., *Perioperative Outcomes and Complications of Pedicle Subtraction Osteotomy in Cases With Single Versus Two Attending Surgeons*. Spine Deformity, 2013. 1(1): p. 51-58.
10. Rinella, A., et al., *Perioperative halo-gravity traction in the treatment of severe scoliosis and kyphosis*. Spine (Phila Pa 1976), 2005. 30(4): p. 475-82.
11. Sink, E.L., et al., *Efficacy of perioperative halo-gravity traction in the treatment of severe scoliosis in children*. J Pediatr Orthop, 2001. 21(4): p. 519-24.
12. Brenn, B.R., et al., *Clotting parameters and thromboelastography in children with neuromuscular and idiopathic scoliosis undergoing posterior spinal fusion*. Spine (Phila Pa 1976), 2004. 29(15): p. E310-4.
13. Katz-Summercorn, A.C., et al., *The use of rapid thromboelastogram for trauma mortality prediction*. Am J Surg, 2014. 208(2): p. 316.
14. Akbarnia, B.A., et al., *Dual growing rod technique for the treatment of progressive early-onset scoliosis: a multicenter study*. Spine (Phila Pa 1976), 2005. 30(17 Suppl): p. S46-57.
15. Uzumcugil, A., et al., *Convex growth arrest in the treatment of congenital spinal deformities, revisited*. J Pediatr Orthop, 2004. 24(6): p. 658-66.
16. Marks, D.S., et al., *Long-term results of convex epiphysiodesis for congenital scoliosis*. Eur Spine J, 1995. 4(5): p. 296-301.
17. Ramo, B.A. and B.S. Richards, *Repeat surgical interventions following "definitive" instrumentation and fusion for idiopathic scoliosis: five-year update on a previously published cohort*. Spine (Phila Pa 1976), 2012. 37(14): p. 1211-7.
18. Richards, B.S., B.P. Hasley, and V.F. Casey, *Repeat surgical interventions following "definitive" instrumentation and fusion for idiopathic scoliosis*. Spine (Phila Pa 1976), 2006. 31(26): p. 3018-26.
19. Bollini, G., et al., *Thoracolumbar hemivertebrae resection by double approach in a single procedure: long-term follow-up*. Spine (Phila Pa 1976), 2006. 31(15): p. 1745-57.
20. Sink, E.L., et al., *Maintenance of sagittal plane alignment after surgical correction of spinal deformity in patients with cerebral palsy*. Spine (Phila Pa 1976), 2003. 28(13): p. 1396-403.
21. Sucato, D.J., *Management of severe spinal deformity: scoliosis and kyphosis*. Spine (Phila Pa 1976), 2010. 35(25): p. 2186-92.
22. Sponseller, P.D., *Pediatric revision spinal deformity surgery: issues and complications*. Spine (Phila Pa 1976), 2010. 35(25): p. 2205-10.

23. Johnston, C.E., *Preoperative medical and surgical planning for early onset scoliosis*. Spine (Phila Pa 1976), 2010. 35(25): p. 2239-44.

Notes:

Preoperative Planning in Adult Severe Deformity (Primary and/or Revision)

Frank J. Schwab, MD

Bassel G. Diebo, MD

Virginie Lafage, PhD

Department of Orthopedic Surgery

New York University Hospital for Joint Diseases

New York, New York, USA

Introduction

Spinal deformity is one of the oldest disease known to humankind[1]. Hippocrates was the first to describe the spinal curves, and Leonardo Da Vinci was the first to draw the human spine (Figure 1). Adult spinal deformity (ASD) is also now recognized to be a rapidly growing healthcare field due to an aging population and quality of life expectations with aging. While primary deformities are common, some of the most challenging patients present with one or several previous surgeries and spinal malalignment. Several studies have demonstrated pain and disability associated with spinal deformity and one prevalence study [2] has shown a rate of over 60% deformity in a population over 60 years of age. Despite the substantially greater number of deformities in the adult population and potential for marked loss of function[3] adult deformity remains poorly understood. One limitation relates to the diversity of pathologies associated with spinal deformity in the adult, lack of a coherent system for categorizing patients, and until recently, poorly understood correlation between deformity parameters and patient reported disability.

PRE-MEETING COURSE

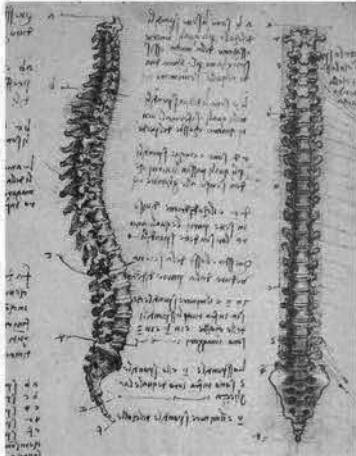


Figure 1: Leonardo Da Vinci drawing of the spine (1490)

What we understand about spinal deformity in the Adult:

The evolution of analyzing the spine grew rapidly in the last decades, especially the analysis of the sagittal plane in the setting of an asymptomatic population or patients presenting with spinal pathologies [4–7]. Key measures of sagittal alignment have been identified, validated and continuously explored by the various study groups focusing on outcomes measures in the setting of ASD (SDSG, ISSG, ESSG etc.) [6, 8–11]. (Figure 2). Alignment objectives have been defined as postoperative SVA < 40mm, PT < 20° and PI-LL ≤ 10° [4, 10, 12]. Accordingly, sagittal realignment planning has become a key component of successful adult spinal deformity (ASD) treatment. Realignment procedures for patients with marked sagittal malalignment often require vertebral osteotomies in addition to long posterior fusion [13, 14]. To achieve optimal clinical outcomes, careful attention must be paid to preoperative planning and intra-operative execution of the plan. If realignment is the primary measure of successful ASD procedure, planning and execution of goals are essential.

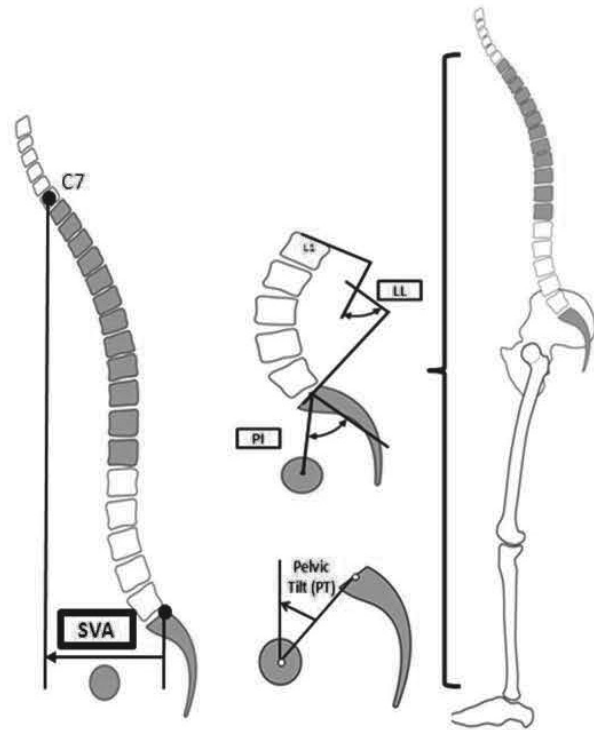


Figure 2: Spino-pelvic parameters: SVA, PI-LL, and PT.

How we apply and teach the principles: From Classification to treatment and follow up

The SRS-Schwab Classification

Based upon recent research on alignment and correlations between radiographic parameters and clinical outcomes, The parameters defined in this hybrid Scoliosis Research Society (SRS)-Schwab classification were chosen based on clinical relevance. This classification system uses frontal and sagittal full-length x-rays in order to provide a standard basis for classification that is easy to use. Because treatment of ASD centers on improving pain and disability, the parameters are strongly associated with HRQOL outcome scores. The cutoff values for the modifier grades were established using the outcome scores in order to have a strong clinical impact, as reported in previous studies [8, 10, 12]. For the classification, the Curve Type is aimed at describing the relevant coronal aspects of the deformity. The sagittal components of the deformity are characterized through the three modifiers.

- Pelvic Tilt
- SVA
- Pelvic Incidence -Lumbar Lordosis

PRE-MEETING COURSE

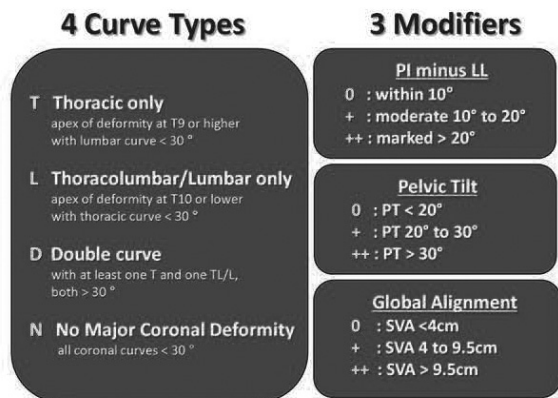


Figure 3: SRS-Schwab Classification

Recent studies on the classifications revealed that changes in classification category through surgery can impact HRQOLs, Smith et al in a recent study showed that patients who improved in SRS-Schwab sagittal modifiers (PT, SVA or PI-LL) were more likely to reach a clinically noticeable difference in HRQOLs (ODI, SF-36, or SRS activity and pain). [15] Classifying the deformity reflects the status of malalignment severity; Terran et al [16] showed that SRS-Schwab classification impacts the decision to pursue operative or non-operative treatment, with operative patients having worse sagittal modifiers grades.

The classification forms a consistent method of analysis for all patients; instills a discipline to see all patients in regards to deformity disability drivers, and serves as a foundation to developing treatment plans and goals.

Pre-operative planning:

Surgical planning for spinal deformity has improved during the last decade due to the recognition of disability drivers, established goals of surgery and the use of software designed for digital imaging systems. The first critical step in preoperative planning is obtaining standardized full length standing films, a recent work by Smith et al revealed that full images significantly improved the surgical planning for spinal pathologies [17]. These must be obtained in the free-standing position including at minimum C7 –femoral heads, ideally including the head to the feet. All standard measures of sagittal alignment should be applied with realignment goals in mind. Realignment goals should be patient specific. While reference values are helpful, the interplay of regional parameters is most critical (ex. Offset between LL and PI).

Once goals of alignment have been identified, simulation should be performed to identify surgical technique options with radiographic goals in mind. Several tools can be used in order to simulate results of realignment (including anterior cages or posterior osteotomies) in order to assess which preoperative surgical plan is best suited for a given patient. This step is crucial for success and various simulations should be considered in order to have an alternative solution if needed during a procedure. Simulation tools may include mathematical formulas [18, 19] and visual manipulation and geometric analysis with software [20]. The surgical plan should be created with what is feasible in mind, in regards to all aspects of surgery included patient medical health, hospital allowances and

surgical team experience and availability. The creation of the plan is reviewed with co-surgeons and the rest of the surgical team in the operating room. The teaching element to residents and fellows occurs in conference or leading by example when routine planning is presented for each case. Once the resident or fellow has learned the basic steps to image analysis and planning he/she is requested to analyze and plan each case independently.

Intra-op Execution

After developing a surgical plan, it is critical to respect predetermined goals, while being flexible with technique in the operating room. There are many scenarios under which the optimal technique could change at the time of surgery. For example greater flexibility of the spine than expected may obviate a need for larger osteotomies, and patient factors may not permit certain realignment plans due to loss of monitoring potentials or hemodynamic stability. Intraoperative imaging is the primary tool to ensuring execution of the surgical plan. Fluoroscopy can be used for imaging osteotomy sites however, long x-ray, before closure, is the best for assessing lumbar lordosis correction and thoracic alignment related to pre-operative goals. The obtained images must be measured for key parameters changes during the operative intervention and compared to the plan. This step can be done by the fellow or resident and serves as a critical teaching step.

Image Guided Surgery (IGS), utilizing fluoroscopy based surgical navigation or computed tomography based surgical navigation can be used intraoperatively to provide multiplanar views of the spinal anatomy. These technologies may evolve into powerful surgical planning tools for spinal deformity and ensuring adequate sagittal realignment, though this has not been fully explored [21, 22].

Proper rod contouring and reduction maneuvers are important tool in sagittal correction, enabling controlled correction and structural support of the newly imposed spinal alignment [23] While rod contouring alone is not sufficient to provide sagittal realignment, ignoring this tactic will nearly ensure a poor radiographic outcome. We can teach this step through a progressive shift of rod contouring responsibility to learners as they go through their educational program.

Learning through Root Cause Analysis and follow up

A recent study by Moal et al [24] suggests that x-ray quality, both at baseline and intra-operatively, can lead to either poor planning or poor intra-operative feedback. This study also found that intra-operative x-rays were a good prediction of post-operative LL, but in general, LL tended to be undercorrected. A deeper analysis revealed that deviation from the pre-operative plan also resulted in undercorrection, especially in patients who needed large correction in LL [24].

Another area with room for improvement and understanding are reciprocal changes in the unfused regions of spine following reconstructive spinal surgery. Many studies have investigated and proposed that these reciprocal changes can be favorable or unfavorable to post-operative alignment [25–29] but more studies should be done to better anticipate this post-operative response. In fact, a study by Blondel et al demonstrated that a lack of restoration of thoracic kyphosis may lead to sagittal overcorrection with posterior malalignment [30].

PRE-MEETING COURSE

A further way of improving outcomes may be to consider age-specific alignment objectives. It is well established that global sagittal alignment[31] and patient reported outcomes change with age[32], and perhaps surgery should be more tailored to a patient's age. A recent study demonstrated that older patients required more rigorous correction to achieve a minimal clinically important difference compared to younger patients at 2 year follow-up[33]. Thus etiology and age remain important pre-operative factors that a surgeon should consider to best optimize an operative plan.

Finally, in order to continue to improve pre-operative planning and assess intra-operative techniques, there needs to be a common language in which surgeons from all over the world can dialogue and share data. A comprehensive spinal osteotomy classification that is anatomically based can provide a universal and objective way of quantifying what works and what is not best practice. The most recent classification provides a simple way of categorizing spinal osteotomies into 6 grades of resection starting from a partial facet joint resection all the way up to a multiple vertebrectomy[34] (Figure X). These 5 grades provide a systematic, simple, and anatomic way of facilitating communication, standardizing outcomes research, and establishing indications.

Conclusions

The treatment of spinal deformity remains challenging and complex. Collective efforts over the past decades have established drivers of disability, classification approaches and treatment goals in the setting of deformity. The learning related to this body of knowledge has evolved substantially. There are many venues where information is disseminated and systematic systems and tools are emerging to bring knowledge and its application into daily practice.

It seems that one effective manner in disseminating and integrating our increased knowledge related to spinal deformity is through standardized and reproducible approaches in clinical practice. This starts with initial radiographic analysis based on acquisition of high quality full length standing x-rays for all spine patients. Additionally, routine use of key radiographic measures should be made for all patients, even those thought of having a primarily degenerative, rather than deformity, pathology. The development of simple clinical tools including a "Surgical Goals" cheat sheet to routinely integrate normative and patient specific acceptable values of sagittal alignment as well as revisiting existing complex formulas to ensure accuracy in their predictions will dually benefit the field.

Optimal patient outcomes in the setting of spinal deformity are critically tied to proper patient assessment and planning. Our ongoing learning must be based on reconciling preoperative plans with intra-operative execution, while retaining flexibility in technique in order to reach goals. Standard practice must include systematic surgical planning and simulation, with various methods currently available to those seeking to use them.

Bibliography:

1. Heary RF, Madhavan K (2008) The history of spinal deformity. *Neurosurgery* 63:5–15. doi: 10.1227/01.NEU.0000324520.95150.4C
2. Schwab F, Dubey A, Gamez L, et al. (2005) Adult scoliosis: prevalence, SF-36, and nutritional parameters in an elderly volunteer population. *Spine* 30:1082–5.
3. Bradford DS, Tay BK, Hu SS (1999) Adult scoliosis: surgical indications, operative management, complications, and outcomes. *Spine* 24:2617–29.
4. Jackson RP, McManus AC (1994) Radiographic analysis of sagittal plane alignment and balance in standing volunteers and patients with low back pain matched for age, sex, and size. A prospective controlled clinical study. *Spine* 19:1611–8.
5. Legaye J, Duval-Beaupere G (2005) Sagittal plane alignment of the spine and gravity: a radiological and clinical evaluation. *Acta orthopaedica Belgica* 71:213–20.
6. Richards BS, Birch JG, Herring J a, et al. (1989) Frontal plane and sagittal plane balance following Cotrel-Dubousset instrumentation for idiopathic scoliosis. *Spine* 14:733–7.
7. Vidal J, Marnay T (1984) [Sagittal deviations of the spine, and trial of classification as a function of the pelvic balance]. *Revue de chirurgie orthopédique et réparatrice de l'appareil moteur* 70 Suppl 2:124–6.
8. Glassman SD, Bridwell K, Dimar JR, et al. (2005) The impact of positive sagittal balance in adult spinal deformity. *Spine* 30:2024–9.
9. Schwab F, Lafage V, Patel A, Farcy J-P (2009) Sagittal plane considerations and the pelvis in the adult patient. *Spine* 34:1828–33. doi: 10.1097/BRS.0b013e3181a13c08
10. Schwab F, Patel A, Ungar B, et al. (2010) Adult spinal deformity-postoperative standing imbalance: how much can you tolerate? An overview of key parameters in assessing alignment and planning corrective surgery. *Spine* 35:2224–31. doi: 10.1097/BRS.0b013e3181ee6bd4
11. Schwab F, Ungar B, Blondel B, et al. (2012) Scoliosis Research Society-Schwab adult spinal deformity classification: a validation study. *Spine* 37:1077–82. doi: 10.1097/BRS.0b013e31823e15e2
12. Lafage V, Schwab F, Patel A, et al. (2009) Pelvic tilt and truncal inclination: two key radiographic parameters in the setting of adults with spinal deformity. *Spine* 34:E599–606. doi: 10.1097/BRS.0b013e3181aad219
13. Bridwell KH, Lewis SJ, Edwards C, et al. (2003) Complications and outcomes of pedicle subtraction osteotomies for fixed sagittal imbalance. *Spine* 28:2093–101. doi: 10.1097/01.BRS.0000090891.60232.70
14. Bridwell KH, Lewis SJ, Lenke LG, et al. (2003) Pedicle subtraction osteotomy for the treatment of fixed sagittal imbalance. *The Journal of bone and joint surgery American volume* 85-A:454–63.
15. Smith JS, Klineberg E, Schwab F, et al. (2013) Change in Classification Grade by the SRS-Schwab Adult Spinal Deformity Classification Predicts Impact on Health-Related Quality of Life Measures: Prospective Analysis of Operative and Non-operative Treatment. *Spine* 38:1663–1671. doi: 10.1097/BRS.0b013e31829ec563

PRE-MEETING COURSE

16. Terran J, Schwab F, Shaffrey CI, et al. (2013) The SRS-Schwab Adult Spinal Deformity Classification: Assessment and Clinical Correlations Based on a Prospective Operative and Nonoperative Cohort. *Neurosurgery* 73:559–68. doi: 10.1227/NEU.0000000000000012
17. Smith JS, Shaffrey CI, Lafage V, et al. (2014) Assessment of Impact of Long-Cassette Standing X-Rays on Surgical Planning for Lumbar Pathology: An International Survey of Spine Surgeons. *IMAST 21st International Meeting on Advanced Spine Techniques*. p 147
18. Lafage V, Bharucha NJ, Schwab F, et al. (2012) Multicenter validation of a formula predicting postoperative spinopelvic alignment. *Journal of neurosurgery Spine* 16:15–21. doi: 10.3171/2011.8.SPINE11272
19. Lafage V, Schwab F, Vira S, et al. (2011) Spino-pelvic parameters after surgery can be predicted: a preliminary formula and validation of standing alignment. *Spine* 36:1037–1045.
20. Akbar M, Terran J, Ames CP, et al. (2013) Use of Surgimap Spine in sagittal plane analysis, osteotomy planning, and correction calculation. *Neurosurgery clinics of North America* 24:163–72. doi: 10.1016/j.nec.2012.12.007
21. Holly LT, Foley KT (2003) Intraoperative spinal navigation. *Spine* 28:S54–61. doi: 10.1097/01.BRS.0000076899.78522.D9
22. Nolte LP, Slomczykowski M a, Berlemann U, et al. (2000) A new approach to computer-aided spine surgery: fluoroscopy-based surgical navigation. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 9 Suppl 1:S78–88.
23. Noshchenko A, Xianfeng Y, Armour GA, et al. (2011) Evaluation of spinal instrumentation rod bending characteristics for in-situ contouring. *Journal of biomedical materials research Part B, Applied biomaterials* 98:192–200. doi: 10.1002/jbm.b.31837
24. Moal B, Lafage VC, Maier SP, et al. (2014) Discrepancies in Preoperative Planning and Operative Execution in the Correction of Sagittal Spinal Deformities. *North American Spine Society 29th Annual Meeting (San Francisco)*. Podium Presentation.
25. Blondel B, Lafage V, Schwab F, et al. (2012) Reciprocal sagittal alignment changes after posterior fusion in the setting of adolescent idiopathic scoliosis. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 21:1964–71. doi: 10.1007/s00586-012-2399-4
26. Lafage V, Ames C, Schwab F, et al. (2012) Changes in thoracic kyphosis negatively impact sagittal alignment after lumbar pedicle subtraction osteotomy: a comprehensive radiographic analysis. *Spine* 37:E180–7. doi: 10.1097/BRS.0b013e318225b926
27. Smith JS, Shaffrey CI, Lafage V, et al. (2012) Spontaneous improvement of cervical alignment after correction of global sagittal balance following pedicle subtraction osteotomy. *Journal of neurosurgery Spine* 17:300–7. doi: 10.3171/2012.6.SPINE1250
28. Klineberg E, Schwab F, Ames CP, et al. (2011) Acute reciprocal changes distant from the site of spinal osteotomies affect global postoperative alignment. *Advances in orthopedics* 2011:415946. doi: 10.4061/2011/415946
29. Ha Y, Schwab F, Lafage V, et al. (2014) Reciprocal changes in cervical spine alignment after corrective thoracolumbar deformity surgery. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 23:552–9. doi: 10.1007/s00586-013-2953-8
30. Blondel B, Schwab F, Bess S, et al. (2013) Posterior global malalignment after osteotomy for sagittal plane deformity: it happens and here is why. *Spine* 38:E394–401. doi: 10.1097/BRS.0b013e3182872415
31. Schwab F, Lafage V, Boyce R, et al. (2006) Gravity line analysis in adult volunteers: age-related correlation with spinal parameters, pelvic parameters, and foot position. *Spine* 31:E959–67. doi: 10.1097/01.brs.0000248126.96737.0f
32. Ware JE, Kosinski M (2005) *SF-36 Physical & Mental Health Summary Scales: A Manual for Users of Version 1, 2nd ed.* 186.
33. Schwab FJ, Lafage R, Liabaud B, et al. (2014) Does One Size Fit All? Defining spino-pelvic alignment thresholds based on age. *North American Spine Society 29th Annual Meeting (San Francisco)*. Podium Presentation.
34. Schwab F, Blondel B, Chay E, et al. (2014) The comprehensive anatomical spinal osteotomy classification. *Neurosurgery* 74:112–20. doi: 10.1227/NEU.000000000000182o

Notes:

PRE-MEETING COURSE

Intraoperative Imaging and Navigation in Complex Deformity and Revision Surgery: How Does it Help us Teach and Learn?

David W. Polly, Jr., MD

Professor of Orthopaedic Surgery

University of Minnesota

Minneapolis, Minnesota, USA

Pedicle screws are currently the preferred anchor strategy for most deformity cases

How do we teach and learn?

- Cognitive
 - General anatomy
 - Deformity anatomy
 - Patient specific anatomy
- Tactile approach
 - Feel of bony containment
 - Palpation
- Methods of feedback to the learner
 - Verbal instruction from the teacher
 - Hand holding to assist the learner
 - Fluoro evaluation for real time 2D feedback
 - Post-op CT scans for precise critical evaluation but in a delayed fashion
 - Intra-op 3D imaging for more rapid feedback
 - Intra-op navigation for real time virtual feedback

What is the current accuracy rate for pedicle screw placement?

- Best data from meta-analyses
 - Kosmopolous Spine 2007
 - Tian International Orthopedics 2009
 - Ledonio Journal Bone and Joint 2011
 - Gelalis Eur Spine J 2012
 - Shin J Neurosurg Spine 2012
 - Mason J Neurosurg Spine 2014

Meta-analysis favors navigation as resulting in more accurate screw placement

- Navigation prevents a perforation for every 11.1 screws placed
- Clinical implications of screw malposition vary from inconsequential to catastrophic

Learning curve

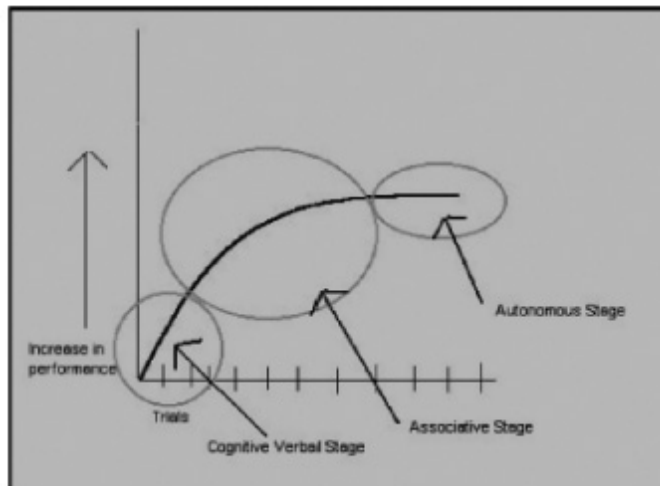


Figure 1. Three stage learning curve. Stage 1(Cognitive-Verbal Stage) is characterized by the acquisition of a movement pattern, which entails abandoning inadequate strategies for adequate strategies, resulting in the greatest rate of learning. Stage 2 is the "As-sociative Stage," where previously learnt strategies that are appropriate to the new situation are strengthened on the basis of feedback, whereas inappropriate features are weakened. Stage 3 is the "Au-tonomous Stage." In this phase the skill can be performed with relatively little interference from other activities (automatic). During this phase, skills continue to become more efficient although the rate of improvement slows with practice (Asymptote).¹

Pedicle screw placement learning curve

Gonzalvo Spine 2009

- Learning curve for pedicle screws
 - 80 screws
 - 25 cases
- Not deformity cases

Lonner Spine 2009 learning curve for thoracic pedicle screws in AIS

Performance continued to improve through 75 cases (time per screw and number of screws placed)

With navigation accuracy is improved (University of Minnesota series)

Larson Spine 2012

0% return to OR for 2500 screws

Intra-op screw repositioning rate 3.6% for peds, 1.8% for adults

Increased utility in very complex cases (congenital scoliosis University of Minnesota series)

Larson JPO 2012

1.8% repositioning rate but

19% of pedicles no safe corridor for screw placement

PRE-MEETING COURSE

- With navigation I can:
 - Let the residents safely do more
 - Their feedback after using navigation is that it accelerates their learning process
 - Resident evaluations of the spine rotation have improved after we started using navigation
 - Residents talk about it as being something that excites them (perhaps a surrogate measure for being an activated learner)

Notes:

Intraoperative Pearls in Severe Pediatric Spine Deformity Surgery Without Navigation

Daniel J. Sucato, MD, MS

Texas Scottish Rite Hospital

Professor, Department of Orthopaedic Surgery

University of Texas at Southwestern Medical Center

Dallas, Texas, USA

Severe Spine Deformity

- Definition-
 - Hard to define- very selective and specific for each deformity
 - Perhaps. "Spinal deformity of significant magnitude which raises heightened awareness for the surgeon and the team requiring preop planning, intraoperative surgical decisionmaking and postoperative care that is more detailed than the conventional or typical deformity"
- Incidence
 - Dependent on many factors including
 - Scope and type of clinical practice
 - Referral patterns
 - Definition
 - Probably 2-5% of all spine deformity
- Differences compared to AIS
 - Larger Spine Cobb magnitude
 - Involves Chest Wall Deformity (not just spine deformity)
 - Often has had previous surgery
 - Surgery has higher risks- neurologic, blood loss, infection, pseudoarthrosis
 - Outcomes can be life-changing- Cosmetically and Self-Esteem, PFT

The 3 P's for Successful Treatment

- Preoperative Evaluation- Need Detailed
 - History
 - Physical examination
 - Imaging studies- always need advanced imaging
 - Modeling with 3 D Printer very helpful
 - Pertinent Consultative services
 - Preoperative Traction- often (usually) utilized
- Performance- Intraoperative
 - Four Phases of Surgery- Each has key steps
 - Positioning
 - Anchor Placement
 - Spine Mobilization
 - Rod Placement/Spine Correction
 - Positioning-
 - Traction-
 - Obtain as much correction as you possibly can with traction
 - Higher likelihood of IONM changes {Lewis, 2011 #5314}
 - Proximally- Mayfield tongs,
 - Distally- skin traction (pelvic traction- can do asymmetrical pull) vs Femoral traction pins
 - Abdomen and axilla free
 - Anchor Placement
 - UNDERSTAND the anatomy prior to surgery
 - Create a map of pedicle placement- know which pedicles are easy and which are challenging
 - CT scan vs MRI
 - Screw Placement Techniques
 - Several options
 - Weigh the risks, costs, of each
 - Understand your skill set, how you were trained, experience level, etc
 - Free-hand navigation- results are very good-{Gelalis, 2012 #5317;Allam, 2013 #5316;Kim, 2004 #1268;Bergeson, 2008 #5320}
 - Several methodologies with overall good results.
 - Pros- Low radiation, learning as you go so easy cases first then hard ones later
 - Cons- Accuracy may be less than with navigation systems
 - Still controversial
 - Navigation
 - Pros- may be more accurate
 - Cons- cost and radiation
 - Select the appropriate screw for each level
 - Multiaxial screws- the working horse of the system
 - Uniaxial screws- good for apical derotation especially for convex screws
 - "Reduction" or Reduction-equivalent screws- Powerful and versatile

PRE-MEETING COURSE

- Gradual correction of the spine
 - Essential for VCR Surgery
 - Game-time decisions
 - If unable to obtain screw
 - Bailout are hooks or wires- very good options which you need to be able to do
 - Spine Mobilization
 - Anterior Release
 - Although fallen out of favor, it is still a VERY good method to increase the flexibility of the spine in all planes especially coronal and axial
 - Indications- curves greater than 85-90 degrees
 - Thoracoscopic (preferred) in the thoracic or open in the lumbar spine
 - Prone thoracoscopic- obviates the need for single lung ventilation and results in outstanding postoperative PFT's (Sucato, Erken et al. 2009)
 - Posterior Releases
 - Ponte (no anterior fusion) or Smith-Petersen (when anterior fusion is present)
 - Indications- most curves but especially when >70-80-degrees
 - Includes: ligamentum flavum, superior and inferior facets
 - Rib osteotomies
 - Concave
 - Indications- severe rib deformities, rib fusions, short sharp apical curves
 - Beware of postoperative pleural effusions
 - Convex
 - Indications- less severe spine and chest wall deformity
 - When rib hump is present
 - Eggshell or Decancellation procedure (Mikles, Graziano et al. 2001; Murrey, Brigham et al. 2002; Boachie-Adjei 2006)
 - Indications
 - Large curve with short apical segment causing the majority of the deformity
 - Technique
 - Vertebral body decancellation through the pedicle
 - Fairly powerful technique
 - Pedicle Subtraction Osteotomy (Bridwell, Lewis et al. 2004; Kim, Bridwell et al. 2007)
 - Limited indications in pediatric deformity
 - Only used in the lumbar spine for primary sagittal plane deformity
 - Asymmetrical coronal plane PSO may be used for combination sagittal and coronal plane deformity
 - Vertebral Column Resection (Boachie-Adjei and Bradford 1991; Bradford and Tribus 1997; Lenke 2009)
 - VERY powerful surgical strategy
 - For the most severe of deformities
 - Indications
 - VERY severe spine deformity
 - Previous surgery
 - Severe chest wall deformity
 - Combination scoliosis and kyphosis
 - Best when the deformity is over small number of levels
 - Technical points
 - Pedicle screw fixation is mandatory
 - Segmental
 - Need fixation adjacent to the area of resection
 - Good baseline spinal cord monitoring is mandatory (unless preexisting neurologic deficits)
 - I like to use both transcranial and mixed or neurogenic MEP (as well as SSEP)
 - Transcranial are more sensitive than NMEP to allow one to look for problems prior to loss of NMEP.
 - Maintain spinal cord perfusion- (mean pressures >80 mm Hg)
 - Provision fixation is mandatory during the final stages of resection
 - Always 2 points of fixation at the completion of the resection
 - Complete the concave resection first
 - Always the most difficult due to small hard concave pedicle and rotational component
 - Allows one to have a provisional rod on the concave and convex side while completing the convex release(work under the convex rod)
 - Assume some subtle changes in IONM during surgery
 - Closure of resection
 - Maintain mean pressures >80 mm Hg
 - May need to use 2 reduction rods to bring proximal and distal segments together
 - Anterior cage is used as fulcrum to prevent translation and as a hinge point
 - Beware of anterior cord kinking on the distal aspect of the proximal segment
 - Usually need to undercut this a bit
 - The distal segment always wants to translate more anterior than the proximal segment- be sure to avoid
- ### How to Avoid Surgical-Related Issues
- Infection: Acute and Delayed
 - Preop and postop antibiotics controversial and no real data to support
 - Keep soft tissues moist intermittent irrigation
 - Careful and fastidious prepping and draping of the patient
 - Bulk of implants — consistent with size of patient
 - Pseudarthrosis
 - Complete facetectomies
 - Bulk of implants- consistent to size of patient
 - Cross links- if use them, place graft first
 - Copious bone graft
 - BMP-2 for all resections

PRE-MEETING COURSE

- Safe Implant Utilization
 - Know the system you are using
 - Understand the anatomy
- Blood Loss
 - Hypotensive Anesthesia
 - Correct Positioning
 - Blood preservation medications
 - Tranexamic acid
 - Amicar
 - Local product use
 - Floseal
 - Tisseal- Fibrin Sealant
 - Thrombin-soaked Gelfoam

Notes:

Teaching How To Do Complex Spine Surgery: The US Model

Munish Chandra Gupta, MD

Professor, Chief of Orthopaedic Spine Service

University of California, Davis

Sacramento, California, USA

Historically, spine fellowships have been apprenticeships. They were found by word of mouth and not advertised. The recommendation of the spine fellows were basically made from the mentor that they were working with during residency. The fellowships were decided by the fellowship hosts on the recommendations as well as invitations to take the fellowship at the spur of the moment without a match. Usually, one year of internship, followed by four years of orthopaedic residency and then one year of spine fellowship training was required before a position as spine surgeon in either private or academic practice was given.

In 2008, the fellowship match was formalized where the fellowships were coordinated by giving all the data to the San Francisco Match Program. All the applications were centralized, then fellowships ranked and chose their applicants after interviews, and the candidates ranked the fellowships. At the end, there was a match of the top choices of the applicants to the top choice of the fellowships that listed them appropriately. The North American Spine Society sponsored this program, and it was basically policed by NASS. If you did not

follow the match guidelines, you would be kicked out of the match program. The applicants for match must be eligible to be board certified in orthopaedic surgery or neurosurgery. Some of the programs only take applicants that are eligible for US or Canadian board certification, but some other programs accept applications from applicants that are eligible for orthopaedic surgery or neurosurgery in other countries. Usually, the match takes place in April for the fellowship starting on August 1, two years after.

The training of these applicants, once they get into the fellowship, is mostly by observation of surgical technique, and then under direct supervision performing the technique. Once the attending surgeons are comfortable with the fellow, the fellow gets graded responsibility of doing more surgery. For example, in our fellowship, the fellows start operating on day one, since they already had some surgical experience in spine surgery.

There are two kinds of spine fellowships; some are ACGME approved and some are outside the ACGME category. The main difference is that in an ACGME approved fellowship, the fellows cannot charge for their services. The fellowships are also governed by the ACGME restrictions and requirements. The main advantage of the non ACGME fellowship is that they receive the same training, but they do not have to be under the scrutiny of the ACGME rules. The fellow charges basically pay for their own expenses and their salary through the charges of their services and, usually, more than that.

The spine fellowships, in general, have improved over the last many years, since there are more of them and there are more training programs for spine surgeons. In fact, there are more spine fellowship spots than there are actually people applying. For example: in 2012, there were 60 programs offering spine fellowships with 112 positions. Only 81 were filled and there were 31 unfilled spots. In this day and age, the applicant is more in the driver's seat, trying to figure out what is the best position for them. On the other hand, the number of spine fellowships that are fully comprehensive, in terms of trauma, degenerative deformity, pediatric, and adult, are limited in number.

Notes:

PRE-MEETING COURSE

Teaching How to Do Complex Spine Surgery: The Canadian Model

Reinhard D. Zeller, MD, FRCS, ScD

Head, Spine Program

Hospital for Sick Children

Associate Professor

Division of Orthopaedic Surgery

University of Toronto

Toronto, Canada

Hospital for Sick Children Spine Program

Toronto: 2.6 Millions (GTA: 5.5 Millions, Ontario: 13.6 Millions = 40% of all Canadians)

Pediatric Spine Program (part of Sickkids Pediatric Orthopedics): more than a 150 pediatric spine operations per year: 118-128 scoliosis, 10 – 15 cervical spine and tumor cases (together with Neurosurgery), EOS, high grade spondylolisthesis, kyphosis, trauma, revision surgery etc.

Two main surgeons: Reinhard Zeller, Steve Lewis (# 3 – 4 cases per week)

General Indications for scoliosis (AIS):

- 50 degrees, maturity: “If there is no further progression, there is no evidence that such a curvature causes major medical problems in the future. We understand that besides functional issues the cosmetic aspect of your back might be of concern to you. We accept to proceed with a spinal fusion if you are ready to accept the risks of this procedure. . . .”
- 60 degrees, maturity: “We recommend a spinal fusion. You recognize that your trunk is significantly leaning to one side and this situation will generate important mechanical problems in the future. . . .”
- over 80 degrees: “We strongly recommend a surgical correction. Respiratory issues are common at that level of deformity and they will become more important the older you get. . . .”

For these reasons and others (late presentation after “conservative treatment” etc.): *Most of our cases are “complex spinal deformities”*

Sickkids Spine Fellowship

- Sickkids Pediatric Orthopedic Fellowship: (<http://www.sickkids.ca/OrthopaedicSurgery/Education-and-Learning/Fellowship-Program/index.html>) Five clinical fellowship positions per year; pediatric ortho fellows interested in complex spine surgery can participate in spine rotations
- Sickkids Spine Fellowship: advanced fellowship in paediatric spinal deformities; the training period can range from six months to one year. Substantial previous experience in spinal surgery is a prerequisite to applying for this fellowship

Cultural Aspects of the Toronto Model

North America (#Steve Lewis) meets Europe (#Reinhard Zeller): *take the best of both worlds to inspire a new fellowship model*

- North American model:
 - Pros:

- Evidence based practice provides a solid foundation for fellowship teaching
- Open exchange of point of views: teachers accept to be challenged
- Surgical teaching is high on the agenda
- Research is favored
- Cons:
 - Evidence based practice sterilizes creativity
 - Procedure based approaches favor productivity but do they provide optimal patient based care?
 - Prone to fashion (“jump on the band wagon”) easily forgetting proven concepts
- European model:
 - Pros:
 - Creativity is paramount
 - Mentorship
 - Clinical teaching (“bedside teaching”)
 - Cons:
 - Dogmatic opinion-based teaching (“my way or the highway”)
 - Surgical teaching varies from institution to institution (from performing even the most complex procedures to holding only retractors)
 - Possibilities for research are limited

The Toronto Model: General Principles

Toronto = “New York run by the Swiss. . . .” (Peter Ustinov)

- Teaching the “Safety First” principle (Nihil non nocere)
 - Provide a wide variety of technical approaches to complex problems
 - VCR and other osteotomies (Steve Lewis)
 - Preoperative halo elongation, three rod constructs (Reinhard Zeller)
 - “Do not choose a procedure because it is more fashionable. . . .” (Augustus White, SRS 2006)

The Toronto Model: General Principles

Why do a fellowship in complex spine surgery?

To learn everything textbooks and pubmed can't teach. . .

- Provide professional guidance through mentorship
- Hone clinical and technical skill
- Surgical innovation: “stimulate out-of-the box thinking”

Provide professional guidance through mentorship

- “Trust is good but control is better”
 - Let the fellow slowly develop his independence under your discreet supervision (but keep a close control as quality of patient care is your first obligation)
- “Be more than just an administrative relation”
 - Building up confidence and helping fellows through a difficult period in life strengthens their future capacities to deal with stressful professional situations (“. . . you will never know how much your kindness & support has meant to me & my family. . . .”)

PRE-MEETING COURSE

- “ Ethical considerations should guide your actions”
 - “Even if you provide the best information for an informed consent, no parent is able decide about putting his child in harm’s way and therefore it is you who will make the final decision about what needs to be done . . .choose wisely”
 - The greatest reward after complex spinal deformity surgery is the patient’s gratitude because you performed a life changing procedure:” . . . As we say up north: you are like a Holstein cow . . . outstanding in your field . . .”
- Provide moral support for their future career:
 - The *Prayer of the Artisan* (authentic medieval prayer): “ . . .Teach me to profit from my past mistakes without letting self-doubt consume me”
 - Recognize cultural differences, be patient and tolerant

Hone clinical skill

New York Times: “Physician Revives a Dying Art: The Physical”

- The old Master – Apprentice relation
 - Teaching through observation: “You have eyes but you don’t see”
 - Systematic approach but be patient specific: “Use the Lenke classification but then find out what makes this patient’s deformity different from the others you saw”
 - Complete clinical evaluation:
 - “Scoliosis is not an x-ray disease and no patient walks around with his x-ray pinned on his back”: always confront clinical and radiological presentation
 - “Evaluate balance, range of motion, flexibility”
 - “Be thorough and complete in your evaluation” (are you aware that your smartphone has an app which measures the angle of trunk inclination?)
 - “Evaluate this patient’s needs”

Hone technical skill

- Preop planning
 - “Come up with a master plan containing a plan B and C; the complete procedure should be entirely programmed in your head before you start”
 - “Did you consider this patient’s needs and shouldn’t we favor a selective over an extensive spinal fusion?”
 - “Have you analyzed all the medical aspects and has the patient’s condition been optimized for the planned procedure?”
 - Perform a last minute flexibility check with a push prone test while the patient is under general anesthesia
- During the surgery
 - Teach “free hand” insertion of pedicle screws with the fellow on the convex side (concave remains in the hands of the senior); teach the “funnel/slide” principle and let the fellow increase his fine motor skills
 - Teach different spinal correction methods: preoperative traction, translation, rod rolling, direct vertebral derotation, careful in situ contouring, cantilever techniques . . .point out advantages and negative side effects, define the optimal correction sequence

- Teach fundamentals: proper spinal exposure and bone fusion techniques first and foremost before insertion of spinal implants (“ it is still called a spinal fusion and not a spinal hardware implantation . . .”)
- Precision comes before speed:
 - “A child is not a miniature adult and bone structures are much more fragile”
 - “Speed comes naturally with time but precision is the first requirement”
- Safety first! Five more degrees of correction don’t justify a permanent foot drop . . .
- Keep your situational awareness up at all times (blood loss, ventilation, evoked potentials, your team, observers . . .)
- After surgery
 - Regular surveillance and careful evaluation of the outcome:
 - Temporary postural problems are common after surgery (left shoulder up leaning to the left after correction of a right sided scoliosis) but they will improve
 - Structural problems will remain but sometimes the patient is able to compensate
 - Function should always be favored over x-ray appearance.

surgical innovation

- Some procedures are out of fashion but they are still efficient:
 - Preoperative halo elongation needs to be performed over several weeks to take advantage of the spinal visco-elasticity
- Be open minded but keep a critical eye on new procedures:
 - Endoscopic spine surgery
- Don’t forget that a golden standard is sometimes less than optimal:
 - EOS: golden standard in the past: “in situ fusion”?
- Fashion comes and goes
 - EOS: serial casting has been used in the past, has been forgotten and now is coming back
- Keep your creative mind active by observing what is done in other surgical specialties
 - Dental implants are inserted in two stages: apply this method to EOS “growing rod” constructs in patients with weak bone structures and severe deformities . . .

Notes:

PRE-MEETING COURSE

Teaching How to do Complex Spine Surgery: The European Model

Henry F. H. Halm

Department of Spine Surgery with Scoliosis Center

Schoen Klinik Neustadt

23730 Neustadt, Germany

HHalm@schoen-kliniken.de

Complex spine surgery can be done as a specialisation after having completed a residency in orthopedic and trauma surgery or neurosurgery. However the way of specialisation after completion of a residency program is different in every european country. Therefore the title "European Model" is misleading.

Leading spine surgeons and organizations of the majority of European countries were contacted by David Marks and myself; not all have responded by now.

With one slide for each country the model of each European country will be presented.

Notes:

Teaching Complex Spine Surgery in Patients with Intra-Spinal Pathology

Tyler R. Koski, MD

Associate Professor of Neurological Surgery

Northwestern University

Chicago, Illinois, USA

I. Neurosurgical Training

- a. Cranial based skills
- b. Spinal skills
 - i. "Traditional" Neurosurgical procedures
- a. Laminectomy
- b. ACDF
 - ii. Instrumented Procedures
 - iii. Intradural Procedures
- a. Intradural Extramedullary Tumors
- b. Intradural Intramedullary Tumors
- c. Tethered cord / Syring
- d. Vascular lesion

II. Gaining microsurgical skills

- a. Comfort with the microscope

- i. Simulation training
- ii. Observer scope assistance
- iii. Advancing responsibilities
- b. Progression of skill-set
 - i. Brain tumor surgery
 - ii. Spinal tumor surgery
 - iii. Vascular anastomosis
- III. Advantages of incorporating microsurgical skills into practice
 - a. Anatomic knowledge advances with intradural work
 - b. Comfort level around cord / nerves increase
 - c. Dural repair becomes routine
- IV. Potential pitfalls
 - a. Paralysis by analysis
 - i. Use of the scope can slow things down
 - b. Much of spinal reconstruction is a "macro" skill

References:

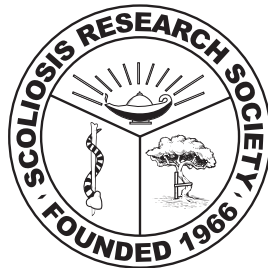
1. El Ahmadieh TY et. al. A didactic and hands-on module enhances resident microsurgical knowledge and technical skill. *Neurosurgery*. 2013 Oct;73 suppl 1:56-6.
2. Mazzola et. al. Efficacy of Neurosurgery Resident Education in the New Millenium" The 2008 Council of State Neurosurgical Societies Post-Residency Survey Results. *Neurosurgery*. 2010. Aug;67(2). 225-33.
3. Dvorak MF et. al. Confidence in Spine Training Among Senior Neurosurgical and Orthopedic Residents. *Spine* 2006. 31(7). 831-37.
4. Clark AJ. et. al. Results of AANS Membership Survey of adult spinal deformity knowledge: impact of training, practice experience, and assessment of potential areas for improved education. *J Neurosurg Spine*. 2014 Jul. 18.

Notes:

PRE-MEETING COURSE

MORNING SESSION II

COMPLEX SCOLIOSIS SURGERY: WHAT PEDIATRIC SPINE SURGEONS CAN LEARN FROM ADULT DEFORMITY SURGEONS AND WHAT ADULT SURGEONS CAN LEARN FROM PEDIATRIC SURGEONS



Moderators:

B. Stephens Richards, III, MD & Maria Cristina Sacramento-Dominguez, MD, PhD

Faculty:

Oheneba Boachie-Adjei, MD; Aina J. Danielsson, MD, PhD; Matthew E. Oetgen, MD; Joseph H. Perra, MD; Greg Redding, MD; Michael Ruf, MD; Paul D. Sponseller, MD; Richard M. Schwend, MD; Mark Weidenbaum, MD

PRE-MEETING COURSE

Neglected Severe Curve in the Adolescent

Richard M. Schwend, MD

Children's Mercy Hospital

Kansas City, Missouri, USA

Unique to the Pediatric Spine

Underlying genetic and pediatric conditions.

Pediatric classification: Neuromuscular, congenital, syndromic, idiopathic

Thorax may still be growing, need for anterior growth arrest

Adding on post op if still growing

Flexibility, ability to tolerate soft tissue releases and (some) preop and intraop traction (Jhaveri SN 2009)

Hypokyphotic or lordotic thoracic spine. More tolerant of anterior release.

Occasionally need for undersized implants

Easy to fuse with allograft

Psychological needs. Emphasis on *appearance* and function

Unique to Adult Spine

Underlying aging and adult medical conditions.

Adult classification

Spine and thorax not growing, but losing height and pulmonary function.

Junctional kyphosis

Rigid deformity, need for extensive release, osteotomies, column resection (Hamzaoglu A 2011, Lenke LG)

Kyphosis

Need for robust implants

More difficult to obtain fusion

Different psychological needs. Emphasis on *comfort* and function

Shared Ground

Cost, benefit and value (Roach JW 2011)

Outcome research. How much correction is enough (Imrie 2011)?

Pelvic and spine balance and motion preservation

Perioperative complex care coordination

Major complication avoidance. SRS Morbidity and Mortality (Hamilton DK 2011)

Approach to prevention of deep infections

Biomechanical considerations and development of new implants (Suk SI 1999 2012, Mazda K 2009)

Intraoperative neurological monitoring (Pereon Y 1999, Schwartz DM 2011)

Intraop imaging

Blood conservation (Sethna NF 2005, Grant JA 2009)

Perioperative pain management

Recommending no to surgery

Return to sports, return to work

Ways to come together and learn from each other

SRS as *the* global spine society

Common literature

Visitations and sabbaticals

Meetings and shared conferences

Scrub with each other

Shared research projects

Combined training programs

Common projects such as mission trips.

References

- Bridwell KH (2006) Decision making regarding Smith-Petersen vs. pedicle subtraction osteotomy vs. vertebral column resection for spinal deformity. *Spine (Phila Pa 1976)* 31:S171–S178
- Grant JA, Howard J, Luntley J et al (2009) Perioperative blood transfusion requirements in pediatric scoliosis surgery: the efficacy of tranexamic acid. *J Pediatr Orthop* 29:300–304
- Hamilton DK, Smith JS, Sansur CA et al (2011) Rates of new neurological deficit associated with spine surgery based on 108, 419 procedures: a report of the scoliosis research society morbidity and mortality committee. *Spine (Phila Pa 1976)* 36:1218–1228
- Hamzaoglu A, Alanay A, Ozturk C et al (2011) Posterior vertebral column resection in severe spinal deformities: a total of 102 cases. *Spine (Phila Pa 1976)* 36:E340–E344
- Imrie M, Yaszay B, Bastrom TP et al (2011) Adolescent idiopathic scoliosis: should 100% correction be the goal? *J Pediatr Orthop* 31:S9–S13
- Jhaveri SN, Zeller R, Miller S et al (2009) The effect of intraoperative skeletal (skull femoral) traction on apical vertebral rotation. *Eur Spine J* 18:352–356
- Lewis SJ, Gray R, Holmes LM et al (2011) Neurophysiological changes in deformity correction of adolescent idiopathic scoliosis with intraoperative skull–femoral traction. *Spine (Phila Pa 1976)* 36:1627–1638
- Mazda K, Ilharreborde B, Even J et al (2009) Efficacy and safety of posteromedial translation for correction of thoracic curves in adolescent idiopathic scoliosis using a new connection to the spine: the universal clamp. *Eur Spine J* 18:158–169
- Pereon Y, Nguyen The Tich S, Delecrin J et al (1999) Somatosensory- and motor-evoked potential monitoring without a wakeup test during idiopathic scoliosis surgery: an accepted standard of care. *Spine (Phila Pa 1976)* 24:1169–1170
- Roach JW, Mehlman CT, Sanders JO (2011) Does the outcome of adolescent idiopathic scoliosis surgery justify the rising cost of the procedures? *J Pediatr Orthop* 31:S77–S80
- Schwartz DM, Sestokas AK, Dormans JP et al (2011) Transcranial electric motor evoked potential monitoring during spine surgery: is it safe? *Spine (Phila Pa 1976)* 36:1046–1049
- Sethna NF, Zurakowski D, Brustowicz RM et al (2005) Tranexamic acid reduces intraoperative blood loss in pediatric patients undergoing scoliosis surgery. *Anesthesiology* 102:727–732

PRE-MEETING COURSE

Stagnara P, Fleury D, Fauchet R et al (1975) Major scoliosis, over 100 degrees, in adults. 183 surgically treated cases. Rev Chir Orthop Reparatrice Appar Mot 61:101–122

Suk SI, Lee CK, Kim WJ et al (1995) Segmental pedicle screw fixation in the treatment of thoracic idiopathic scoliosis. Spine (Phila Pa 1976) 20:1399–1405

Suk SI, Kim JH, Kim SS et al (2012) Pedicle screw instrumentation in adolescent idiopathic scoliosis (AIS). Eur Spine J 21:13–22

Notes:

The Long Term Adult Sequellae of Residual Deformity in the Operated Adolescent

*Ohereba Boachie-Adjei, MD, DSc
Prof. Orthopedic Surgery Weill
Medical College of Cornell University
Chief Emeritus, Scoliosis Service
Hospital For Special Surgery
535 East 70th Street
New York, New York, 10021
Oboachie@gmail.com
212-606-1948*

1. Residual Deformity and Pain following Segmental Instrumentation
 - a. Historical Perspectives
 - b. Clinical Presentation and Treatment Methods
 - c. Methods to Avoid/Minimize residual deformity when treating Adolescent deformity
2. Historical Perspectives
 - a. Long-Term effects on Personality Development in Patients with Adolescent Idiopathic Scoliosis: Influence of Type of Treatment
 - i. Women treated for adolescent idiopathic scoliosis (AIS), compared with matched control subjects function well with regard to marital status and number of children.
 - ii. Final Curve same in Both groups
 - iii. Surgical pts had better emotional make up than Brace who in turn did better than Non op group
 - iv. Implication: Not to withhold Surgery for AIS

- b. Evaluation of Postoperative Residual Spinal Deformity and Patient outcomes in Idiopathic Scoliosis
 - i. Patients with a greater Cobb angle or rotation angle in the thoracic curve had a negative self-image.
 - ii. Self-image improved after surgery by greater correction of the thoracic Cobb angle.
 - iii. Implication: Thoracic scoliosis with prominence should be substantially reduced by the surgical treatment to improve satisfaction rates and self-image
 - iv. Larger preoperative Cobb angle and positive sagittal balance at the most recent follow-up were related to poor outcome in QOL as assessed by the SRS-22.
- c. Long Term Outcomes and Length Of Fusion
 - i. Increased incidence of low back pain in patients fused distal to L4
 - ii. Degenerative disc changes were more common in the patient group than in the control group,
 - iii. The surgical pts higher pain incidence
 - iv. No differences in terms of pain and back function were detected between those with a “ high” fusion (down to L3 or above) versus a “ low” fusion (down to L4 or below)
- d. Surgical Techniques and curve correction
 - i. The pedicle screw construct does not give a better correction of Mild to Moderate Lenke 1 AIS in the coronal plane as compared with the hybrid construct or the universal system with segmental collar button intraspinous wire construct
 - ii. In the sagittal plane, PS lordoses the thoracic spine. One has to consider other benefits of Pedicle screws for mild to Moderate AIS.
 - iii. PS may be more beneficial for complex spine deformities
- e. Transition Zone Syndromes and Adjacent segment disease
 - i. Compensatory hypermobility adjacent to fusion levels
 - ii. Hypermobility: proportional to length and rigidity of instrumentation
 - iii. Similar changes occur in proximal junction
- f. Posterior instrumented fusion concerns:
 - i. Weakening of paraspinal muscles and loss of biological protection of the transition zone
 - ii. Damage to facets joints
3. Clinical Presentation and Treatment Methods
 - a. Classic presentation: Harrington rod fusion and The flatback syndrome
 - i. Contributing Factors
 1. Distraction inst. lower lumbar
 2. Adjacent Segment Degeneration
 3. Spinal imbalance
 4. Junctional deformity (Proximal and distal)
 - b. Residual and Progressive deformity related to Segmental Instrumentation
 - i. Proximal junctional deformity as adult
 - ii. Distal adj seg degeneration
 - iii. Spondylolisthesis L5-S1

PRE-MEETING COURSE

4. Methods to Avoid/Minimize residual deformity when treating Adolescent deformity

- a. Achieve Optimum Spinal Alignment in the coronal and sagittal planes
- b. Avoid distraction in the lumbar spine
- c. Do not Perform Suboptimal Fixation
- d. Avoid adding on in young patients
- e. Do not violate adjacent segments proximal or distal
- f. Recognize Primary Pathology and select proper fusion levels
- g. Consider appropriate motion segment preservation
- h. Prevent spinal decompensation
- i. Fusion to L5 in AIS should be a Rare/Never Event

5. Famous Quotes on Scoliosis

- a. Spinal Fusion does not cure Scoliosis, It controls it and Young Patients eventually become Adults. *Eduardo Luque MD*
- b. "In the field of scoliosis, there is one rule to observe; keep your eye upon the patient, and not upon the curve."- *John Cobb MD*

6. References

1. Back Pain and Function 23 Years After Fusion for Adolescent Idiopathic Scoliosis: A Case-Control Study—Part II Aina J. Danielsson, MD, PhD and Alf L. Nachemson, MD, PhD SPINE Volume 28, Number 18, pp E373–E383
2. Evaluation of Postoperative Residual Spinal Deformity and Patient Outcome in Idiopathic Scoliosis Patients in Japan Using the Scoliosis Research Society Outcomes Instrument Kei Watanabe, MD, PhD,* Kazuhiro Hasegawa, MD,† Toru Hirano, MD,* SPINE Volume 32, Number 5, pp 550–554
3. Long term effects on Personality Development in Patients with Adolescent Idiopathic Scoliosis: Influenc of type of treatment: Fallstron PhD, Cochran T MD, NAchemson A MD PhD . Spine vol 11. 7- 1986
4. Quality of Life in Patients Treated Surgically for Scoliosis Longer Than Sixteen-Year Follow-up Kazushi Takayama, MD, PhD,* Hiroaki Nakamura, MD, PhD,* and Hideki Matsuda, MD† SPINE Volume 34, Number 20, pp 2179–2184
5. The Deformity-Flexibility Quotient Predicts Both Patient Satisfaction and Surgeon Preference in the Treatment of Lenke 1B or 1C Curves for Adolescent Idiopathic Scoliosis Peter O. Newton, MD,*† Vidyadhar V. Upasani, MD,† Tracey P. Bastrom,. SPINE Volume 34, Number 10, pp 1032–1039
6. Cochran T, Irstram L, Nachemsen A. Long term anatomic and functional changes in patients with adolescent idiopathic scoliosis treated by Harrington rod fusion. Spine 1983;8:576-84
7. Michel CR, Lalain JJ. Late results of Harrington’s operation: Long-term evolution of the lumbar spine below the fusion segments. Spine 1985;10:414-20
8. Shono Y, Kaneda K, Abumi K, et al. Stability of posterior spinal instrumentation and its effect on adjacent motion segments in the lumbosacral spine. Spine. 1998; 23:1550-1558.

9. Bastian L, Lange U, Knop C, et al. Evaluation of the mobility of adjacent segments after posterior thoracolumbar fixation: a biomechanical study. Eur Spine J. 2001; 10:295-300.

10. A Pedicle Screw Construct Gives an Enhanced Posterior Correction of Adolescent Idiopathic Scoliosis When Compared With Other Constructs Myth or Reality Vagmin Vora, MS Orth, MD,* Alvin Crawford, MD,† Nadir Babekhir,† Oheneba Boachie-Adjei, MD,‡ Lawrence Lenke, MD,§ Melissa Peskin, BA,‡ Gina Charles,‡ and Yongjung Kim, MD§ Study Design. Tricenter retrospective. SPINE Volume 32, Number 17, pp 1869–1874

Notes:

Severe Spine Deformity in Adolescence: What are the Pulmonary Implications?

Greg Redding, MD
Children’s Hospital and Regional Medical Center
Seattle, Washington, USA

Severe spine deformity can be defined in several ways. The usual descriptor is the Cobb angle with specified length of the curve, apical vertebral level, and sagittal plane deformities. Classification systems that take these features into account have been used successfully for years. (1) Additional features include severity of rotation and spine stiffness, although these are infrequently quantified. Additional considerations of severity include functional impacts of the deformity, such as lung function.

The correlation between Cobb angle and lung function is poor in early onset scoliosis (EOS) and only slightly better in adolescent idiopathic scoliosis (AIS). There is a general relationship between Cobb angle and length of the AIS curve with Vital Capacity but features including number of vertebrae involved, kyphosis, coronal imbalance, and Cobb angle account for only 20% of the relationship between structural spine features and vital capacity. (2) Since the degree of pulmonary compromise is rarely severe in most cases of AIS, these are not pressing considerations for most patients.

PRE-MEETING COURSE

AIS produces restrictive respiratory disease in children and adults. This results from loss of intra-thoracic volume, loss of chest wall compliance and excursion, and loss of respiratory muscle force generation. Severe lung disease is quantified by several functional measures rather than a single index, similar to structural features used to depict severity. Vital capacity is most useful as it is cheap, standardized, and sensitive to most of the structural aspects of a spine deformity. Additional measures include gas exchange awake and asleep, response to exercise, and pulmonary hypertension in severe cases.

Pulmonary disability is defined by the American Thoracic Society occurs when impairment is sufficient to diminish one's ability to perform normal jobs. Moderate impairment occurs with vital capacity is 50-60% of predicted. (3) Severe disability occurs when vital capacity is < 50% predicted. Post-operative pulmonary complications triple in adolescents with AIS whose vital capacities are <40% of predicted using arm span instead of height for normal values.

The frequency of severe AIS, defined in pulmonary terms, is less than 10% of cases. (4) The surgical approaches to these patients must account for this limited functional reserve, knowing that the fusion can further compromise lung function post-operatively. The use of an anterior approach and/or thoracoplasty increase the likelihood of lung function decline at least for months after spine fusion. If chosen as strategies, additional respiratory support should be anticipated, particularly night time respiratory support with non-invasive positive pressure ventilation.

Expiratory muscle strength, an easily measured clinical "lung" function, is reduced in severe scoliosis. It is important for cough effectiveness and mucus clearance from the airways. It is reduced in proportion to vital capacity and total lung capacity. In severe cases, a Cough Assist can be used proactively to maintain clear airways, especially when respiratory infections occur in the year after spine fusion.

Finally, pulmonary function declines with age in normal human beings. (6) Children undergoing spine fusion for AIS rarely experience improvement in lung function two years later. Their lung function is likely to decline at the same rate at best with time. That decline can be accelerated by smoking and obesity during adulthood. Patients with initial severe AIS will benefit from proactive counseling and management by providers with pulmonary expertise in adulthood. Transitions from pediatric to adult care must take these considerations into account.

References

1. Lenke LG, Bets RB, Harms, J et al, JBJS AM, 2001; 83:1169-1181.
2. Newton PO, JBJS, 87 (9); 1937-1945, 2007.
3. Johnston CE et al, Spine 36 (14):1096-1102, 2011.
4. Newton PO et al, Spine 32 (17):1875-1882, 2007.
5. Stanojevic S et al, Breathe, 9 (6):463-474.

Notes:

The Adult Sequelae of Severe Scoliosis in Adolescence

Aina Danielsson, MD, PhD

Dept. of Orthopaedics

Sahlgren University Hospital

Göteborg, Sweden

- Severe scoliosis= above Cobb 40°-50°, i.e. those who undergo surgery during adolescence

Introduction

- Problems in the literature
 - No long-term prospective controlled study exist
 - What matters today did not matter before- comparisons over time troublesome or impossible to perform
 - Relative lack of results for comparison with untreated patients
 - Most studies that exist concern patients operated using earlier types of instrumentation (Harrington, CD, TSRH)
 - Questions:
 - Is surgery better than natural history?
 - Outcome in the long run — at age 40? -or at age 60?
 - But so far followed only up to age 40-50. And then?
 - What is the effect of the additional marginal correction achieved by newer systems?
 - Outcome needs to be put in the perspective of the indication for surgery
 - (i.e. you want to save pulmonary function — pulmonary function is the most important outcome variable)
 - Studies with untreated patients for comparison
 - Weinstein et al: Iowa 50 Y follow-up¹ — only study with long term outcome including AIS only
 - Pehrsson et al²: analysis of mortality for subgroup of AIS
- ### Mortality and General Health Issues
- Natural history: AIS does not result in increased mortality
 - Published studies — results:
 - Danielsson (Harrington) 2001, n=139: 2/156 deceased at age of 40, at a normal level. Pulmonary disease, coronary heart disease or neoplasms (malignant or benign) equal to healthy age-matched controls³.

PRE-MEETING COURSE

Radiography and reoperations

- Natural history: Single thoracic curves 50-75° progress 0.73°/year over a 40-year period
- Various degree of complications and reoperations, seem to have some effect on curve size at FU
- Published studies – results:
 - Danielsson (Harrington), 2001, n=139: curve increase 4°/23 y, complication rate 5%, reop. 5%⁴.
 - Padua (Harrington), 2001 n=70: curve increase 20°/24 y, rod removal in 68% (complications)⁵.
 - Helenius (Harrington), 2003 n=78: curve increase 7°/21 y, complic. 12%, rod removal in 64% (routine)⁶.
 - Helenius (CD), 2003 n=57: curve increase 7°/13 y, complic. 26%⁶.
 - Benli (TSRH) 2007 n=109: curve increase 8°/11 y, complic. Rate 20%, reoperation rate 9%. Abnormal balance: preop 80%, postop 5%, FU 9%⁷.
 - Larson (TSRH/CD, thoracic only) 2013 n=19: curve increase 9°/20y⁸.
 - Sudo (anterior instrumentation, thoracic curves) 2013 n=25: curve increase 9°/15y⁹.
 - Min (pedicle screws) 2013, n=48: curve increase 5°/10y. 6/48 pat rod removal due to low grade infection, lost correction from initial 70% to 42%¹⁰.

Degenerative Changes

- Concerns about discs below the fusion
- Published studies – results:
 - Danielsson (Harrington), 2001, 25 Y FU, n=32: If fused to L4 or L5: 75% had severe degenerative changes on unfused discs on MRI. Correlated to lumbar pain and Ølordosis¹¹.
 - Green 2011, 12 Y FU, posterior fusion LIV T12-L3: new disc pathology in 85% of pts, mostly L5-S1 disc¹².

Mobility and muscle strength

- Danielsson et al 2006, n=135, 23 Y FU¹³
 - Range of motion of the cervical, thoracic and lumbar spine was significantly decreased
 - The total length of the fusion affected the lumbar mobility negatively, but neither cervical nor thoracic mobility were affected.
 - No correlation between the degree of thoracic kyphosis and the cervical flexion.
 - Muscle endurance for both lumbar flexor and extensor muscles was significantly decreased compared to controls, for ST with 31 and 41%
 - The stronger and the more mobile the spine is, the better the physical function.

Back Pain and Function

- Natural history: Back pain more frequent. Severity?
- Back pain do occur. Most studies: light pain, few patients with severe pain. Do not seem to correlate to curve size.

Weinstein et al 2003, FU 50y (untreated) ¹	61	-	-	Normal ADL and no great impact on work
Danielsson et al 2000, FU 20-28y (Harr.) ¹⁴	65	8.3	2.4	Slightly Ø physical function, normal ADL
Helenius 2003, FU 21y (Harr.) ⁶	13	-	-	Normal ADL and functional activities
Helenius 2003, FU 13y (CD) ⁶	11	-	-	Generally do well, if >45° slightly Ø physical function
Niemeyer 2005, FU 11-30y (Harr.) ¹⁵	-	6.0	0.5	Normal ADL
Bjerkreim 2007, FU >10y (CD) ¹⁶	45	6.9	-	Back function good/excellent/fair in 97%, seldom analgesics
Bartie 2009, FU 19 y (Harr.) ¹⁷	75	-	-	Fused down to L4: pain more frequent
Kelly 2010, FU 17 y (anterior surgery) ¹⁸	-	8.1	-	
Larson 2013, FU 20y (TSRH/CD) ⁸	-	4.3	2.5	
Akazawa 2013, FU 31 y (mixed ant./post.) ¹⁹	68	-	-	No difference in terms of Roland-Morris Disability Score towards control group

ODI = Oswestry Disability Index, VAS= Visual Analogue Scale for pain, Harr.= Harrington instrumentation

Quality of Life (QoL)

- Natural history: No studies with modern QoL questionnaires on this patient group has been published
- General Health Related Quality of Life – compare to general population
 - SF-36. Harrington groups:
 - Danielsson 2000: somewhat reduced Physical function, otherwise at normal levels³
 - Padua 2001⁵ and Andersen 2006²⁰ – similar results

PRE-MEETING COURSE

- Götze 2003²¹ summary scores only, the physical same as age norms but mental subscore lower than age-related.
- Bartie 2009: minimal reduction¹⁷
- Scoliosis specific quality of life: Scoliosis Research Society Questionnaire
 - SRS-24 and 30
 - A number of studies with outcome presented with SRS-30 or -24, only one measurement at follow-up or not full data presented
 - SRS-22
 - Benli 2007 (TSRH)⁷
 - Akazawa 2012: lower results than the control group¹⁹

Socio-demographics

- Natural history: Function, childbearing, marriage – no apparent disadvantageous effects compared to healthy population
- A number of outcome studies show similar rates for working, marriage rates and number of children
- Danielsson 2001: childbearing and deliveries no major problems, except for the fact that some patients are afraid that their future children will have back problems and therefore refrain from having children²²

CONCLUSIONS

Most but not all have a good quality of life.

Complications after surgery occur, seem to affect curve change over the time.

Some have back problems (mostly mild), which seldom interferes with life.

BUT: Results known until age 40 (-50). What will happen during further aging?

REFERENCES

1. Weinstein SL, Dolan LA, Spratt KF, et al. Health and function of patients with untreated idiopathic scoliosis: a 50-year natural history study. *Jama* 2003;289:559-67.
2. Pehrsson K, Larsson S, Oden A, et al. Long-term follow-up of patients with untreated scoliosis. A study of mortality, causes of death, and symptoms. *Spine* 1992;17:1091-6.
3. Danielsson AJ, Wiklund I, Pehrsson K, et al. Health-related quality of life in patients with adolescent idiopathic scoliosis: a matched follow-up at least 20 years after treatment with brace or surgery. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2001;10:278-88.
4. Danielsson AJ, Nachemson AL. Radiologic findings and curve progression 22 years after treatment for adolescent idiopathic scoliosis: comparison of brace and surgical treatment with matching control group of straight individuals. *Spine* 2001;26:516-25.
5. Padua R, Padua S, Aulisa L, et al. Patient outcomes after Harrington instrumentation for idiopathic scoliosis: a 15- to 28-year evaluation. *Spine* 2001;26:1268-73.
6. Helenius I, Remes V, Yrjonen T, et al. Harrington and Cotrel-Dubousset instrumentation in adolescent idiopathic scoliosis. Long-term functional and radiographic outcomes. *J Bone Joint Surg Am* 2003;85-A:2303-9.
7. Benli IT, Ates B, Akalin S, et al. Minimum 10 years follow-up surgical results of adolescent idiopathic scoliosis patients treated with TSRH instrumentation. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2007;16:381-91.
8. Larson AN, Fletcher ND, Daniel C, et al. Lumbar curve is stable after selective thoracic fusion for adolescent idiopathic scoliosis: a 20-year follow-up. *Spine (Phila Pa 1976)* 2012;37:833-9.
9. Sudo H, Ito M, Kaneda K, et al. Long-term outcomes of anterior spinal fusion for treating thoracic adolescent idiopathic scoliosis curves: average 15-year follow-up analysis. *Spine (Phila Pa 1976)* 2013;38:819-26.
10. Min K, Sdzuy C, Farshad M. Posterior correction of thoracic adolescent idiopathic scoliosis with pedicle screw instrumentation: results of 48 patients with minimal 10-year follow-up. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2013;22:345-54.
11. Danielsson AJ, Cederlund CG, Ekholm S, et al. The prevalence of disc aging and back pain after fusion extending into the lower lumbar spine. A matched MR study twenty-five years after surgery for adolescent idiopathic scoliosis. *Acta Radiol* 2001;42:187-97.
12. Green DW, Lawhorne TW, 3rd, Widmann RF, et al. Long-term magnetic resonance imaging follow-up demonstrates minimal transitional level lumbar disc degeneration after posterior spine fusion for adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)* 2011;36:1948-54.
13. Danielsson AJ, Romberg K, Nachemson AL. Spinal range of motion, muscle endurance, and back pain and function at least 20 years after fusion or brace treatment for adolescent idiopathic scoliosis: a case-control study. *Spine* 2006;31:275-83.
14. Danielsson AJ, Nachemson AL. Back pain and function 23 years after fusion for adolescent idiopathic scoliosis: a case-control study-part II. *Spine* 2003;28:E373-83.
15. Niemeyer T, Bovingloh AS, Grieb S, et al. Low back pain after spinal fusion and Harrington instrumentation for idiopathic scoliosis. *Int Orthop* 2005;29:47-50.
16. Bjerkreim I, Steen H, Brox JJ. Idiopathic scoliosis treated with Cotrel-Dubousset instrumentation: evaluation 10 years after surgery. *Spine (Phila Pa 1976)* 2007;32:2103-10.
17. Bartie BJ, Lonstein JE, Winter RB. Long-term follow-up of adolescent idiopathic scoliosis patients who had Harrington instrumentation and fusion to the lower lumbar vertebrae: is low back pain a problem? *Spine (Phila Pa 1976)* 2009;34:E873-8.
18. Kelly DM, McCarthy RE, McCullough FL, et al. Long-term outcomes of anterior spinal fusion with instrumentation for thoracolumbar and lumbar curves in adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)* 2010;35:194-8.

PRE-MEETING COURSE

19. Akazawa T, Minami S, Kotani T, et al. Long-term clinical outcomes of surgery for adolescent idiopathic scoliosis 21 to 41 years later. *Spine (Phila Pa 1976)* 2012;37:402-5.
20. Andersen MO, Christensen SB, Thomsen K. Outcome at 10 years after treatment for adolescent idiopathic scoliosis. *Spine* 2006;31:350-4.
21. Gotze C, Liljenqvist UR, Slomka A, et al. Quality of life and back pain: outcome 16.7 years after Harrington instrumentation. *Spine* 2002;27:1456-63; discussion 63-4.
22. Danielsson AJ, Nachemson AL. Childbearing, curve progression, and sexual function in women 22 years after treatment for adolescent idiopathic scoliosis: a case-control study. *Spine* 2001;26:1449-56.

Notes:

VCR in Children & Adolescents: Learning Techniques used First in Adults

Paul Sponseller, MD

Johns Hopkins University

Bloomberg Children's Center

Baltimore, Maryland, USA

I. Vertebral Column Resection

Complete destabilization of spine requiring anterior column support

Powerful tool for Focal Severe Deformity

Prior Work on this:

Leatherman, Bradford, Suk

Lenke: 100+ cases with no new permanent Deficit

II. Teachings in Peds Spine

Use global forces, including traction/distraction, to realign deformity

Preserve cord vascularity

III. New Skills for Peds Surgeon

The Spinal Canal:

Controlling epidural bleeding

Working around cord/nerve roots

Awareness of angulation, translation

The Anterior Column

Exposing vertebral body & discs from posteriorly

Deformity often facilitates this

The Reconstruction

Preserving stability while working

Troubleshooting

IV. Steps in learning

Read:

Watch: Live surgery demonstration

"Baby Steps": Ponte- PSO-HVR-VCR

Work with partner

V. Planning

3-D Model

Careful baseline neuro exam

Preop Traction- stretch soft tissue envelope

VI. Habits / timing

Stay fresh, focused

Allow enough time

Have your best assistant: colleague, neurosurgeon

Stage if needed

Notes:

Debate: Distal Level Preservation in Adolescents with Severe Curves versus Less Residual Deformity: Fuse to L3

Matthew E. Oetgen, MD

Children's National Medical Center

Division of Orthopaedic Surgery and Sports Medicine

Washington, DC, USA

(202) 476-4063

moetgen@childrensnational.org

A. Direct Head to Head Comparison

a. Ding, R. *Journal of Spinal Disorders and Techniques*

b. Compared Radiographic and patient reported outcomes of patients with adolescent idiopathic scoliosis s/p PSF to L3 vs L4

c. No difference found in any radiographic or patient reported outcomes between groups at 2 years post-op

B. What is the question with this debate?

a. Fuse to L3 à accept some disc wedging and residual deformity for increased motion segments below fusion

b. Fuse to L4 à Full correction but decreased motion segments below fusion

PRE-MEETING COURSE

- C. Health of discs below fusions for scoliosis
- Histologic study of discs removed during anterior spinal fusion (Rajasekaran, Spine 2011)
 - Evidence of disc degeneration which correlated with Cobb angle and disc wedging
 - No correlation of degenerative disc changes with clinical symptoms
 - Multiple MRI Studies assessing health of discs
 - High incidence of DDD but little evidence of correlation with clinical symptoms
- D. Back Pain
- Long-term studies show high incidence of low back pain after posterior spinal fusion, up to 80%
 - The incidence of back pain in long term follow up appears to be higher in patient after posterior spinal fusion as compared to controls
 - When directly assessing pain in patients fused to L3 vs L4
 - Patients fused to L4 appear to have higher pain intensity, but not more pain, or more frequent pain. No difference in patient reported outcomes. (Bartie, Spine 2009)
 - Slightly more motion with in patients fused to L3 vs L4, but no difference in pain, effect on life, or back function (Danielsson, Spine 2003)
 - No clear answer regarding back pain comparing fusion to L3 vs L4
- E. Range of Motion
- Patients appear to have more range of motion in the lumbar spine when comparing residual motion in those fused L3 vs L4
 - This motion did not lead to improved function, patient reported outcome, or muscle endurance (Danielsson, Spine 2006)
 - Using motion analysis, Lee and colleagues found a decrease in lumbar motion in the coronal and sagittal planes in patient fused to L3 compared to those fused to L1 or L2. While this study suggests a significant decrease in motion associated with lower instrumented vertebrae in fusions, patients fused below L4 were not included in this analysis. (Lee, Spine 2013)
- F. Functional Effects of Distal Fusion Level
- Fabricant, JPO 2012
 - Assess return to sports activity in adolescents after posterior spinal fusion with a mean follow up of 5.5 years
 - 60% of patients returned to athletics at or above pre-op levels
 - Linear relationship between lowest instrumented vertebrae and ability to return to sports activity
 - Most common reason for inability to return to sports: loss of flexibility (47% of patients unable to return to sports)
- G. Summary of Fusion L3 vs L4
- No evidence of worse clinical outcomes in patients after posterior spinal fusion associated with degenerative disc disease found on post-op MRI
 - No definitive evidence of increased low back pain in patients depending on lowest instrumented vertebrae (L3 vs L4)
- As the lowest instrumented vertebrae extends more distal in the lumbar spine patients appear to lose lumbar motion and have more difficulty returning to athletic activity
 - It appears reasonable to fuse to L3 as compared to L4 to improve patient function with little evidence this approach leads to worse long term results.
- H. References
- Lee MC, Öunpuu S, Solomito M, Smith BG, Thomson JD. Loss in spinal motion from inclusion of a single midlumbar level in posterior spinal fusion for adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)*. 2013 Oct 15;38(22):E1405-10.
 - Akazawa T, Minami S, Kotani T, Nemoto T, Koshi T, Takahashi K. Long-term clinical outcomes of surgery for adolescent idiopathic scoliosis 21 to 41 years later. *Spine (Phila Pa 1976)*. 2012 Mar 1;37(5):402-5.
 - Green DW, Lawhorne TW 3rd, Widmann RF, Kepler CK, Ahern C, Mintz DN, Rawlins BA, Burke SW, Boachie-Adjei O. Long-term magnetic resonance imaging follow-up demonstrates minimal transitional level lumbar disc degeneration after posterior spine fusion for adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)*. 2011 Nov 1;36(23):1948-54.
 - Bartie BJ, Lonstein JE, Winter RB. Long-term follow-up of adolescent idiopathic scoliosis patients who had Harrington instrumentation and fusion to the lower lumbar vertebrae: is low back pain a problem? *Spine*. 2009 Nov 15;34(24):E873-8.
 - Danielsson AJ, Nachemson AL. Back pain and function 23 years after fusion for adolescent idiopathic scoliosis: a case-control study-part II. *Spine*. 2003 Sep 15;28(18):E373-83.
 - Ding R, Liang J, Qiu G, Shen J, Li Z. Evaluation of quality of life in adolescent idiopathic scoliosis with different distal fusion level: a comparison of L3 versus L4. *J Spinal Disord Tech*. 2014 Jul;27(5):E155-61.
 - Fabricant PD, Admoni S, Green DW, Ipp LS, Widmann RF. Return to athletic activity after posterior spinal fusion for adolescent idiopathic scoliosis: analysis of independent predictors. *J Pediatr Orthop*. 2012 Apr-May;32(3):259-65.
 - Takayama K, Nakamura H, Matsuda H. Low back pain in patients treated surgically for scoliosis: longer than sixteen-year follow-up. *Spine*. 2012 May 1;37(10):826-32.
 - Lerner T, Frobin W, Bullmann V, Schulte T, Brinckmann P, Liljenqvist U. Changes in disc height and posteroanterior displacement after fusion in patients with idiopathic scoliosis: a 9-year follow-up study. *J Spinal Disord Tech*. 2007 May;20(3):195-202.
 - Balderston RA, Albert TJ, McIntosh T, Wong L, Dolinskas C. Magnetic resonance imaging analysis of lumbar disc changes below scoliosis fusions. A prospective study. *Spine*. 1998 Jan 1;23(1):54-8.

PRE-MEETING COURSE

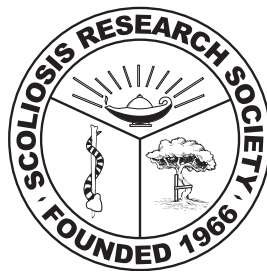
11. Violas P, Estivalezes E, Briot J, Sales de Gauzy J, Swider P. Quantification of intervertebral disc volume properties below spine fusion, using magnetic resonance imaging, in adolescent idiopathic scoliosis surgery. *Spine*. 2007 Jul 1;32(15):E405-12.
12. Rajasekaran S, Vidyadhara S, Subbiah M, Kamath V, Karunanithi R, Shetty AP, Venkateswaran K, Babu M, Meenakshi J. ISSLS prize winner: a study of effects of in vivo mechanical forces on human lumbar discs with scoliotic disc as a biological model: results from serial postcontrast diffusion studies, histopathology and biochemical analysis of twenty-one human lumbar scoliotic discs. *Spine*. 2010 Oct 1;35(21):1930-43.
13. Danielsson AJ, Romberg K, Nachemson AL. Spinal range of motion, muscle endurance, and back pain and function at least 20 years after fusion or brace treatment for adolescent idiopathic scoliosis: a case-control study. *Spine*. 2006 Feb 1;31(3):275-83.

Notes:

PRE-MEETING COURSE

AFTERNOON SESSION 1

LEARNING FROM OUR COMPLICATIONS: THE COMPLICATION I HAVE LEARNED THE MOST FROM IN COMPLEX DEFORMITY AND WHAT IT CAN TEACH YOU



Moderators:

Behrooz A. Akbarnia, MD & Karl E. Rathjen, MD

Faculty:

*Ahmet Alanay, MD; Sigurd H. Berven, MD; Laurel C. Blakemore, MD; John R. Dimar, II, MD; Kamal N. Ibrahim, MD, FRCS(C), MA;
Stefan Parent, MD, PhD; Christopher I. Shaffrey, MD;
Michael G. Vitale, MD, MPH*

PRE-MEETING COURSE

The Complication I Have Learned the Most From in Complex Scoliosis Deformity: Complication 1

Kamal N. Ibrahim, MD, FRCS(c), MA

DuPage Medical Group

Chicago, Illinois, USA

A straightforward case of 50-degree RT thoracic curve with thoracic hypokyphosis. Surgery went very well. I did 4 SP osteotomies at the apex to improve the kyphosis. The osteotomy sites were covered with gelfoam and cottonoid. Near the end of the case after the correction was achieved and during inserting the set screw into the tulip at T8 on the right the set screw was not engaging easily so as usual mild pressure was exerted on the inserter to engage the set screw, the tulip tilted toward the canal and the set screw with the introducer slipped into the canal through one of the osteotomy site. Motor monitor was lost, all recommended steps were taken (raising BP, warming, transfusion etc.), large laminectomy was done, and there was no dural tear or obvious cord injury. Neurosurgeon was consulted and he didn't have anything to add. Wake up test was done and he didn't move one leg. All setscrews were loosened, rods were removed and the wound was closed. He woke up with Browns Squared syndrome. MRI didn't show any cord edema or ischemia. Subsequent days he showed some recovery so was taken back after a week for inserting the rods without any aggressive correction. He recovered gradually and recovered completely after 4 months. It was a significant cord concussion but no cord injury.

It is a simple incident but it can happen to anyone especially with the increase of the number of osteotomies, which are currently done. My approach now is to cover the osteotomy area with thick gauze, which will withstand any similar slippage, covering with cottonoid is not enough.

Notes:

The Complication I've Learned the Most From in Complex Scoliosis Deformity: Failure to Correct (Or Worsening) Trunk or Shoulder Balance

Laurel C. Blakemore, M.D.

Chief and Associate Professor, Pediatric Orthopaedics

Department of Orthopaedics and Rehabilitation

University of Florida College of Medicine

Gainesville, Florida, USA

BIBLIOGRAPHY

- Behensky H et al. Fixed lumbar apical vertebral rotation predicts spinal decompensation in Lenke type 3C adolescent idiopathic scoliosis after selective posterior thoracic correction and fusion. *Eur Spine J.* 2007 Oct;16(10):1570-8.
- Cao K et al. Association of postoperative shoulder balance with adding-on in Lenke Type II adolescent idiopathic scoliosis. *Spine (Phila Pa 1976).* 2014 May 20;39(12):E705-12.
- Hong J et al. Analysis of factors that affect shoulder balance after correction surgery in scoliosis: a global analysis of all the curvature types. *Eur Spine J.* 2013 Jun;22(6):1273-85.
- Ilharborde B et al. How to determine the upper level of instrumentation in Lenke types 1 and 2 adolescent idiopathic scoliosis: a prospective study of 132 patients. *J Pediatr Orthop.* 2008 Oct-Nov;28(7):733-9.
- Kuklo T et al. Correlation of radiographic, clinical, and patient assessment of shoulder balance following fusion versus nonfusion of the proximal thoracic curve in adolescent idiopathic scoliosis. *Spine (Phila Pa 1976).* 2002 Sep 15;27(18):2013-20.
- Lewis SJ et al. Modified T4 hemivertebrectomy for persistent high left shoulder after surgery for double thoracic scoliosis. *Spine (Phila Pa 1976).* 2014 Jun 15;39(14):E856-9.
- Ono T et al. Defining 2 components of shoulder imbalance: clavicle tilt and trapezial prominence. *Spine (Phila Pa 1976).* 2012 Nov 15;37(24):E1511-6.
- Paul JC et al. Gait stability improvement after fusion surgery for adolescent idiopathic scoliosis is influenced by corrective measures in coronal and sagittal planes. *Gait Posture.* 2014.
- Qiu X et al. Discrepancy between radiographic shoulder balance and cosmetic shoulder balance in adolescent idiopathic scoliosis patients with double thoracic curve. *Eur Spine J.* 2009 Jan;18(1):45-51.
- Roussouly P et al. Pre- and post-operative sagittal balance in idiopathic scoliosis: a comparison over the ages of two cohorts of 132 adolescents and 52 adults. *Eur Spine J.* 2013 Mar;22 Suppl 2:S203-15.
- Trobisch P et al. Postoperative trunk shift in Lenke 1 and 2 curves: how common is it? An analysis of risk factors. *Eur Spine J.* 2011 Jul;20(7):1137-40.
- Wang Y et al. Lowest instrumented vertebra selection in Lenke 3C and 6C scoliosis: what if we choose lumbar apical vertebra as distal fusion end? *Eur Spine J.* 2012 Jun;21(6):1053-61.

PRE-MEETING COURSE

Wang Y et al. Postoperative trunk shift in Lenke 1C scoliosis: what causes it? How can it be prevented? *Spine (Phila Pa 1976)*. 2012 Sep 1;37(19):1676-82.

Yang S et al. Does anterior shoulder balance in adolescent idiopathic scoliosis correlate with posterior shoulder balance clinically and radiographically? *Eur Spine J*. 2012 Oct;21(10):1978-83.

Zhao Y et al. Prediction of postoperative trunk imbalance after posterior spinal fusion with pedicle screw fixation for adolescent idiopathic scoliosis. *J Pediatr Orthop B*. 2011 Jul;20(4):199-208.

Notes:

The Domino Effect in the Treatment of the Rheumatoid Spine: Crisis Management

John R. Dimar II, MD

Norton Leatherman Spine Center

Louisville, Kentucky, USA

Epidemiology

Rheumatoid arthritis (RA) is a chronic inflammatory arthritis that affects all synovial joints in the body to various degrees. RA has an incidence of .5-1%, is more frequent in females (4X), occurs in the 40-50s, and generally leads to permanent disability. The etiology is not precisely known but the onset of RA is believed to occur after some environmental trigger, particularly in individuals with the HLA-DR4 cell surface markers, that activates an autoimmune inflammatory cascade resulting in the formation of autoantibodies that attack the synovial linings of the joints causing joint destruction and pannus formation. RA affects the joints of the hands, wrists, and feet but also can affect all the major joints including the shoulder, elbows, hips and knees. RA may also affect the spine, in particular the classic involvement of the C1-2 vertebra (atlanto-axial subluxation & spinal cord compression), but may also affect the facet joints in the thoracic and lumbar spine along with the sacroiliac joints. RA is also associated with other systemic problems including severe osteopenia (osteoporosis), pulmonary fibrosis etc. Current commonly employed treatment includes NSAID, DMARDs, steroids, & tumor necrosis factors inhibitors.

Case Report:

58 F with Rheumatoid Arthritis, Hypertension, & Obesity Referred by NES with a remote History of a T8-9 Thoracic Disc Excision & a More Recent L3-4 Disc Excision 2 Years Ago. Following Multiple Surgeries She now Presents in a WC (May 2014) with Severe, Recurrent L4 Radiculopathy and Left > Right Quadriceps Weakness.

Medications:

Methotrexate, Leflunomide (Arava), and Etanercept (Enbrel) for RA

1. Arava-14 day half-life, DMARD
2. Methotrexate- 12 hour half-life, DMARD, folate antagonist
3. Enbrel-4 day half-life, TNF inhibitor
4. Prednisone Periodically, & NSAIDs

Surgical History

1. 2005: Left T8-9 laminectomy with discectomy
2. 2007: Right L3-4 Laminectomy, Foraminotomy & Discectomy
3. 9/2009: TLIF L3-4 with PLSF Fusion, Right ICBG, and instrumentation
4. 8/2011: L2-3, L4-5 Anterior Interbody Fusion & PLSF from L2-5, Left ICBG for a Massive HNP L5-S1 with Left EHL/Gastroc. O/S & Bladder Loss of Control
5. 5/28/14: T11-L4 Posterolateral Extension of Fusion & L1-2 Decompression for Massive L1-2 HNP After Presenting 24 hours Previously in Wheel Chair with Diffuse LE Weakness
6. 5/28/14: L1-2 Decompression— Following Notification of RR Weakness & MRI Showing Retained Disc, 3 Hours Later
7. 5/29/14: L1-2 Decompression — Following Minimal Improvement & a Myelo/CT Showing Retained Disc at L1-2
8. 6/2/14: L2 Vertebrectomy via Left Muscle Splitting Flank Approach, Disc Excision, AIBF with Cage Following a 2nd Myelo/CT Showing Retained Disc
9. 6/2/14: Placed on Forteo™, Vitamin.D3 & Calcium Citrate
10. 7/22/14: Posterior I&D for Drainage, Antibiotics, Drains & Cultures Which Showed MRSA. Closure of Dehisced Flank Wound, Negative Cultures.
11. 7-24-14: Posterior I&D for Drainage, Antibiotics, Drains & Cultures
12. 7-26-14: Posterior I&D for Drainage, Antibiotics, Drains, Cultures, & Re-grafting, & 6 Weeks of Vancomycin
13. Subsequent Surgery: ??????????

PRE-MEETING COURSE

- The incidence is increasing
 - ASD surgery indications are broadening
 - Older patients with poorer bone quality
 - More aggressive correction of lumbar lordosis and sagittal imbalance
 - More rigid constructs

What Do We Know?

- Radiographic PJK occurs much more common than clinically symptomatic PJK
- The use of hooks, wires or pedicle screws at the proximal level have not been shown to change PJK rates
- The presence of PJK usually does not result in differences in HRQOL outcomes
- Cases of catastrophic PJK occur

Terminology

- “Adjacent Segment Pathology” as the general term to describe changes that occur adjacent to a previously operated level
- Radiographic Adjacent Segment Pathology (RASP) refers to radiographic changes that occur at the adjacent segment
PJK is a subset of RASP
- Clinical Adjacent Segment Pathology (CASP) refers to clinical symptoms and signs that occur at the adjacent segment
Proximal Junctional Failure (PJF) is a subset of CASP

Radiographic Proximal Adjacent Segment Pathology: General Definition

- Exaggerated posterior convex angulation found at the proximal end of the instrumented vertebra resulting in kyphosis
- This angulation may or may not be symptomatic
- Several methods of measuring adjacent segment pathology have been reported in the literature
- Method for measuring proximal juncture angle:
 - Cephalad endplate of two supra-adjacent vertebrae above UIV
 - Caudal endplate of the UIV
- PJK defined as $> +10^\circ$ and
 - $+10^\circ$ more than pre-operative

What the Literature Shows

- Proximal junctional kyphosis in primary adult deformity surgery: evaluation of 20 degrees as a critical angle. Bridwell KH et al. Neurosurgery. 2013 Jun;72(6):899-906.
 - PJK $>20^\circ$ occurs in 27.8% of primary ASD treated with pedicle/rod constructs after an average follow-up of 3.5 years
 - 37% were over the age of 55 years at the time of surgery
 - A higher mean age (>55 years), higher BMI and medical comorbidities were both identified as risk factors
 - PJK $>20^\circ$ will likely not require revision surgery
 - SRS outcome scores are not significantly different from those patients who do not develop PJK
- Proximal junctional kyphosis as a distinct form of adjacent segment pathology after spinal deformity surgery: a systematic review. Kim HJ et al. Spine 2012 Oct 15;37(22 Suppl):S144-64.

- o The incidence of PJK ranged from 17%-39% and the majority seemed to occur within two years of surgery
- The most common patient demographic associated with a higher PJK risk was increased age
- Surgery-related risk factors: fusions to the sacrum, combined anterior/posterior surgery, thoracoplasty and UIV at T1-T3
- Incidence, Mode, and Location of Acute Proximal Junctional Failures Following Surgical Treatment for Adult Spinal Deformity. Hostin R et al. Spine 2012 Sep 13.
 - 1218 consecutive ASD surgeries from 10 deformity centers were analyzed to evaluate the incidence and nature of acute PJF
 - Acute PJF = $>15^\circ$ post-operative increase in PJK, vertebral fracture of upper instrumented vertebrae (UIV) or UIV + 1, failure of UIV fixation, or need for proximal extension of fusion within 6 months of surgery
 - 68 APJF cases were identified (5.6%)
 - Mean age of 63 years (range, 26–82 yr), mean fusion levels of 9.8 (range, 4–18), and mean time to APJF of 11.4 weeks (range, 1.5–28 wk)
 - Fracture was the most common failure mode (47%), followed by soft-tissue failure (44%)
 - 66% of patients experiencing TL area compared with 34% experiencing UT area
 - Fracture was significantly more common for TL-APJF relative to UT-APJF ($P = 0.00$), whereas soft-tissue failure was more common for UT-APJF ($P < 0.02$)
 - Patients experiencing TL-APJF were also older, had fewer fusion levels and had worse postoperative sagittal vertical axis ($P < 0.01$)

Risk Factors for Proximal Junctional Failure Following Adult Spinal Deformity Surgery Hart R, ISSG IMAST 2012

- PJF patients were matched to a control group of demographically matched patients without PJF from a prospective ASD database
- A total of 52 PJF and 54 non-PJF were included in the analysis
- The PJF group comprised 37 TL and 15 UT patients
- TL group: significant differences between PJF and NOPJF groups
 - Increasing age
 - Greater operative change in LL and PI-LL
 - Greater preoperative thoracic kyphosis (TK), less lumbar lordosis (LL), sacral slope (SS), and difference between pelvic incidence and lumbar lordosis (PI-LL)
- In the UT group significant differences between PJF and NOPJF
 - Increasing age
 - Greater preoperative Sagittal Vertical Axis (SVA), Pelvic Tilt (PT), PI-LL, and TK
 - Performance of a Pedicle Subtraction Osteotomy (PSO)

PRE-MEETING COURSE

- Age matching all groups
 - PJF had a significantly greater TK (-44.27 vs. 32.53; $p=0.006$), lower LL (24 vs. 45.23; $p<0.0001$), SS (28.02 vs. 34.90; $p=0.004$) and PI-LL (31.67 vs. 13.57; $p=0.002$)
 - PJF had a greater operative change in LL (25.82 vs. 10.23; $p=0.002$) and change in PI-LL (-24.92 vs. -10.35; $p=0.005$)
- 35.1% of TL PJF patients were revised compared to 9.5% in non-PJF patients ($p=0.016$).
- 66.7% of UT PJF patients were revised compared to 18.3% in non-PJF patients ($p=0.003$)

Identification of decision criteria for revision surgery among patients with proximal junctional failure after surgical treatment of spinal deformity. Hart R et al. Spine 2013 Sep 1;38(19):E1223-7.

- 57 patients with PJF was identified retrospectively from 1218 consecutive patients of which 27 (47.4%) patients underwent revision surgery within 6 months of the index operation
- Factors that influence the probability of revision included a traumatic etiology of PJF, severity of PJK angulation, higher SVA, and female sex
- Soft tissue *versus* bony mode of failure, patient age and BMI, levels fused, and upper thoracic *versus* thoracolumbar proximal junction were not related

Does a long-fusion "T3-sacrum" portend a worse outcome than a short-fusion "T10-sacrum" in primary surgery for adult scoliosis?

O Shaughnessy BA et al. Spine 2012 May 1;37(10):884-90.

- The UT group experienced an increased number of perioperative complications (30.0% vs. 15.8%), more pseudarthrosis (20.0% vs. 5.3%), and a higher prevalence of revision surgery (20.0% vs. 10.5%)
- The LT group had more proximal junctional kyphosis (18.4% vs. 10.0%)
- Function ($P = 0.07$) and mental health ($P = 0.27$) poorer in the UT

Is the T9, T11, or L1 the more reliable proximal level after adult lumbar or lumbosacral instrumented fusion to L5 or S1? Kim YJ et al. Spine 2007 Nov 15;32(24):2653-61.

- A clinical and radiographic assessment in addition to revision prevalence of 125 adult lumbar deformity patients
- Evaluation performed for proximal fusion levels T9–T10 (group 1, $n=37$), T11–T12 (group 2, $n=49$), and L1–L2 (group 3, $n=39$) proximal fusion levels
- Proximal junctional kyphosis
 - Group 1: 51%
 - Group 2: 55%
 - Group 3: 36% ($P=0.20$)
- Revision surgery
 - Group 1: 24%
 - Group 2: 24%
 - Group 3: 26%
- Three different proximal fusion levels did not demonstrate significant radiographic and clinical outcomes or revision prevalence after surgery
- Therefore the more distal proximal fusion level at a neutral and stable vertebra may be satisfactory

Changes in thoracic kyphosis negatively impact sagittal alignment after lumbar pedicle subtraction osteotomy: a comprehensive radiographic analysis. Lafage V et al. Spine 2012 Feb 1;37(3):E180-7.

- The unfused thoracic spine assumes a hypokyphotic posture for maximal compensation in patients with positive SVA and loss of LL
- Studies have demonstrated a progressive increase in unfused TK after lumbar PSO
- 34 adult patients (mean age = 54 years) underwent lumbar PSO with upper instrumented vertebra below T10 were included
- 5 patients were classified as "favorable reciprocal change"
 - The increase in TK countered an excessive negative SVA or decrease of PT
- 11 patients were classified as "neutral" because they exhibited a change in TK of less than 50
- 18 patients were classified as "unfavorable reciprocal change"
 - The increase in TK "led" to a postoperative SVA more than 4 cm and/or a postoperative PT more than 200
- Unfavorable RC was attributed to junctional failure in 6 of 18 patients
- Risk factors for unfavorable thoracic RC include older patients, larger preoperative PI and PT, and worse preoperative T1SPI
- Susceptibility to TL PJK is likely related to exaggerated compensatory thoracic kyphosis to offset a significant surgical correction of lumbar lordosis
- Initial compensation with loss of SVA may predispose to development of PJK
- Obese elderly females with poor bone quality may represent highest risk population for PJK
- Clinical symptoms rather than absolute reliance on imaging should drive the decision to pursue revision surgery

Prevention Strategies

- None have been definitively shown to reduce the incidence of PJK
- Prophylactic vertebroplasty
- Hooks at UIV
 - Downgoing transverse process
 - Unilateral up-going pedicle (Bridwell)

- Reduced diameter rods
- Semirigid rods
- Mersiline tape (Lenke)
- Minimally invasive screw placement approaches

Prophylactic Vertebroplasty

Use of vertebroplasty to prevent proximal junctional fractures in adult deformity surgery: a biomechanical cadaveric study. Kebaish KM et al. Spine J. 2013 Dec;13(12):1897-903.

- Prophylactic vertebroplasty at the upper instrumented level and its supra-adjacent vertebra reduced the incidence of junctional fractures after long posterior spinal instrumentation in this axially loaded cadaveric model
- Teating both UIV and UIV+1 levels, the disc cranial to the vertebroplasty level becomes part of the transitional zone, protecting the disc immediately above the construct.

PRE-MEETING COURSE

Prophylactic Vertebroplasty Proximal to Fusion Instrumentation to Prevent Proximal Junctional Problems in Osteoporotic Spine: SRS Paper #17 2009. Tezer M et al. *Spine: Affiliated Society Meeting Abstracts: 23–26 September 2009 - Volume 10 - Issue - p 63–64*

- Vertebroplasty in proximal uninstrumented segment adjacent to fusion construct was performed in 89 patients with osteoporosis
- Mean postoperative follow up was 44 months (24–72)
- The average age of the patients was 67 years (56–79)
- There were no proximal junctional segment fractures during the follow up course
- At final follow up, none of the vertebroplasty cases required revision

The Effect of Prophylactic Vertebroplasty on the Incidence of Proximal Junctional Kyphosis and Proximal Junctional Failure Following Long Posterior Fusion in Adult Spinal Deformities: A Prospective Study: SRS Paper #34. Martin CT et al. *Spine: Affiliated Society Meeting Abstracts: 2010 - Volume - Issue - p 71*

- 41 adult patients treated with long PSF who received prophylactic vertebroplasty at the upper instrumented vertebra (UIV) and supra adjacent vertebra (UIV+1)
- Average age was 65.1 yrs (41 87)
- Two failures due to PJK
- Five patients required revision for reasons other than PJK/PJF
- “Prophylactic vertebroplasty in long PSF in adult spinal deformity is a safe and effective method of minimizing the incidence of PJF/PJK”

Conclusions

- PJF should be distinguished from PJK, which is a recurrent deformity with limited clinical impact
- PJF is a significant complication following adult spinal deformity surgery with potential for neurologic injury and increased need for surgical revision
- Risk factors for proximal junctional failure include age, severity of sagittal plane deformity, and extent of operative sagittal plane realignment
- Techniques for avoiding PJF will likely require multiple refinements in perioperative and surgical strategies

Notes:

Surgical Simulation: What is Available in 2014 and How Can It Help Us Learn?

Stefan Parent, MD, PhD

Hôpital Ste-Justine, Université de Montréal

3175 Côte Ste-Catherine, Room 7904

Montreal, Quebec, Canada

H3T 1C5

Stefan.parent@umontreal.ca

INTRODUCTION

Surgical training is a long and complex process that necessitates years of observation and practice to master the basic principles to perform surgery safely. This training is usually acquired through mentoring and although this remains the most common form of training, medical schools and residency programs have proposed alternative methods to improve training programs. Malcolm Gladwell says that it takes roughly ten thousand hours of practice to achieve mastery in a field. He based this estimate by studying the lives of successful people to find out how they achieved a high level of expertise.

Surgical training not only includes learning technical skills but also the development of cognitive and clinical skills. Even the best educators and mentors in their respective fields cannot simply transfer the experience gathered through years of practice to trainees. Therefore, there exists a need for innovative methods to practice clinical decision-making without subjecting patients to unnecessary “experiments”.

Simulation systems have been proposed to replace patients for skills practice and increase the number of hours of practice trainees have before actually treating patients. Other means of increasing surgical training includes animal models and cadavers. Surgical simulation may or may not involve the use of computers. Although the cost of these alternative methods may seem high with prices ranging from about U.S. 5000\$ for laparoscopic simulators to U.S. 200,000\$ for more complex anesthesia simulators, the cost associated with traditional training is not insignificant. The cost of these alternative teaching methods must therefore be considered in the larger scope of improved [1] surgical training.

While there are several compelling reasons to use surgical simulators, none of the methods simulating training has been shown to be superior to the mentor approach.

SPINE SURGERY SIMULATOR

One such innovative method was proposed by Aubin et al. [1] and is based on the development of a spine surgery simulator. This solution is specifically tailored to spine deformity surgery and is based on a patient-specific 3D reconstruction of the spine. The biomechanical model was developed using a kinetic modeling approach based on differential equations that include the properties of the spine (stiffness, size), the constraints of the instrumentation (rod size and material, implant characteristics and geometry) and external loads applied to the spine (derotation maneuvers and sequence of spinal reduction). The patient-specific spine model is composed of rigid bodies corresponding to the thoracic, lumbar and sacral vertebrae and flexible elements representing the intervertebral structures. The spine stiffness is estimated based on the pre-operative side-

PRE-MEETING COURSE

bending radiographs. Implants (hooks, different types of screws and rods) are modeled as rigid bodies and are attached to the 3D spine model by respecting their biomechanical behavior (a multi-axial screw has more degrees of freedom than a mono axial screw).

Different spinal procedures can therefore be simulated by changing the number of implants and by modifying the points of fixation to the spine. Different implant strategies can be tested as well as different instrumentation lengths and level selection for the same patients. These can then be compared to define the optimal surgical strategy and help the surgeon or trainee to better understand the impact of the different surgical strategies on the final result.

HOW CAN THIS INFORMATION BE USED?

The Spine Surgery Simulator has been successfully used to compare different surgical strategies by 32 experienced surgeons for 5 AIS cases. [2] This study evaluated the effect of different surgical instrumentation strategies for the same patients which is only possible by using a spine surgery simulator. This study highlighted the fact that there exists a very large variability among experienced spine surgeons. These findings led to another study [3] to help determine the correction objectives of different spine surgeons for the same cases. These correction objectives significantly influenced the number of fusion levels, rod shapes and implant patterns and different correction objectives produced surgeon-specific instrumentation strategies for the same patient. By using an optimized approach, the authors reported a more effective strategy of using less screws and fusing less levels.

More recently, an evaluation of alternative screw densities was performed using the spine surgery simulator. The results showed that the lower density group achieved similar deformity correction while maintaining lower implant-vertebra loads. [4] Evaluation of actual corrective forces in spinal instrumentation showed that monoaxial screws were associated with higher extra forces when compared to multiaxial screws. The lowest extra forces were associated with a dorso-axial screw system providing 6 degrees of freedom.

Different surgical steps can also be compared using the surgical simulator to highlight specific differences between correction techniques. For example, it would be hard to imagine different methods of correction on the same patient and then compare the outcomes. With the surgical simulator, it is possible to perform the same surgery with the same implant placement and then change a specific surgical step performed by different surgeons. Vertebral derotation is such an example and the simulator was used to compare different derotation methods. The simulator was able to discern between subtle variations and propose an optimal strategy for correction of the axial plan deformity.

BRACE SIMULATOR

Our research group developed a brace simulator over the years. [5-11] This simulator is helpful as it can test several brace configurations for the same patient prior to making the brace. This brace simulator adds a reconstruction of the chest cage and uses this information to optimize the design of braces. This simulator has led to better brace design with lighter braces (under evaluation currently).

GROWTH MODULATION

An adaptation of the Spine Simulator can be used to evaluate growth modulation implants and future developments before testing them in animals. The growth modulation model adds a personalized growth parameter to the personalized 3D model of the spine and modulates growth according to growth plate reactive forces following Hueter-Volkman law. This helps researchers evaluate growth modulation implants and techniques prior to animal testing thus decreasing the cost of implant development. The personalized model is further adapted to reflect actual curve progression as observed in an actual patient. This technique has led to a rapid cycle of new implant development and testing.

CONCLUSION

Spinal deformity surgery is a very complex specialty that could benefit from the use of surgical simulation to optimize surgical strategy and better predict outcome. The use of surgical simulation can be useful in assessing the loads created at the implant-bone interface and in the surgical construct. Moreover, surgical strategy can be tailored to surgeon specific correction objectives for a specific patient based on this personalized simulation approach.

Selected References

1. Aubin, C.-E., et al., *Preoperative planning simulator for spinal deformity surgeries*. Spine, 2008. **33**(20): p. 2143-2152.
2. Robitaille, M., C.-E. Aubin, and H. Labelle, *Effects of alternative instrumentation strategies in adolescent idiopathic scoliosis: a biomechanical analysis*. Journal of orthopaedic research : official publication of the Orthopaedic Research Society, 2009. **27**(1): p. 104-113.
3. Majdouline, Y., et al., *Scoliosis correction objectives in adolescent idiopathic scoliosis*. Journal of pediatric orthopedics, 2007. **27**(7): p. 775-781.
4. Wang, X., et al., *Biomechanical comparison of alternative densities of pedicle screws for the treatment of adolescent idiopathic scoliosis*. European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society, 2011.
5. Clin, J., C.-E. Aubin, and H. Labelle, *Virtual prototyping of a brace design for the correction of scoliotic deformities*. Medical & biological engineering & computing, 2007. **45**(5): p. 467-473.
6. Clin, J., et al., *A new method to include the gravitational forces in a finite element model of the scoliotic spine*. Medical & biological engineering & computing, 2011. **49**(8): p. 967-977.
7. Clin, J., et al., *A biomechanical study of the Charleston brace for the treatment of scoliosis*. Spine, 2010. **35**(19): p. E940-7.
8. Clin, J., et al., *Biomechanical modeling of brace treatment of scoliosis: effects of gravitational loads*. Medical & biological engineering & computing, 2011.
9. Clin, J., et al., *Biomechanical modeling of brace design*. Studies in health technology and informatics, 2006. **123**: p. 255-260.

PRE-MEETING COURSE

10. Clin, J., et al., *Comparison of the biomechanical 3D efficiency of different brace designs for the treatment of scoliosis using a finite element model.* European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society, 2010. **19**(7): p. 1169-1178.
11. Clin, J., et al., *Correlation between immediate in-brace correction and biomechanical effectiveness of brace treatment in adolescent idiopathic scoliosis.* Spine, 2010. **35**(18): p. 1706-1713.

Notes:

Quality, Safety and Value: The Adult Spine Surgery Initiatives and What Can We Learn

Sigurd H. Berven, MD
 Professor in Residence
 Department of Orthopaedic Surgery
 UC San Francisco
 San Francisco, California, USA

I) Value-based Healthcare

In a healthcare economy with limited resources, providers and consumers of healthcare services need to be accountable for the end result of care, and the cost of care. The value proposition in healthcare is an analysis of the benefits of care relative to the direct cost and risk of providing the care. Measurement of benefits and costs is challenging, and a consensus on the measures that encompass the relevant components of the value equation has not been reached.

- Measuring Outcomes:

Clinical outcome is the end result of health care delivered to patients or populations. Measuring clinical outcomes may include metrics for quality of care, patient-centered assessment of health status, and costs and risks of providing care. Traditional outcome measures in adult spine surgery including fusion rates, complication rates, and radiographic outcomes do not adequately reflect the patient’s healthcare experience. Patient-centered outcomes are the most useful and measurement of the impact of an intervention on health-related quality of life.

The utility score is a measure of health status preference that is useful in providing a patient-centered measure of health with a value component—the quality-adjusted life year.

- Measuring Cost and Risk:

Measuring cost of care is complex, and may encompass both direct costs of treatment and alternative treatments, and indirect costs including time from work or family role, loss of productivity, and cost of caretakers. Costs of care in adult spine surgery are variable, and determinants of cost of care include the underlying diagnosis type for surgery, length of surgical construct, and surgical strategy.¹ Complications of care and risk of care are important components of the cost numerator in the value equation. Complications in adult spinal deformity are reported variably, and the cost of complications including reoperation and readmission comprise a significant portion of the total cost of care in adult spine surgery.

The total hospital costs of adult scoliosis surgery average over \$120,000, and operating room costs including implants comprise the majority of the total cost of care. Reoperations increase the costs of care by 70%, and are a significant burden in the total cost of care for adult scoliosis.²

There is no single measure or dashboard that summarizes the cost and risk of care, and quality metrics that measure complications may provide a myopic perspective without including consideration of outcome.

Perspectives on Cost:	
Hospital perspective-	Episode of care during inpatient length of stay/90 days
Payor perspective-	Episode of care during duration of coverage
Physician/Patient Perspective	Episode of care is the lifetime of the patient

II) The Value Equation

The right goal for healthcare delivery is superior patient value.³ Patient value is measured at the level of specific medical conditions. Measurement of outcomes of care needs to reflect the patient’s long-term healthcare experience, and the impact of one intervention compared with alternatives on the patients self-assessment of health-related quality of life. The value equation in healthcare is an analysis of the benefits of care relative to the direct cost and risk of providing the care

$$\text{Value} = \text{Fxn}(\text{Benefit}/\text{Cost})$$

The value equation may vary depending on the perspective of the stakeholder in the healthcare economy. Hospitals and facilities providing care may measure outcome and costs by factors that affect their short-term, single admission interaction, including length of stay, implant utilization, and complications. Third party payors for healthcare may focus on a timeframe that is longer than a single admission, and may include factors in the value equation such as readmission within 90 days, or cost of outpatient care.

Patients, physicians, and society consider value over a lifetime. The cost of a single episode of care will be significantly discounted by the duration

PRE-MEETING COURSE

of the benefit. Patient preference for different health states over time offer the most useful measure of value of healthcare interventions.

III Measurements of Quality, Safety and Value

Hospitals and payors for healthcare have established measures of quality that may be misinterpreted as measures of outcome or value. Length of stay, surgical times, compliance with antibiotic or thromboembolic prophylaxis, and perioperative complications are process measures that may be useful to compare hospital and provider performance when appropriately matched and stratified. However, none of these process measures are useful in measuring the patient's healthcare experience, or the impact of an orthopaedic intervention on long-term health-related quality of life. In fact, a focus on quality and process measures alone may be misleading in the pursuit of value in healthcare, and may provide incentive for counterproductive care strategies that serve the measurement system rather than the patient.

The priority of the patient's self assessment of the impact of healthcare on their long-term health status requires emphasis, and efforts to substitute process measures for health status measures need to be avoided in the pursuit of a value-based healthcare system.⁴

III) Disease-specific measures of Outcome-

a. In Adult Spine Surgery, patient self-assessment of health status and quality of life may include disease-specific measures, and general health status measures.

i. Disease-specific measures are useful to optimize responsiveness to change, and psychometric properties.

a. ODI

b. SRS-22

ii. General health status outcome tools are useful in providing a measure of outcome that may be translatable across a spectrum of medical and surgical conditions.

a. SF-36

b. Utility Scores

i. EQ5D

ii. HUI

iii. SF6D

IV) An introduction to Utility scores

a. Health-related quality of life may be measured and ranked by a community preference, or societal preference, for various health state. Generic indices to reflect preference-based health-related quality of life include:

a. EuroQol –Dimension (EQ-5D)

i. Developed using time trade off

b. Short Form 6-D

i. Developed using standard gamble

c. Health Utilities Index

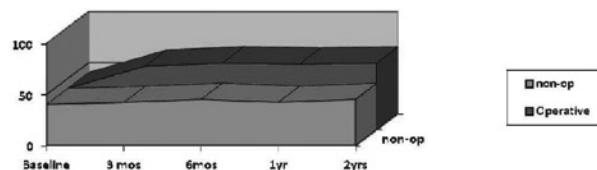
i. Developed using standard gamble

d. Quality of Well-being Scale- Self-Administered Form (QWB-SA)

i. Developed using VAS valuation

b. Quality-Adjusted Life Year:

The area under the time utility curve represents the value of an intervention in units of Quality-adjusted life years (QALYs)



V) Crosslinking Disease-specific measures and Utility Scores

Disease-specific measures in spine surgery have the advantage of increased responsiveness to change and better psychometrics, including floor and ceiling effects, than general health status measures. Therefore, validated disease-specific measures have utility in outcome analysis. The SRS-22 has been validated as a consistent measurement for assessment of patient-based health status in adult spinal deformity.⁵ The SRS-22 has better responsiveness and psychometric parameters than alternative measures including the SF-12.⁶

A valid translation or cross-linking of disease-specific measures and utility scores may be useful in applying disease-specific measures.

Transformations of the ODI and the SRS-22 to utility scores have been presented.^{7,8}

VI) Threshold for cost effectiveness in medical and surgical care

a. Measure of \$/QALY permit a comparison of the cost-effectiveness of healthcare alternatives that may be useful in public policy decision-making regarding allocation of care

b. Establishing a threshold for cost-effectiveness of medical and surgical interventions requires a consideration of a society's willingness to pay for healthcare interventions.

c. Thresholds may differ based upon age considerations of the population under care, and upon patient preferences for care.

d. Adult deformity and adult spinal conditions have an impact on health status that is comparable with other common medical conditions.⁹

VII) Applying Cost and Value considerations in Adult Spine Surgery Initiatives

Adult Spine Surgery initiatives for Spinal Deformity include considerations of safety and quality of care. Complications of spinal surgery in adult deformity are common and significant. The significance of complications includes compromise in health status, including long term compromise, and increase in the cost of care.^{10,11} Improvement of safety through reduction of complications is an important quality goal, and a priority of adult spine surgery initiatives.

The value of surgery for adults with spinal deformity is an important consideration in defining the role of adult deformity surgery in a value-based healthcare economy. Adults with spinal disorders self-report significant reductions in HRQOL compared with other common medical conditions. Surgery for spinal disorders incurs significant direct costs as well as costs and risks from complications of care. An understanding of the

PRE-MEETING COURSE

value of operative care for spinal disorders requires information on costs of care, and change in quality of life for patients treated non-operatively compared with patients treated operatively.

The duration of improvement in HRQOL is an important factor in determining the value of an operative intervention. Revision surgery is a significant expense that may importantly compromise the value of the index procedure. Strategies to optimize value in orthopaedic surgery include reducing the cost of the initial episode of care, improving the change in QALYs, and improving the durability of the outcome.

Analysis of the Incremental Cost-effectiveness for Adult Scoliosis demonstrates that surgical care for adult scoliosis may be cost-effective compared with non-operative care if the durability of the outcome is greater than 10 years.¹²

A focus on the value of care is an important priority for future initiatives in adult spinal deformity. Value of care in adult spinal deformity may be improved through awareness of cost contributors, critical assessment of the incremental impact of new technologies and devices on the outcome and cost of care, improving the durability of care, and minimizing complications including readmissions and reoperations. Surgery for adult spinal deformity has a significant and measurable impact on health related quality of life. Demonstrating that improvement in health status can be durable and affordable is an important priority for preserving access to spine care for our patients with adult deformity.

(Endnotes)

- 1 McCarthy IM, Hostin RA, O'Brien MF, Fleming NS, Ogola G, Kudyakov R, Richter KM, Saigal R, Berven SH, Ames CP; International Spine Study Group: Analysis of the direct cost of surgery for four diagnostic categories of adult spinal deformity. *Spine J.* 2013 Dec;13(12):1843-8
- 2 McCarthy IM, Hostin RA, Ames CP, Kim HJ, Smith JP, Boachie-Adjei O, Schwab FJ, Klineberg EO, Shaffrey CI, Gupta MC, Polly DW; International Spine Study Group: Total hospital costs of surgical treatment for adult spinal deformity: an extended follow-up study. *Spine J.* 2014 Jan 24
- 3 Porter ME, Teisberg EO: *Redefining Health Care. Creating Value-based competition on results.* Harvard Business School Press, 2006.
- 4 Berven S, Smith A, Bozic K, Bradford DS: Pay-for-performance: considerations in application to the management of spinal disorders. *Spine (Phila Pa 1976).* 2007 May 15;32(11 Suppl):S33-8.
- 5 Berven S, Deviren V, Demir-Deviren S, Hu SS, Bradford DS: Studies in the modified Scoliosis Research Society Outcomes Instrument in adults: validation, reliability, and discriminatory capacity. *Spine (Phila Pa 1976).* 2003 Sep 15;28(18):2164-9;
- 6 Bridwell KH, Cats-Baril W, Harrast J, Berven S, Glassman S, Farcy JP, Horton WC, Lenke LG, Baldus C, Radake T. The validity of the SRS-22 instrument in an adult spinal deformity population compared with the Oswestry and SF-12: a study of response distribution, concurrent validity, internal consistency, and reliability. *Spine (Phila Pa 1976).* 2005 Feb 15;30(4):455-61.
- 7 Carreon LY, Glassman SD, McDonough CM, Rampersaud R, Berven S, Shainline M: Predicting SF-6D utility scores from the Oswestry disability index and numeric rating scales for back and leg pain. *Spine (Phila Pa 1976).* 2009 Sep 1;34(19):2085-9.
- 8 Berven S, Richardson S, Hu SS: Translation of the SRS-22 to Utility Score. . Scoliosis Research Society 46th Annual Meeting & Course, Louisville, KY. Sept. 14-17, 2011.
- 9 Fu KM, Bess S, Shaffrey CI, Smith JS, Lafage V, Schwab F, Burton DC, Akbarnia BA, Ames CP, Boachie-Adjei O, Deverin V, Hart RA, Hostin R, Klineberg E, Gupta M, Kebaish K, Mundis G, Mummaneni PV; International Spine Study Group: Patients with adult spinal deformity treated operatively report greater baseline pain and disability than patients treated nonoperatively; however, deformities differ between age groups. *Spine (Phila Pa 1976).* 2014 Aug 1;39(17):1401-7
- 10 Glassman SD, Hamill CL, Bridwell KH, Schwab FJ, Dimar JR, Lowe TG: The impact of perioperative complications on clinical outcome in adult deformity surgery. *Spine (Phila Pa 1976).* 2007 Nov 15;32(24):2764-70.
- 11 Hellsten EK, Hanbidge MA, Manos AN, Lewis SJ, Massicotte EM, Fehlings MG, Coyte PC, Rampersaud YR: An economic evaluation of perioperative adverse events associated with spinal surgery. *Spine J.* 2013 Jan;13(1):44-53
- 12 McCarthy I, O'Brien M, Ames C, Robinson C, Errico T, Polly DW Jr, Hostin R; International Spine Study Group: Incremental cost-effectiveness of adult spinal deformity surgery: observed quality-adjusted life years with surgery compared with predicted quality-adjusted life years without surgery. *Neurosurg Focus.* 2014 May;36(5):E3.

Notes:

Quality, Safety and Value: The Pediatric Spine Surgery Initiatives and What We Learn

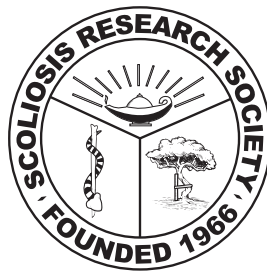
Michael G. Vitale, MD, MPH

Please reference addendum for course listing.

PRE-MEETING COURSE

PRE-MEETING COURSE

AFTERNOON SESSION II HOW WE LEARN: MENTORS, MENTEES AND REVERSE MENTORING



Moderators:

Kit M. Song, MD, MHA & Muharrem Yazici, MD

Faculty:

Keith H. Bridwell, MD; Jacob M. Buchowski, MD, MS; Michelle S. Caird, MD; John B. Emans, MD; Frances A. Farley, MD; Adrian C. Gardner, FRCS; Hamid Hassanzadeh, MD; Daniel Hedequist, MD; Robert N. Hensinger, MD; Charles E. Johnston, MD; Khaled Kebaish, MD; Michael P. Kelly, MD; John Kostuik, MD, FRCSC; David S. Marks, FRCS; Peter O. Newton, MD; Brandon A. Ramo, MD; Alistair G. Thompson, FRCS

PRE-MEETING COURSE

The Current Management of High Grade Spondylolisthesis in Birmingham UK
Adrian Gardner, BM, MRCS, FRCS, (Tr&Orth)
Consultant Spinal Surgeon Royal Orthopaedic Hospital
Birmingham, United Kingdom

This presentation describes the current management of high grade spondylolisthesis in Birmingham UK and will be followed by a description of how and why this is the treatment of choice in our unit.

Initial management with staged posterior instrumentation to the pelvis with autologous fibula grafting in an anterior to posterior direction with a posterior fusion not inclusive of most proximal level. After confirmation of fusion removal of iliac bolts and shortening of the length of instrumentation was performed for the final construct.

A subsequent case with this plan was performed but there was a pseudarthrosis of the fibula graft at the sacrum. This was revealed with pain when an iliac bolt broke. The revision was performed using hollow threaded cages packed with autologous iliac crest and BMP with S2AI screws.

The hollow cage has been used in an anterior to posterior direction to revise a non-union of a high grade spondylolisthesis crisis.

Notes:

High-Grade Spondylolisthesis Reduction – Learning from Our Mentors and Teaching our Trainees
David S. Marks FRCS, FRCS(Orth)
Consultant Orthopaedic Spine Surgeon to The Royal Orthopaedic Hospital & The Birmingham Children’s Hospital
Birmingham, United Kingdom

This section of the discussion will focus on the evolution of treatment for high grade spondylolisthesis at the Royal Orthopaedic Hospital following the introduction of pedicle screw systems and the rise of anterior surgery

The author will follow on from his Mentor, an Emeritus Fellow of the Society, to show the ways in which the concepts of treatment he learnt were developed further, in Fellowship and then on return to take up a full time practice.

Areas discussed include the reasons behind the introduction of pedicle screws (following fellowships in USA and Germany) together with the move to increasingly radical L5 vertebral resection and the concepts of ‘complete’ spondyloptosis reduction.

The issues of outcomes and complications will be aired The decision to return to a less aggressive mode of treatment, especially with respect to reduction, will be introduced. The evolution of learning will be emphasised.

This talk will lead to the establishment of our current practice – which will be presented by a colleague and Candidate Fellow who has trained both at our unit and in Fellowship in the UK.

Areas discussed:

- Pedicle Screw systems
- Neurophysiological monitoring
- Anterior L5 vertebrectomy
- Complications

Notes:

PRE-MEETING COURSE

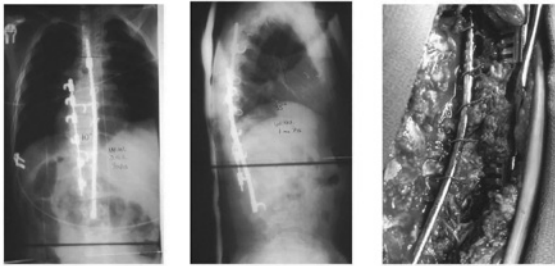
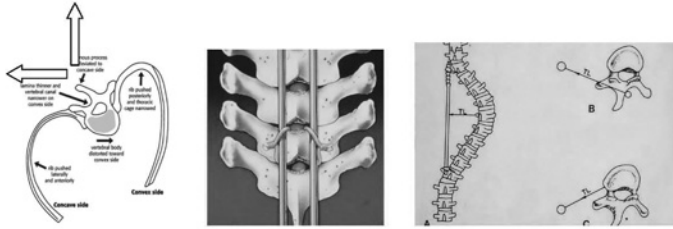
Restoration of Sagittal Plane in Lordoscoliosis

Charles E. Johnston, MD
Assistant Chief of Staff
Texas Scottish Rite Hospital
Dallas, Texas, USA

Historical Perspective - "Pre-Newton" era

A. Pre- 1985 : Concave distraction rod with sublaminar or transverse process wires (White/Punjabi)

Translation of apical segments dorsally and toward concavity

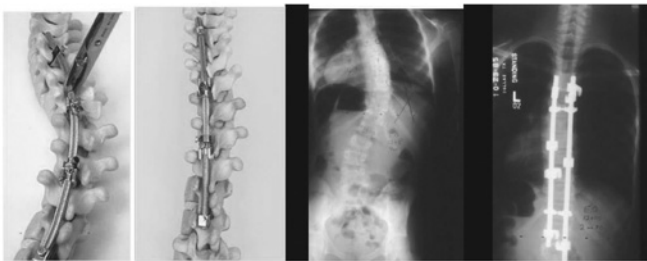


Drawbacks: 1. Neurologic risk (sublaminar)
2. Difficult revision (canal intrusion, dural scar)

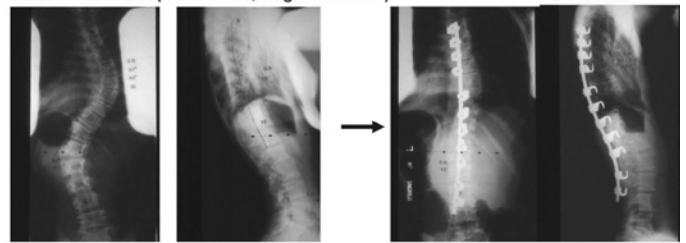
B. 1985 → mid 90's – Cotrel-Dubousset

C- Principle : convert coronal plane deformity (lordoscoliosis) into sagittal plane normality by rotating pre-contoured rod w/apical distraction

"Classic" C-D (8 hooks, 2 DTT)



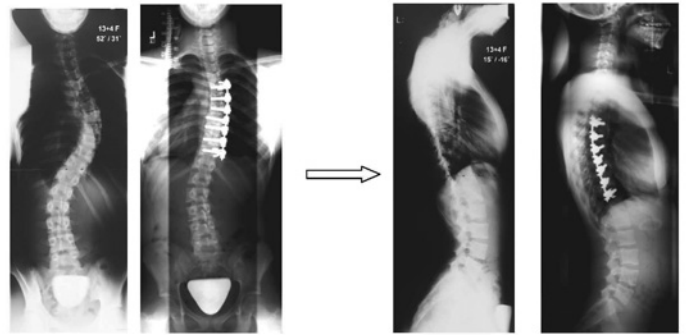
TSRH modification (more hooks, single stiffer rod)



Drawbacks : 1. hooks (canal intrusion, stability);
2. Difficult revision/removal (C-D)
3. Rod rotation slipping ;
4. ? true apical derotation ;
5. Coronal imbalance after selective Th fusions (necessity of under-correcting MT curve)

C. 1990's anterior thoracic instrumentation

(open → thoracoscopic) Principle: compression from convexity (e.g. threaded rod) after discectomy → coronal correction + kyphosis in instrumented segment



Drawbacks: 1. Open: perceived excessive chest wall incursion (PFT's)
2. Thoracoscopic: excessive technical difficulty, length of surgery
3. Both: higher pseudo rate, instrument failure
4. TPS era/ Posterior only takes over

Anterior still utilized by a few practitioners (e.g. Newton)

D. Late 90's Thoracic pedicle screw instrumentation – Suk , Lenke

The rest is recent history – see Newton handout

Notes:

PRE-MEETING COURSE

Junctional Kyphosis: Prevention and Treatment

John P. Kostuik, MD
Phoenix, Arizona, USA

Proximal Junctional Kyphosis (PJK) was essentially unknown when I began practice in 1967. During the Harrington rod era, I performed numerous Harrington instrumentations on older female patients many of whom had osteopenia or osteoporosis but do not recall any cases of PJK. Caudal disc degeneration was common when the fusion extended distally to L3- L5.

With the advent of more rigid segmental fixation with the use of sub laminar wires cases of PJK began to appear. The advent of the use of pedicle screws in the MIS 1980's saw a further increase, likely due to two factors; increasing construct rigidity and increasing numbers of older females being operated upon. Today PJK is endemic.

In 2006 in a paper published with Dr. Kebaish we found an incidence of PJK of 16%. All patients were female over age 60, all with osteoporosis. The incidence was 50% greater with the use of hooks proximally, a fact which has since been disputed.

In the early 1990's I began to prophylactically use PMMA at one or two levels proximal to the fusion in order to prevent the development of vertebral body fracture. Subsequent studies have shown this to be a valuable tool in helping to prevent PJK. Several examples will be illustrated.

Notes:

Deciding When to Initiate Surgical Treatment for Early Onset Deformity

John B. Emans, MD
Children's Hospital, Harvard Medical School
Boston, Massachusetts, USA

Daniel Hedequist, MD
Children's Hospital, Harvard Medical School
Boston, Massachusetts, USA

Deciding when to initiate surgical treatment for early onset deformity:

- a) EOS decision-making dilemmas:
 - i) When to intervene in EOS? (assuming growth friendly, distraction-based treatment)
 - (1) Earlier first surgery:
 - (a) Better chance for spine and chest and lung growth
 - (b) Smaller deformity
 - (c) Operation easier?
 - (d) More operations (lengthenings)
 - (e) Greater chance of complications, including early growth-stopping complications like spontaneous fusion
 - (2) Later first surgery:
 - (a) Larger structures
 - (b) Operation easier?
 - (c) Less surgery, fewer complications. If spontaneous fusion may occur closer to maturity
 - (d) Deformity, particularly thoracic deformity may become irrevocably worse
 - (3) Chest-based decision algorithm:
 - (a) Base decision about when to intervene more on magnitude of thoracic deformity rather than magnitude of spine deformity
 - (b) If in doubt, intervene before thoracic deformity too severe, since none of our techniques good at correcting thoracic deformity
 - (c) Otherwise consider delaying surgical intervention, since earlier intervention may = earlier complications
 - b) Caveat: MAGEC may change all this if it proves to have fewer complications and less early spontaneous fusion.

Notes:

PRE-MEETING COURSE

Vertebral Column Resection

Jacob M. Buchowski, MD, MS

Professor of Orthopaedic and Neurological Surgery

Washington University in St. Louis

St. Louis, Missouri, USA

- 1) Spectrum of Amount of Bone Resection
 - a) Facetectomy
 - b) PCO
 - c) PSO
 - d) Extended PSO
 - e) VCR
- 2) Why Posterior VCR?
 - a) With severe angular deformity posterior access is facilitated while anterior access is limited
 - b) Indicated for severe and stiff deformities
 - i) Sagittal plane
 - ii) Coronal plane
 - iii) Both
- 3) Advantages of PVCR
 - a) Single approach
 - b) Surgeon familiarity with posterior anatomy
 - c) Circumferential access to neural elements
 - d) More correction
 - e) More control during correction
 - f) Decreased operative time than A/P reconstruction
 - g) Less morbidity in patients with compromised pulmonary function
- 4) Indications for VCR
 - a) Sagittal Deformities
 - i) Severe kyphosis
 - ii) Angular kyphosis
 - iii) Post-traumatic kyphosis/deformity
 - iv) Post-infectious deformity
 - b) Coronal deformities
 - i) Severe rigid scoliosis
 - ii) Congenital scoliosis
 - iii) Residual/increasing scoliosis following surgery
 - iv) i.e. crankshaft
- 5) Advances Making PVCR Possible and Safer
 - a) Improved instrumentation
 - i) Segmental pedicle screw instrumentation
 - ii) Iliac fixation
 - iii) Intervertebral cages
 - iv) Dominoes allowing use of multiple rods
 - (1) No implant failure in our experience with 3 or 4 rods
 - b) Improved SCM
 - i) SSEP/DNEP/tcMEP/EMG
 - ii) Can potentially identify problems prior to development of a neurologic deficit
 - c) Improved bone grafting and use of biologics to fusion rates
- 6) How to Prevent Complications
 - a) Combined motor (MEP or DNEP) and SSEP monitoring for every case
 - b) If monitoring is lost:
 - i) Raise MAPs >90
 - ii) Ensure adequate hematocrit
 - iii) Ease correction
 - c) Must have adequate number of fixation points above and below PVCR
 - i) At least 4 or 6 points of fixation above and below planned VCR site
 - d) Place temporary rods prior to vertebral resection or laminectomy
 - i) Prevents sudden subluxation of spine
 - e) Perform a wide laminectomy
 - i) From inferior aspect of pedicles one level above VCR to superior aspect of pedicles one level below
 - ii) Leaves dura decompressed following osteotomy closure
 - f) Avoid overcompression/shortening of spinal column
 - i) Use an intervertebral cage at VCR site
 - ii) Shortening may cause kinking of vascular supply to spinal cord
 - iii) If SCM data during compression, may need to distract open osteotomy site and use a larger cage
- 7) Prerequisite Skills Needed to Safely Perform a VCR
 - a) Placement of instrumentation in severe curves
 - b) Lumbar & TL PSOs
 - c) Hemivertebra excision
 - d) PLIFs and TLIFs
 - e) Handling neural elements and scarred dura
- 8) Before performing VCR for deformity, best to start with VCR's for:
 - a) Tumor
 - b) Infection
 - c) Trauma
 - d) Hemivertebra excision
- 9) Conclusions
 - a) Posterior VCR is a valuable tool in adult deformity surgery particularly in correction of angular kyphosis and kyphoscoliosis
 - b) Avoids additional morbidity of an anterior approach
 - c) Allows better correction of rigid deformities
 - i) Can expect > 50% correction rates for sagittal & coronal curves
 - d) Generally results in good outcome, but there is a high complication rate
 - e) Can be technically challenging, but careful technique prevents catastrophic spinal cord injuries
- 10) Case Example

PRE-MEETING COURSE

11) References

- a) Leatherman KD. The management of rigid spinal curves. *Clin Orthop Relat Res* 1973;215-24.
- b) Boachie-Adjei O, Bradford DS. Vertebral column resection and arthrodesis for complex spinal deformities. *J Spinal Disord* 1991;4:193-202.
- c) Bradford DS, Tribus CB. Vertebral column resection for the treatment of rigid coronal decompensation. *Spine (Phila Pa 1976)* 1997;22:1590-9.
- d) Suk SI, Kim JH, Kim WJ, et al. Posterior vertebral column resection for severe spinal deformities. *Spine (Phila Pa 1976)* 2002;27:2374-82.
- e) Suk SI, Chung ER, Lee SM, et al. Posterior vertebral column resection in fixed lumbosacral deformity. *Spine (Phila Pa 1976)* 2005;30:E703-10.
- f) Suk SI, Chung ER, Kim JH, et al. Posterior vertebral column resection for severe rigid scoliosis. *Spine (Phila Pa 1976)* 2005;30:1682-7.
- g) Lenke LG, O'Leary PT, Bridwell KH, et al. Posterior vertebral column resection for severe pediatric deformity: minimum two-year follow-up of thirty-five consecutive patients. *Spine (Phila Pa 1976)* 2009;34:2213-21.
- h) Lenke LG, Sides BA, Koester LA, et al. Vertebral column resection for the treatment of severe spinal deformity. *Clin Orthop Relat Res* 468:687-99.
- i) Auerbach JD et al. Major Complications and Comparison between 3-Column Osteotomy Techniques in 105 Consecutive Spinal Deformity Procedures: SRS 2009 Paper #68. *Spine* 2012. [Epub ahead of print].
- j) Pelosi L, Lamb J, Grevitt M, et al. Combined monitoring of motor and somatosensory evoked potentials in orthopaedic spinal surgery. *Clin Neurophysiol* 2002;113:1082-91.
- k) Hyun SJ, Rhim SC, Kang JK, et al. Combined motor- and somatosensory-evoked potential monitoring for spine and spinal cord surgery: correlation of clinical and neurophysiological data in 85 consecutive procedures. *Spinal Cord* 2009;47:616-22.

Notes:

How We Learn: Mentors, Mentees and Reverse Mentoring Modern Treatment in Congenital Cervicothoracic Scoliosis

Michelle S. Caird MD, Frances A. Farley MD, Robert N. Hensinger MD
Department of Orthopaedic Surgery
University of Michigan
Ann Arbor, Michigan, USA

I. BACKGROUND

A. Etiology

- 1. Failure of formation
- 2. Failure of segmentation

B. Presentation

- 1. Head tilt
- 2. Torticollis
- 3. Asymmetric shoulders (Sprengel's Deformity)
- 4. Limited neck motion

C. Work up

- 1. Plain radiographs, CT, MRI spinal column
- 2. Renal ultrasound
- 3. Dynamic flexion-extension

D. Associated Anomalies

- 1. Other vertebral anomalies
- 2. Spinal cord anomalies
- 3. Scapular abnormalities
- 4. Renal anomalies
- 5. Auditory defects

II. NON-SURGICAL TREATMENT AND NATURAL HISTORY

A. Results in cervical tilt – can be severe

B. Pain uncommon early, neck pain can develop with age/progression (Instability?)

C. Progression rates depend on congenital anomalies present (McMaster)

D. Bracing???

III. SURGICAL TREATMENT

A. Indications and Treatment points

- 1. Severe decompensating curve
- 2. Proven progression
- 3. Curve with bad prognosis (unilateral bar with contralateral hemivert)
- 4. Remember: Early recognition of progressive patterns is critical
- 5. Remember: Neuromonitoring required
- 6. Remember: Missing posterior elements for dissection
- 7. Remember: Preoperative halo traction may be helpful

B. Posterior Spinal Fusion insitu à gradual correction with Halo and casts

- 1. Relative neurologic safety
- 2. Early fusion – decreased pulmonary function??
- 3. Incomplete correction of large deformity
- 4. MRIa – pre op (vertebral artery)
- 5. Pseudoarthrosis
- 6. Cast/brace-wear troubles

PRE-MEETING COURSE

- C. Hemivertebra resection (Ruf and Harms)
 - 1. Improved deformity correction
 - 2. Increased risk of neurological and vascular injury
- D. VEPTR opening wedge thoracostomy (standard midthoracic) (Campbell)
 - 1. Stabilized cervical tilt and improved head/trunk decompensation
 - 2. Avoids early fusion
 - 3. Multiple procedures
- E. Distraction-based instrumentation (Skaggs)
 - 1. Improved deformity correction
 - 2. Avoids early fusion
 - 3. High thoracic hooks risk to brachial plexus (neuromonitoring needed)
 - 4. Multiple procedures

- N. Winter RB, Moe JH, Lonstein JE. Posterior spinal arthrodesis for congenital scoliosis: an analysis of the cases of two hundred and ninety patients, five to nineteen years old. *J Bone Joint Surg Am.* 1984;66A:1188-97.
- O. Winter RB, Moe JH, Lonstein JE. The incidence of Klippel-Feil syndrome in patients with congenital scoliosis and kyphosis. *Spine.* 1984;9:363-366.
- P. Zheng CK, Kan WS, Li P, et al. Treatment for severe idiopathic upper thoracic scoliosis in adolescence. *Spinal Disord Tech* 2013;26:107-111.

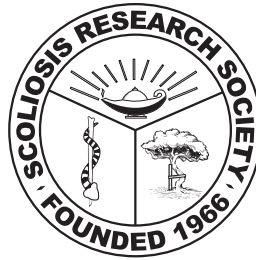
IV. REFERENCES

- A. Andras L, Tobin R, Skaggs DL. Congenital cervicothoracic scoliosis treated with hemiepiphysiodesis and placement of distraction-based instrumentation: A case report. *JBJS Case Connect.* 2013;3:e56.
- B. Bess S, Akbarnia BA, Thompson GH, et al. Complications of growing-rod treatment for early-onset scoliosis: analysis of one hundred and forty patients. *J Bone Joint Surg Am.* 2010;92A:2533-43.
- C. Campbell RM, Adcox BM, Smith MD, et al. The effect of mid-thoracic VEPTR opening wedge thoracostomy on cervical tilt associated with congenital thoracic scoliosis in patients with thoracic insufficiency syndrome. *Spine.* 2007;32:2171-2177.
- D. Farley FA, Hall J, Goldstein SA. Characteristics of congenital scoliosis in a mouse model. *J Pediatr Orthop.* 2006;26:341-6.
- E. Guille JT, Sherk HH. Current Concepts Review: Congenital osseous anomalies of the upper and lower cervical spine in children. *J Bone Joint Surg Am.* 2002;84A:277-288.
- F. Hensinger RN, Lange JE, MacEwen GD. Klippel-Feil syndrome: a consolidation of associated anomalies. *J Bone Joint Surg Am.* 1984;56A:1246-1253.
- G. Hensinger RN. Osseous anomalies of the craniovertebral junction. *Spine.* 1986;12:323-333.
- H. Karol LA. Early definitive spinal fusion in young children: what we have learned. *Clin Orthop Relat Res.* 2011;469:1323-29.
- I. McMaster MJ, Ohtsuka K. The natural history of congenital scoliosis: A study of two hundred and fifty-one patients. *J Bone Joint Surg Am.* 1982;64A:1128-47.
- J. Ruf M, Jensen R, Harms J. Hemivertebra resection in the cervical spine. *Spine.* 2005;30:380-385.
- K. Samartzis D, Kalluri P, Herman J, et al. Cervical scoliosis in the Klippel-Feil patient. *Spine.* 2011;36:E1501-1508.
- L. Smith MD. Congenital scoliosis of the cervical or cervicothoracic spine. *Orthop Clin North Am.* 1994;25:301-310.
- M. Winter RB. Convex anterior and posterior hemi-arthrodesis and hemiepiphysiodesis in young children with progressive congenital scoliosis. *J Pediatr Orthop* 1981;1:361-366.

Case Discussion & Educational Program

Case Discussion & Educational Program





The Scoliosis Research Society gratefully acknowledges K2M for their support of the E-Poster CD-Rom, E-Poster Kiosks, Internet Kiosks and Message Board.



COMPLEX SPINE
INNOVATIONS™



CASE DISCUSSION PROGRAM

WEDNESDAY, SEPTEMBER 10, 2014

4:45 – 5:45 PM

These sessions are open to all Annual Meeting delegates. Pre-registration is not required and no additional fee applies.

The Case Discussion sessions allow an opportunity to present unique and challenging clinical cases to the SRS with a panel of experts present to review and discuss each case and the clinical issues that are highlighted, as well as answer questions from audience participants. The panels will also prepare case studies for presentation and discussion, as time allows. All of the following Case Discussion presentations were selected from those submitted through the abstract submission and review process.

Case Discussion #1: Adolescent Scoliosis Surgery

ROOM: KAHTNU 1

Moderators: John M. Flynn, MD & James F. Mooney, III, MD

Cases for Discussion:

1A. Posterior Release, Temporary Internal Distraction Using the Magnetic Rod and Definitive Posterior Fusion for Severe Idiopathic Kyphoscoliosis in a 13-Year-Old AIS Patient

Heiko Koller, MD; Michael Mayer, PhD; Axel Hempling; Luis Ferraris, MD; Oliver Meier, MD

1B. Tension Pneumothorax as a Complication of Inadvertent Pleural Tears during Posterior Spinal Surgery

Stephen J. Lewis, MD; Sam Keshen; Noah D. Lewis; Taylor E. Dear; Arne Mehrkens, MD; Ahtsham U. Niazi, FRCPC

1C. Cardiac Tamponade following Posterior Spinal Fusion in a Patient with Severe Scoliosis

Burt Yaszay, MD; Carrie E. Bartley, MA; Peter O. Newton, MD

1D. Modified T4 Hemivertebrectomy for Persistent High Left Shoulder following Surgery for Double Thoracic Scoliosis

Stephen J. Lewis, MD; Noah D. Lewis; Sam Keshen; Taylor E. Dear

Case Discussion #2: Cervical, Congenital and Neuromuscular Deformity

ROOM: KAHTNU 2

Moderators: Michael T. Hresko, MD & David L. Skaggs, MD

Cases for Discussion:

2A. Severe Cervical Kyphosis and Spondyloptosis in Larsen Syndrome with Progressive Myelopathy Ameliorated with Decompression and Fusion: A Report of Two Cases

Joshua M. Pahys, MD; Patrick J. Cahill, MD; Jahangir Asghar, MD; Randal R. Betz, MD; Amer F. Samdani, MD

2B. The Role of Instrumented Fusion in the High Cervical Area in Young Children: A Mini Series

Pedro M. Fernandes, Licenciature; Dezsoe J. Jeszenszky, MD, PhD

2C. Optimal Blood Conservation Strategies can Prevent Blood Transfusion in Jehovah's Witness Myelomenigocele Patient with Severe Deformity

Preethi M. Kulkarni, MD; Marina Moguilevitch, MD; Adam L. Wallowick, MD; Vishal Sarwahi, MD; Terry D. Amaral, MD

2D. Case of Early Distal Junctional Kyphosis in a Neuromuscular Scoliosis Patient Treated with Posterior Spinal Fusion Associated with Postural Habits

Elias C. Papadopoulos, MD; Francisco J. S. Pérez-Grueso, MD

2E. Safety and Efficacy of One-Stage Spinal Osteotomy for Severe and Rigid Congenital Scoliosis (CS) Associated with Split Spinal Cord Malformation(SSCM)

Huiren Tao, MD, PhD; Michael S. Chang, MD

CASE DISCUSSION PROGRAM

Case Discussion #3: Neurologic Deterioration and Other Major Complications

ROOM: TUBUGHNENQ 3

Moderators: Ahmet Alanay, MD & Theodore J. Choma, MD

Cases for Discussion:

3A. Severe Kyphoscoliosis Surgery, Staged Due to TcMEP Loss with Prolonged Delay of Second Stage from Severe Nutritional Deterioration

Terry D. Amaral, MD; Saankritya Ayan, MD; Adam L. Wollowick, MD; Vishal Sarwahi, MD

3B. Implant Failures in Neurologically Intact Syndromic Kyphoscoliotic Growing Spine with Significant Spinal Cord Abnormalities

Terry D. Amaral, MD; Preethi M. Kulkarni, MD; Aviva G. Dworkin, BS; Adam L. Wollowick, MD; Vishal Sarwahi, MD

3C. Malignant Hyperthermia during Scoliosis Surgery: A Sentinel, Near Fatal Event

Jahangir Asghar, MD; Joshua M. Pahys, MD; Patrick J. Cahill, MD; Amer F. Samdani, MD; Harry L. Shufflebarger, MD

3D. Lower Extremity Paralysis Presenting 36 Hours after Attempted Posterior Spinal Fusion for Severe Scoliosis in an Adolescent

Joshua M. Pahys, MD; Patrick J. Cahill, MD; Amer F. Samdani, MD; Jahangir Asghar, MD; Randal R. Betz, MD

Case Discussion #4: Adult Deformity

ROOM: TUBUGHNENQ 4

Moderators: Lloyd A. Hey, MD, MS & Hee-Kit Wong, MD

Cases for Discussion:

4A. Non-Contiguous Two Level VCR for Severe Thoracic Kyphosis in an Osteoporotic Patient

Floreana A. Naef; Khaled Kebaish, MD

4B. Severe PJK with Previous Anterior and Posterior Instrumentation in an Osteoporotic Patient Requiring Additional Revision and Extended PSO in Thoracic Spine

Floreana A. Naef; Khaled Kebaish, MD

4C. Adult Idiopathic Scoliosis with Iatrogenic Flat Back Presenting with Coronal and Sagittal Decompensation after Scoliosis Surgery

Vishal Sarwahi, MD; Saankritya Ayan, MD; Terry D. Amaral, MD; Preethi M. Kulkarni, MD; Adam L. Wollowick, MD

4D. Severe Kyphosis in Adult Patient with Significant Cardiopulmonary Compromise: Safety, Work-Up and Treatment Options

Preethi M. Kulkarni, MD; Terry D. Amaral, MD; Adam L. Wollowick, MD; Vishal Sarwahi, MD

4E. Choosing Fusion Levels in Adult Idiopathic Scoliosis with Significant Degeneration and Kyphosis

Vishal Sarwahi, MD; Saankritya Ayan, MD; Etan P. Sugarman, MD; Terry D. Amaral, MD; Adam L. Wollowick, MD

EDUCATIONAL PROGRAM

Pre-registration is required for all of the following sessions and space is limited. There is an additional cost of \$30 for the Half-Day Courses and an additional registration fee of \$150 applies to the Hibbs Society Program. Tickets will be collected at the door by ushers. There may be a limited number of tickets available at the Registration Desk.

HIBBS SOCIETY MEETING

Tuesday, September 9, 2014 1:00 – 5:00 PM

15th Hibbs Society Program (3RD YR. FOCUSSED ON PJK/PJF)

ROOM: TIKAHNTNU C/F

Chair: Robert W. Gaines, Jr., MD

Indian approach to PJK/PJF—Dr. Arvind Jayaswal—Director Spine Deformity Program—All-India Institute for Medical Sciences—New Delhi, India—“Special Invited Expert”—2014

PJK/F IN EOS

El-Hawary/chest wall/spine study group—27% PJK/PJF in 40 patient/3 yr EOS series— incidence w spine/rib instrumentation

PJK/F IN Scheurmanns Kyphosis

DeKleuver/Holland—long-term Follow-up with posterior correction and PJK

Mehdian/Nottingham—long-term Follow-up with PJK and rib-hook re-operation

Gaines/Missouri—long-term follow-up of 8 cases with anterior-only “bone-on-cage” w NO PJK/PJF

PJK/F IN ADULT DEGEN

President Glassman —“Alignment is not balance”

Yagi/Japan—Classification of PJK/PJF from series of 1668 AdultSpineDeformity series —1.4% PJF/22%

PJK incidence; 11 cases w SCI from PJF—and 50% new PJF p re-operation for first PJF

Ames/SRS adult committee—crying need for Classification/SRS membership survey—

Hart/Ames/ISSG—evaluation of Classification criteria in predicting new PJK/PJF

Sethi, et.al./Seattle—Conference-based approach to reducing PJK/PJF/complications in ASD series

Dewald/Chicago—SS implants have reduced incidence of PJK/PJF vs. Ti and CoCr in ASD

Yagi/Japan—Teriparatide pre-op reduces PJK/PJF in ASD when used pre-operatively

Obrien/Washington, DC—Intra-op vertebroplasty of UIV isn't “uniform” in preventing PJK/PJF

SPINO-PELVIC PARAMETERS AND MATHEMATICAL MODELS MAY APPLY TO JUNCTIONAL PROBLEMS

Deinlein/Hedlund—how to apply “spine equation” to ? avoid PJK/PJF ???

NEW IDEAS TO PREVENT JUNCTIONAL PROBLEMS

Bylski-Austrow/Cincinnati—flexible rods for correction of EOS—exptl. study

Albert/Dayton—SSI w polyester bands totally avoid PJK/PJF in neuromuscular series of 29 children

EDUCATIONAL PROGRAM

LUNCHTIME SYMPOSIUM

Wednesday, September 10, 2014 12:10- 1:10 PM

Are You Ready for ICD-10?

Chair: Christopher J. DeWald, MD

Room: Tikahtnu AB

- 12:10 – 12:12 PM **Introduction**
Christopher J. DeWald, MD
- 12:12 – 12:24 PM **ICD-10: What is It and Why are Switching to it?**
Shay Bess, MD
- 12:24 – 12:36 PM **What makes up an ICD-10 Code?**
Matthew D. Helper, MD
- 12:36 – 12:48 PM **What Documentation is Required to Formulate an ICD-10?**
R. Dale Blasier, MD, FRCS(C)
- 12:48 – 1:00 PM **Implementation and Practice Readiness for ICD-10**
Christopher J. DeWald, MD
-

Ethical Dilemmas in Spine Surgery

Chairs: Richard E. McCarthy, MD & Lori A. Karol, MD

Room: Indlughet Hall 1/2

- 12:10 – 12:15 PM **Introduction**
Richard E. McCarthy, MD
- 12:15 – 1:00 PM **Ethics Film**
Lori A. Karol, MD & Richard E. McCarthy, MD
- 1:00 – 1:10 PM **Discussion**
-

2014 Global Outreach – “Update on Missions and Activities in Endorsed GOP Sites”

Chairs: Hossein Mehdian FRCS & Youssry M.K. El-Hawary, MD

Room: Tikahtnu CF

- 12:10 – 12:15 PM **Welcome & Introduction**
Hossein Mehdian MD, FRCS(Ed)
- 12:15 – 12:23 PM **Uganda Spine Mission: Then & Now**
Isador Lieberman MD, FRCS
- 12:23 – 12:31 PM **Bangladesh: Treatment of Complex Spinal Disorders**
Dilip Sengupta, MD
- 12:31 – 12:49 PM **Bulgaria: Global Outreach Program (GOP) Experience**
Ahmet Alanay, MD
- 12:49 – 12:77 PM **Kolkata, Deformity Surgery Mission**
Jeff Mc Connell, MD
Ujjwal Debnath, MD, FRCS
- 12:77 – 12:55pm **Application of Surgimap in GOP Sites**
Frank Schwab, MD
- 12:55 – 1:10pm **Discussion**

EDUCATIONAL PROGRAM

HALF-DAY COURSES

Thursday, September 11, 2014 1:30 – 4:30PM

Pre-Registration is recommended for all Half-Day Courses to avoid registration lines on-site. There is an additional cost of \$30 for the Half-Day Courses which includes access to the networking lunch. All courses run concurrently, so each delegate may only register for one course.

Half-Day Course: Surgical Techniques in the Management of Adult Spinal Deformity: Tips and Tricks

Co-Chairs: Sigurd H. Berven, MD & John R. Dimar, II, MD

Room: Tikahtnu AB

- 1:30 – 1:35 PM **Introduction**
Sigurd H. Berven, MD
- 1:35 – 1:45 PM **Posterior- Only Approaches to Degenerative Scoliosis**
Jwalant S. Mehta, FRCS(Orth)
- 1:45 – 1:55 PM **Anterior Column Surgery for Degenerative Scoliosis**
John C. France, MD
- 1:55 – 2:05 PM **The Direct Lateral Approach and Deformity Correction**
Vedat Deviren, MD
- 2:05 – 2:15 PM **Minimally Invasive Approaches to Degenerative Scoliosis**
Praveen V. Mummaneni, MD
- 2:15 – 2:25 PM **Cervical Deformity**
Christopher P. Ames, MD
- 2:25 – 2:35 PM **Posterior-Based Osteotomies for Deformity Correction**
Henry F. H. Halm, MD
- 2:35 – 2:45 PM **Posterior-Based Osteotomies for Deformity Correction (PSO and VCR)**
Lawrence G. Lenke, MD
- 2:45 – 3:05 PM **Disucssion**
- 3:05 – 3:15 PM **Anterior and Posterior Approach to High-Grade Spondylolisthesis**
Robert W. Gaines, Jr., MD
- 3:15 – 3:25 PM **Posterior-Only Approach to High-Grade Spondylolisthesis**
S. Rajasekaran, MD, FRCS, MCh, PhD
- 3:25 – 3:35 PM **Iliac Fixation**
Khaled Kebaish, MD
- 3:35 – 3:45 PM **Enhancing the Value of Surgery: How Can I Reduce Cost and Improve the Durability**
Jahangir K. Asghar, MD
- 3:45 – 3:55 PM **Surgical Strategies in the Elderly Patient with Deformity**
Christopher I. Shaffrey, MD
- 3:55 – 4:05 PM **Enhancing the Value of Surgery: How Can I Reduce Cost and Improve the Durability of Surgery?**
Lloyd A. Hey, MD, MS
- 4:05 – 4:30 PM **Discussion**

EDUCATIONAL PROGRAM

Half-Day Course: Safety in Spine Surgery

Co-Chairs: Kit M. Song, MD, MHA & Mark Weidenbaum, MD

Room: Idlughet 1/2

- 1:30 – 1:32 PM **Introduction of "Safety in Spine Surgery"**
Mark Weidenbaum, MD
- 1:32 – 1:35 PM **Case Presentation #1 – Wrong Level Surgery**
TBD
- 1:35 – 1:43 PM **How is Aviation Safety Similar to, and Different From, the OR?**
Captain Stephen W. Harden, BS, ATP
- 1:43 – 1:47 PM **Discussion**
- 1:47 – 1:55 PM **Why Does Safety Matter?**
Erin Dupree, MD, FACOG
- 1:55 – 1:59 PM **Discussion**
- 1:59 – 2:07 PM **Efforts by Nursing Organizations to Improve OR Safety**
Mary Anne Douglas, RN, MD, CNOR
- 2:07 – 2:11 PM **Discussion**
- 2:11 – 2:19 PM **What are the Views of Payors and Risk Managers?**
Michelle Hoppes, RN, MS, AHRMQP, DFASHRM
- 2:19 – 2:23 PM **Discussion**
- 2:23 – 2:31 PM **Trying to Move the Needle: What's Working and What's Not**
William Robb, MD
- 2:31 – 2:35 PM **Discussion**
- 2:35 – 2:56 PM **Case #1 Discussion**
Moderators: Kit M. Song, MD, MHA & Mark Weidenbaum, MD
Panel: John R. Dimar, II, MD; Mary Anne Douglas, MD; Michelle Hoppes, MD
- 2:56 – 2:59 PM **Case Presentation #2**
TBD
- 2:59 – 3:05 PM **Pre-Operative Risk Mitigation**
Todd J. Albert, MD
- 3:05 – 3:11 PM **The Wisdom of Crowds**
Michael G. Vitale, MD, MPH
- 3:11 – 3:17 PM **Hands-Off Practices**
John R. Dimar, II, MD
- 3:17 – 3:40 PM **Case #2 Discussion**
Moderators: Kit M. Song, MD, MHA & Mark Weidenbaum, MD
Panel: John R. Dimar, II, MD; Erin Dupree, MD; Munish C. Gupta, MD; Steven Harden, MD; Michael G. Vitale, MD, MPH
- 3:40 – 3:43 PM **Case Presentation #3 – Intraoperative Neurological Monitoring Deficit**
TBD
- 3:43 – 3:49 PM **Intraoperative Neurological Monitoring (IONM)**
Suken A. Shah, MD
- 3:49 – 3:55 PM **Venous Thromboembolism**
Munish C. Gupta, MD
- 3:55 – 4:01 PM **Blood Loss and Hemodynamic Instability**
Todd J. Albert, MD
- 4:01 – 4:25 PM **Case #3 Discussion**
Moderators: Kit M. Song, MD, MHA & Mark Weidenbaum, MD
Panel: Todd J. Albert, MD; Mary Anne Douglas, MD; Erin Dupree, MD; Munish C. Gupta, MD; Suken A. Shah, MD

EDUCATIONAL PROGRAM

Half-Day Course: Early Onset Scoliosis

Course Chairs: Ron El-Hawary, MD, MSc, FRCS; Nicholas D. Fletcher, MD; David S. Marks, FRCS; Michael J. Mendelow, MD; David L. Skaggs, MD, MMM
Room: Tikahtnu CF

- 1:30 – 1:35 PM **Introduction**
David L. Skaggs, MD, MMM
- 1:35 – 1:57 PM **What a Pediatric Spine Surgeon Needs to Know About Pulmonology**
Gregory Redding, MD
- 1:57 – 2:07 PM **Natural History of Early Onset Scoliosis (EOS) and What Happens With Early Fusion**
John E. Lonstein, MD
- 2:07 – 2:17 PM **Discussion**
- 2:17 – 2:22 PM **Casting Results**
James O. Sanders, MD
- 2:22 – 2:27 PM **Early Results of Magnetic Growing Rods**
Kenneth M.C. Cheung, MD
- 2:27 – 2:37 PM **Pediatric Devices and the FDA**
Zane Wyatt, PhD
- 2:37 – 2:47 PM **Discussion**
- 2:47 – 2:57 PM **Lengthening the Spine**
TBD
- 2:57 – 3:07 PM **Complications in Distraction Based Growth Friendly Implants**
Ron El-Hawary, MD
- 3:07 – 3:17 PM **Changes in Sagittal Spinal Profile of Early Onset Scoliosis (EOS) after the Treatment with Distraction Based Growing Implants**
Yong Qiu, MD
- 3:17 – 3:27 PM **Discussion**
- 3:27 – 3:34 PM **Restoration of Shoulder Balance and Correction of Head Tilt in Cervicothoracic Congenital Scoliosis**
David L. Skaggs, MD, MMM
- 3:34 – 3:41 PM **Masters Techniques: Magnetic Growing Rods**
Hilali H. Noordeen, FRCS
- 3:41 – 3:48 PM **Masters Techniques: Anterior Tether**
Peter O. Newton, MD
- 3:48 – 3:58 PM **Discussion**
- 3:58 – 4:08 PM **Debate: Early Surgery is Best for Early Onset Scoliosis (EOS) vs. Late Surgery is Best for Early Onset Scoliosis (EOS)**
Moderator: John B. Emans, MD
Debaters: Robert M. Campbell, Jr., MD & Charles E. Johnston, MD
- 4:08 – 4:13 PM **Discussion**
- 4:13 – 4:23 PM **Debate: The Use of Iliac Screws with Distraction-Based Implants versus the Use of "S" Rods in the Pelvis with Distraction-Based Implants**
Moderator: Michael J. Mendelow, MD
Debaters: John T. Smith, MD; Paul D. Sponseller, MD
- 4:23 – 4:30 PM **Discussion**

EDUCATIONAL PROGRAM

LUNCHTIME SYMPOSIUM

Friday, September 12, 2014 12:00 – 1:00 PM

From Study Group to Podium: Challenges and Opportunities in Multicenter/Study Group Research

Chair: Peter O. Newton, MD

Room: Tikahtnu AB

- 12:00 – 12:10 PM **What it Takes to Get Started**
Lawrence G. Lenke, MD
- 12:10 – 12:20 PM **The Inner Working of the Harms Study Group**
Michelle C. Marks, PT, MA
- 12:20 – 12:30 PM **The Power of Prospective Multicenter Data**
Lori Dolan, PhD
- 12:30 – 12:40 PM **Avoiding the Pitfalls in Registry Data**
Peter O. Newton, MD
- 12:40 – 1:00 PM **Questions/Panel Discussion**
-

Optimum Performance in Surgery- and in Life

Chair: David A. Hanscom, MD

Room: Indulghet 1/2

- 12:00 – 12:15 PM **Creating a Rich Life**
Scott S. Russo, Jr., MD
- 12:15 – 12:30 PM **Balancing a Rich Life with Spine Surgery and Productivity Demands**
John M. Flynn, MD
- 12:30 – 12:45 PM **Athletic Performance Principles in the OR – and in Life**
David A. Hanscom, MD
- 12:45 – 1:00 PM **Panel Discussion**
Moderator: David A. Hanscom, MD
Panel: All faculty
-

Research Grant Outcomes LTS

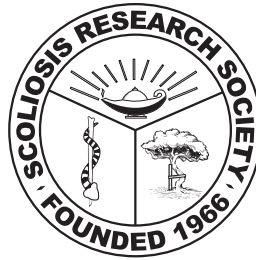
Chair: Andrew G. King, MD

Room: Tikahtnu CF

- 12:00 – 12:05 PM **Introduction**
Andrew G. King, MD
- 12:05 – 12:15 PM **The True Patho-Anatomy of the Rib Hump in Adolescent Idiopathic Scoliosis and Its Influence on Future Surgical Intervention**
Sriram Balasubramanian, MD
- 12:15 – 12:25 PM **Prospective Study of Motion Preservation Evaluation Below Fusions of the Spine in Adolescent Idiopathic Scoliosis**
Michelle C. Marks, PT, MA
- 12:25 – 12:35 PM **Treatment of the Growing Spine with Bisphosphonates: Mechanical Properties and Healing**
Michelle S. Caird, MD
- 12:35 – 12:45 PM **Classification for Adult Spinal Deformity**
Virginie LaFage, PhD
- 12:45 – 1:00 PM **Discussion**

Scientific Program

Scientific Program



The Scoliosis Research Society gratefully acknowledges
Medtronic for support of the Pre-Meeting Course,
Half-Day Courses, Welcome Reception and
Beverage Breaks.



Medtronic



SCIENTIFIC PROGRAM THURSDAY, SEPTEMBER 11, 2014

*Hibbs Award Nominee for Best Clinical Paper

†Hibbs Award Nominee for Best Basic Science Paper

The Russell A. Hibbs Awards are presented to both the best clinical and basic science papers presented at the 49th Annual Meeting and Course. The top podium presentations accepted in each category are invited to submit manuscripts for consideration. Winners are selected on the basis of manuscripts and podium presentations.

Session 1	Adolescent Idiopathic Scoliosis
Session Times:	7:55 – 9:49 AM
	ROOM: IDLUGHET HALL 1/2
	Moderators: <i>B. Stephens Richards, III, MD & Muharrem Yazici, MD</i>
7:55 – 8:00 AM	Welcome
8:00 – 8:04 AM	Paper #1: A Preliminary Validation of a Severity Index for Early Detection of Progressive Adolescent Idiopathic Scoliosis <i>Claudio Vergari, PhD; Kariman Abelin-Genevois, MD, MSc; Remi Kohler; Xavier Drevelle; Eric Ebermeyer; Isabelle Courtois; Jean Dubousset; Wafa Skalli, PhD</i>
8:04 – 8:08 AM	Paper #2: Integrated Multi-Dimensional Maturity Assessments Predicting the High-Risk Occurrence of Peak Angle Velocity during Puberty in Progressive Female Idiopathic Scoliosis <i>Shi Benlong; Saihu Mao, MD; Xu Sun, MD, PhD; Zhu Ze-zhang; Bangping Qian, MD; Zhen Liu; Yong Qiu, MD</i>
8:08 – 8:12 AM	Paper #3: Health, Function, Quality of Life and Self-Esteem in AIS: Preliminary Results from BrAIST <i>Lori A. Dolan, PhD; Stuart L. Weinstein, MD</i>
8:12 – 8:21 AM	Discussion
8:22 – 8:26 AM	Paper #4: Does It Make a Difference to Stop Fusion at L3 versus L4 in Terms of Disc and Facet Joint Degeneration: An MRI Study with Minimum Five-Year Follow Up <i>Meric Enercan; Sinan Kahraman; Mustafa F. Seckin; Tunay Sanli, MA; Mesut Kilic, MD; Cagatay Ozturk, MD; Onur Levent Ulusoy; Ahmet Alanay, MD; Azmi Hamzaoglu, MD</i>
8:26 – 8:30 AM	Paper #5: Radiographic Results of Selecting the Touched Vertebra as the Lowest Instrumented Vertebra in Lenke 1A AIS Curves at a Minimum Five-Year Follow Up <i>Lawrence G. Lenke, MD; Peter O. Newton, MD; Ronald A. Lehman, MD; Michael P. Kelly, MD; David H. Clements, MD; Thomas J. Errico; Amer F. Samdani, MD; Randal R. Betz, MD; Kathy Blanke, RN</i>
8:30 – 8:34 AM	Paper #6: 15 to 25 Year Functional Outcomes of Patients Treated with Posterior Cotrel-Dubousset (CD) Instrumentation <i>Andy A. Beltran, MS; Stephen Albanese, MD; Allen L. Carl, MD; Khalid Hesham, MD; William Lavelle, MD</i>
8:34 – 8:43 AM	Discussion
8:44 – 8:48 AM	Paper #7: Spontaneous Derotation of Compensatory Lumbar Curve after Selective Thoracic Fusion in Adolescent Idiopathic Scoliosis <i>Noriaki Yokogawa; Hideki Murakami; Katsuhito Yoshioka, MD; Satoshi Kato, MD; Hiroyuki Hayashi; Hiroyuki Tsuchiya; Satoru Demura</i>
8:48 – 8:52 AM	Paper #8: Factors Predicting When L3 is Not Distal Enough for an "Ideal" Result in Lenke 5 Curves <i>Lee Phillips; Burt Yaszay, MD; Tracey Bastrom, MA; Suken A. Shah, MD; Baron S. Lonner, MD; Firoz Miyanji, MD, FRCS; Amer F. Samdani, MD; Stefan Parent, MD, PhD; Jahangir Asghar, MD; Patrick J. Cahill, MD; Peter O. Newton, MD</i>
8:52 – 8:56 AM	Paper #9: What is Different about Patients with Lenke 5 Curves Who Achieve a Minimal Clinically Important Difference (MCID) in Appearance? <i>Amer F. Samdani, MD; Robert J. Ames, BA; Tracey Bastrom, MA; Firoz Miyanji, MD, FRCS; Joshua M. Pahys, MD; Michelle C. Marks, PT, MA; Baron S. Lonner, MD; Peter O. Newton, MD; Harry L. Shufflebarger, MD; Randal R. Betz, MD; Patrick J. Cahill, MD</i>
8:56 – 9:05 AM	Discussion

SCIENTIFIC PROGRAM THURSDAY, SEPTEMBER 11, 2014

- 9:06 – 9:10 AM **Paper #10: Cervical Spine Compensation in Adolescent Idiopathic Scoliosis**
Elizabeth P. Norheim, MD; Leah Y. Carreon, MD, MSc; Daniel J. Sucato, MD, MS; Lawrence G. Lenke, MD; Aygul Dankowski, PhD; Steven D. Glassman, MD
- 9:10 – 9:14 AM **Paper #11: Quantitative Analysis of the Three-Dimensional Morphology of Adolescent Idiopathic Scoliosis (AIS) with Implications for Surgical Strategy**
Tom P. Schüssler, MD; Marijn van Stralen, PhD; Winnie C. Chu, FRCS, FHKAM, MD; Tsz-ping Lam, MB, BS; Bobby K. Ng, MD; Koen L. Vincken, PhD; Jack C. Cheng, MD; Rene M. Castelein, MD, PhD
- 9:14 – 9:18 AM **Paper #12: Breast Asymmetry in Idiopathic Scoliosis**
Atsushi Ono; Kanichiro Wada; Toshihiro Tanaka; Taito Itabashi; Gentaro Kumagai; Shugo Maeda; Yasuyuki Ishibashi
- 9:18 – 9:27 AM **Discussion**
- 9:28 – 9:32 AM **Paper #13: Do Crosslinks Improve Clinical or Radiographic Outcomes of Posterior Spinal Fusion with Pedicle Screws in Adolescent Idiopathic Scoliosis? A Multicenter Cohort Study**
Sumeet Garg, MD; Cameron Niswander; Zhaoxing Pan, PhD; Mark A. Erickson, MD
- 9:32 – 9:36 AM **Paper #14: Spinal Deformity Surgery: In Cases of Intraoperative Monitoring Alert, the use of a Flexible Epidural Spinal Electrode Allows the Determination of a Lesional Level**
Jean-Luc Jouve, MD; Sebastien Pesenti; Elie Choufani; Isabelle Suprano; Gérard Bollini; Martine Gavaret, MD, PhD
- 9:36 – 9:40 AM **Paper #15: Biomechanical Comparison of Posterior Ponte Osteotomy versus Anterior Discectomy for Spinal Deformity**
Patrick Bosch, MD; Kevin Bell, PhD; Ozgur Dede, MD; James W. Roach, MD; Cheng Wang
- 9:40 – 9:48 AM **Discussion**

9:49 – 10:05 AM **Refreshment Break**
ROOM: IDLUGHET 3, LEVEL 1

Session 2 **Quality, Safety and Value**

Session Times: 10:06 AM – 12:30 PM

ROOM: IDLUGHET HALL 1/2

Moderators: *Todd J. Albert, MD & Henry F. Halm, MD*

- 10:06 – 10:10 AM **Paper #16: Results of the SRS M&M Database 2009-2012: A Report from the Morbidity & Mortality Committee**
Douglas C. Burton, MD; Brandon B. Carlson, MD, MPH; Howard M. Place, MD; Jonathan E. Fuller, MD; Kathy Blanke, RN; Robert H. Cho, MD; Kai-Ming Fu, MD, PhD; Robert F. Heary, MD; Aruna Ganju, MD; Jose A. Herrera-Soto, MD; A. Noelle Larson, MD; William Lavelle, MD; Ian W. Nelson, MB, BS, MCh (Orth), FRCS; Karl E. Rathjen, MD; Alejo Vernengo-Lezica, MD; Joseph M. Verska, MD
- 10:10 – 10:14 AM **Paper #17: Association between Surgeon Experience and Complication Rates in Adult Scoliosis Surgery: A Review of 5,117 Cases from the Scoliosis Research Society Database 2004-2007**
Branko Skovrlj, MD; Samuel K. Cho, MD; John Caridi, MD; Motasem Al Maaieh; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Yongjung J. Kim, MD
- 10:14 – 10:18 AM **Paper #18: What is the Frequency of Intraoperative Alerts using Current Neuromonitoring Methodology?**
Arvydas A. Tamkus, MD, PhD, DABNM; David W. Polly, MD
- 10:18 – 10:27 AM **Discussion**
- 10:28 – 10:32 AM **Paper #19: Revision Rate in Adult Spinal Deformity Surgery**
Steven D. Glassman, MD; Leah Y. Carreon, MD, MSc; John R. Dimar, MD

SCIENTIFIC PROGRAM THURSDAY, SEPTEMBER 11, 2014

- 10:32 – 10:36 AM **Paper #20: Incidence and Risk Factors for Early Wound Complications after Spinal Arthrodesis in Children**
Christopher T. Martin, MD; Andrew J. Pugely, MD; Yubo Gao, PhD; Ryan M. Ilgenfritz, MD; Stuart L. Weinstein, MD
- 10:36 – 10:40 AM **Paper #21: Efficacy and Safety of Intrawound Vancomycin for Reducing Surgical Site Infection (SSI) in Spine Surgery**
Thomas Cheriyan; Carl B. Paulino, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Jeffrey A. Goldstein, MD; Thomas J. Errico, MD
- 10:40 – 10:49 AM **Discussion**
- 10:50 – 10:54 AM **Paper #22: Long-Term Cost-Effectiveness of Adult Spinal Deformity Surgery (ASD)**
Ian McCarthy, PhD; Chessie Robinson, MA; Michael F. O'Brien, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Virginie Lafage, PhD; Robert A. Hart, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Gregory M. Mundis, MD; Frank J. Schwab, MD; Khaled Kebaish, MD; Justin S. Smith, MD, PhD; Richard Hostin, MD; International Spine Study Group
- 10:54 – 10:58 AM **Paper #23: Post-Operative Blood Salvage and Autotransfusion following Surgery for Adult Spinal Deformity: A Randomized Controlled Trial**
Venu M. Nemani, MD, PhD; Han Jo Kim, MD; Curtis A. Mina, MD; Thomas Ross, MS, RN; Matthew E. Cunningham, MD, PhD; Bernard A. Rawlins, MD; Oheneba Boachie-Adjei, MD
- 10:58 – 11:02 AM **Paper #24: Perioperative Use of Adjunctive Medications for Pain Management Improves Outcomes after Posterior Spinal Fusion for AIS**
Suken A. Shah, MD; Karen Sacks, MSN; Kenneth J. Rogers, PhD; Dinesh K. Choudhry, MD
- 11:02 – 11:11 AM **Discussion**
- 11:12 – 11:16 AM **Paper #25: The Use of Chewing Gum Post-Operatively in Pediatric Scoliosis Patients Facilitates an Earlier Return to Normal Bowel Function**
Joseph Khoury, MD; Jonathan K. Jennings, MD; Shawn R. Gilbert, MD; John S. Doyle, MD
- 11:16 – 11:20 AM **Paper #26: Is MRI Necessary for Adolescent Idiopathic Scoliosis When Patients Present with Curves Over 80 Degrees?**
Daniel J. Sucato, MD, MS; Dong-Phuong Tran, MS; Lawrence G. Lenke, MD
- 11:20 – 11:24 AM **Paper #27: How Quantity and Quality of Brace Wear Affect the Brace Treatment Outcomes for AIS Patients**
Edmond H. Lou, PhD; Douglas L. Hill, MBA; James V. Raso, MASc; Marc J. Moreau, MD; Douglas Hedden, MD
- 11:24 – 11:33 AM **Discussion**
- 11:34 – 11:39 AM **Special Presentation: AUC**
Lumbar Degenerative Scoliosis: The Appropriateness of Five Commonly Used Approaches to Surgery
Teryl Nuckols, MD
- 11:39 – 11:42 AM **Discussion**
- 11:43 – 11:48 AM **Harrington Lecture Introduction**
Steven D. Glassman, MD
- 11:48 – 12:09 PM **Harrington Lecture**
"50 Years of Spine Deformity Surgery"
Jean-Pierre C. Farcy, MD
- 12:09 – 12:30 PM **Presentation of the Lifetime Achievement Awards**
David S. Bradford, MD
Presented by: *David W. Polly, MD*
Alvin H. Crawford, MD
Presented by: *John P. Dormans, MD*

SCIENTIFIC PROGRAM THURSDAY, SEPTEMBER 11, 2014

12:30 – 1:30 PM **Networking Lunch**

Open to all Half-Day Course participants. Tickets will be required.

ROOM: IDLUGHET 3, LEVEL 1

Member Information Session

ROOM: TIKAHNTU CF, LEVEL 3

1:30 – 4:30 PM **Half-Day Courses (See Page 115)**

Early Onset Scoliosis

ROOM: TIKAHNTU CF

Safety in Spine Surgery

ROOM: IDLUGHET HALL 1/2

Surgical Techniques in the Management of Adult Spinal Deformity: Tips and Tricks

ROOM: TIKAHNTU AB

SCIENTIFIC PROGRAM FRIDAY, SEPTEMBER 12, 2014

Session 3	Cervical, Tumor and Basic Research (Runs Concurrently with Session 4 from 7:55 – 9:49 AM)
Session Times:	7:55 – 9:49 AM
	ROOM: IDLUGHET HALL 1/2
	Moderators: Kamal N. Ibrahim, MD, FRCS(C), MA & Luiz E. Rocha, MD
7:55 – 8:00 AM	Welcome
8:00 – 8:04 AM	Paper #28: Risk of Development of New Onset Post-Operative Cervical Deformity (CD) in Thoracolumbar Adult Spinal Deformity (ASD) and Effect on Clinical Outcomes at Two-Year Follow Up <i>Alex Soroceanu, MD, CM, MPH, FRCS(C); Peter G. Passias, MD; Anthony J. Boniello, BS; Justin K. Scheer, BS; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Munish C. Gupta, MD; Eric Klineberg, MD; Virginie Lafage, PhD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; International Spine Study Group</i>
8:04 – 8:08 AM	Paper #29: The Presence of Pre-Operative Cervical Deformity in Adult Spinal Deformity Patients is a Strong Predictor of Inferior Outcomes and Failure to Reach MCID at Two-Year Follow Up: Analysis of 235 Patients <i>Christopher P. Ames, MD; Peter G. Passias, MD; Alex Soroceanu, MD, CM, MPH, FRCS(C); Anthony J. Boniello, BS; Justin K. Scheer, BS; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Munish C. Gupta, MD; Eric Klineberg, MD; Virginie Lafage, PhD; Justin S. Smith, MD, PhD; International Spine Study Group</i>
8:08 – 8:12 AM	Paper #30: What is the Best Construct Across the Cervicothoracic Junction? <i>Justin S. Yang, MD; Jacob M. Buchowski, MD, MS; Vivek Verma, MD</i>
8:12 – 8:21 AM	Discussion
8:22 – 8:26 AM	Paper #31: More than 10-Year Follow Up after Total En Bloc Spondylectomy for Spinal Tumors <i>Satoshi Kato, MD; Hideki Murakami; Satoru Demura, MD; Katsuhito Yoshioka, MD; Hiroyuki Hayashi; Noriaki Yokogawa; Takayoshi Ishii; Hiroyuki Tsuchiya</i>
8:26 – 8:30 AM	Paper #32: The Use of Intraoperative Cell Salvage in Metastatic Spine Tumor Surgery <i>Naresh S. Kumar, MBBS, FRCS (Orth&Tr), DM; Yongsheng Chen, MBBS, MRCS; Aye Sandar Zaw, MBBS, MPH; Hee-Kit Wong</i>
8:30 – 8:34 AM	Paper #33: META: An MRI-Based Scoring System Differentiating Metastatic from Osteoporotic Vertebral Fractures <i>So Kato, MD; Takahiro Hozumi; Kiyofumi Yamakawa; Takahiro Goto, MD</i>
8:34 – 8:43 AM	Discussion
8:44 – 8:48 AM	Paper #34: The Cellular and Biological Profile of Autologous Bone from Various Graft Sites <i>Brandon Lawrence, MD; Sarina Sinclair, PhD; William R. Spiker, MD; Darrel S. Brodke, MD</i>
8:48 – 8:52 AM	Paper #35: Local versus Systemic Antibiotics for Surgical Infection Prophylaxis in a Rat Model <i>Fred A. Sweet, MD</i>
8:52 – 8:56 AM	Paper #36: The Type of Metal, Local Antibiotics or Prophylactic IV Antibiotics: What Influences Post-Operative Spine Infections with MRSA the Most? <i>Sachin Gupta; Sukanta Maitra; Blythe Durbin-Johnson, PhD; Maria das Gracias C. Pereira, DVM, PhD; Pumibal Wetpiriyakul, MD; Munish C. Gupta, MD; Kavita Gupta</i>
8:56 – 9:05 AM	Discussion
9:06 – 9:10 AM	Paper #37: Intermediate Dosing of Recombinant Human Bone Morphogenetic Protein-2 (rhBMP-2) Improves Fusion Rates with No Increase in Major Complications but does not Improve Health Related Quality of Life for Adult Spinal Deformity (ASD) at Minimum Two Years: A Prospective, Multicenter Analysis <i>Shay Bess, MD; Breton Line, BSME; Virginie Lafage, PhD; Christopher P. Ames, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Munish C. Gupta, MD; Eric Klineberg, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group</i>

SCIENTIFIC PROGRAM FRIDAY, SEPTEMBER 12, 2014

- 9:10 – 9:14 AM **Paper #38: Bone Morphogenetic Protein (BMP-2) Usage and Cancer Correlation: An Analysis of 10,416 Spine Fusion Patients from a Multicenter Spine Registry**
Lance K. Mitsunaga, MD; Yuexin Chen, BS; Kamran Majid, MD; Kern H. Guppy, MD, PhD; Jessica Harris, MS, RD; Julie L. Alvarez, MPH; Liz W. Paxton; Ravi S. Bains, MD
- 9:14 – 9:18 AM **Paper #39: Use of Recombinant Bone Morphogenetic Protein (BMP) is Associated with Reduced Risk of Re-Operation after Spine Fusion for Scoliosis**
Justin C. Paul, MD, PhD; Baron S. Lonner, MD; Thomas J. Errico
- 9:18 – 9:27 AM **Discussion**
- 9:28 – 9:32 AM **Paper #40: Risk of Neurological Injuries in Spinal Deformity Surgery**
Julian J. Leong, MA, FRCS, PhD; Mary R. Curtis, BSc; Emma V. Carter, MSc; Joseph Cowan, MB, ChB, FRCP; Jan Lehovsky
- 9:32 – 9:36 AM **Paper #41: Improvement of Motor Evoked Potential Responses Using Novel Transcranial Electrical Stimulation Technique in Intraoperative Neurophysiologic Monitoring during Spinal Deformity Surgery: Multi-Train Stimulation**
Shunji Tsutsui, MD, PhD; Hiroshi Iwasaki, MD; Hiroshi Yamada, MD, PhD; Hiroshi Hashizume, MD, PhD; Akihito Minamide, MD, PhD; Yukihiro Nakagawa; Hideto Nishi, MD; Munehito Yoshida, MD
- 9:36 – 9:40 AM **Paper #42: The Importance of “Time to Surgery” for Traumatic Spinal Cord Injured Patients: Results from an Ambispective Canadian Cohort of 949 Patients**
Marcel F. Dvorak, MD, FRCSC; Charles G. Fisher, MD, MHS, FRCSC; Brian K. Kwon, MD; Brian M. Drew, MD; Michael G. Fehlings, MD, PhD; Jerome Paquet; Henry Ahn, MD, PhD, FRCSC; Najmedden Attabib, MD, FRCSC; Chris S. Bailey, MD; Sean Christie; Neil Duggal, MD, MSc, FRCSC, FACS; Joel Finkelstein, MSc, MD, FRCSC; Daryl R. Fournay, MD, FRCSC, FACS; R. John Hurlbert, MD, PhD, FRCSC, FACS; Michael G. Johnson; Jean-Marc Mac-Thiong, MD, PhD; Stefan Parent, MD, PhD; Eve C. Tsai, MD, PhD; Nader Fallah; Vanessa Noonan, PhD, PT; Carly S. Rivers, PhD
- 9:40 – 9:48 AM **Discussion**

9:49 – 10:09 AM Refreshment Break

ROOM: IDLUGHET 3, LEVEL 1

This break is supported, in part, by a grant from Medtronic

Session 4 Early Onset, Congenital and Neuromuscular (Runs Concurrently with Session 3 from 7:55 – 9:49 AM)

Session Times: 7:55 – 9:49 AM

ROOM: TIKAHNTU AB

Moderators: Hilali H. Noordeen, FRCS & Suken A. Shah, MD

7:55 – 8:00 AM **Welcome**

8:00 – 8:04 AM **Paper #43: Comparison of Early Spinal Fusion with Late Spinal Fusion in Pediatric Patients with Congenital Spinal Deformity: Long-Term Follow-Up Study**

Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Toshiki Saito; Toshiaki Kotani; Shohei Minami; Koki Uno, MD, PhD; Teppei Suzuki; Toru Hirano; Haruhisa Yanagida, MD; Toru Yamaguchi, MD; Manabu Ito, MD, PhD

8:04 – 8:08 AM **Paper #44: Long-Term Quality of Life after Early Fusion Surgery in Congenital Scoliosis Patients 10 Years of Age or Younger Assessed after a Minimum of 10 Years: A Multicenter Study**

Toshiaki Kotani; Shohei Minami; Tsutomu Akazawa, MD; Tsuyoshi Sakuma, MD, PhD; Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Koki Uno, MD, PhD; Teppei Suzuki

8:08 – 8:12 AM **Paper #45: Characterizing Endothoracic Deformity in EOS: The Spinal Penetration Index**

Charles E. Johnston, MD; Anna M. McClung, BSN, RN; Ryan D. Muchow, MD

8:12 – 8:21 AM **Discussion**

SCIENTIFIC PROGRAM FRIDAY, SEPTEMBER 12, 2014

- 8:22 – 8:26 AM **Paper #46: An Analysis of Thoracic Cage Deformities and Pulmonary Function Tests in Congenital Scoliosis**
Xuhong Xue, MD; Jianxiong Shen, MD
- 8:26 – 8:30 AM **Paper #47: Posterior Hemivertebra Resection in Children**
Lucas Piantoni, MD; Ida Alejandra Francheri, MD; Carlos A. Tello, MD; Mariano A. Noel, MD; Eduardo Galaretto, MD; Rodrigo G. Remondino, MD; Ernesto Bersusky, MD
- 8:30 – 8:34 AM **Paper #48: Final Fusion after Growing Rod Treatment for Early Onset Scoliosis: Is it Really Final?**
Connie Poe-Kochert, BSN; Claire Shannon, MD; Jeff Pawelek, MD; George H. Thompson, MD; Christina Hardesty, MD; David S. Marks, FRCS; Behrooz A. Akbarnia, MD; Richard E. McCarthy, MD; John B. Emans, MD; Growing Spine Study Group
- 8:34 – 8:43 AM **Discussion**
- 8:44 – 8:48 AM **Paper #49: Pre-Operative Halo-Gravity Traction for Severe Spinal Deformities at an SRS-GOP Site in West Africa: Protocols, Complications and Results**
Venu M. Nemani, MD, PhD; Han Jo Kim, MD; Benjamin T. Bjerke-Kroll, MD, MS; Mitsuru Yagi, MD, PhD; Maria Cristina Sacramento-Dominguez, MD, PhD; Harry Akoto, MD; Munish C. Gupta, MD; W. F. Hess, MD; Elias C. Papadopoulos, MD; Francisco J. S. Pérez-Gruoso, MD; Ferran Pellise, MD; Bettye Wright, RN, PA; Irene Wulff, MD; Jennifer Ayamga, MPhil; Rufai M. Mahmud, MD; Oheneba Boachie-Adjei, MD
- 8:48 – 8:52 AM **Paper #50: The Radiographic and Clinical Impact of Pre-Operative Halo-Gravity Traction in the Treatment of Early Onset Spinal Deformity**
Patrick A. Sugrue, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Michael P. Kelly, MD; Scott J. Luhmann, MD; Brenda A. Sides, MA; David B. Bumpass, MD; Isaac Karikari, MD; Jeffrey L. Gum, MD
- 8:52 – 8:56 AM **Paper #51: Serial Casting for Infantile Idiopathic Scoliosis: When Can a Cure be Achieved?**
Daniel J. Sucato, MD, MS; Dong-Phuong Tran, MS; Anna M. McClung, BSN, RN; Charles E. Johnston, MD
- 8:56 – 9:05 AM **Discussion**
- 9:06 – 9:10 AM **Paper #52: Re-Operation after Magnetically Controlled Growing Rod Implantation: A Review of 23 Patients with Minimum Two-Year Follow Up**
Kenneth MC. Cheung, MBBS(UK), MD, FRCS(England), FHKCOS, FHKAM(ORTH); Kenny Kwan; John Ferguson; Colin Nnadi, FRCS(Orth); Ahmet Alanay, MD; Muharrem Yazici, MD; Gokhan H. Demirkiran; Behrooz A. Akbarnia, MD
- 9:10 – 9:14 AM **Paper #53: Pulmonary Function in Patients with Early Onset Idiopathic Scoliosis Mean 24 Years after Maturity**
Aina J. Danielsson, MD, PhD; Kerstin Löfdahl-Hällerman, MD, PhD
- 9:14 – 9:18 AM **Paper #54: Incidence of False Positive Spinal Cord Monitoring Alerts in Surgery for Early Onset Scoliosis**
Oliver M. Stokes, MB BS, MSc, FRCS (Tr&Orth); Edward Bayley, MRCSEd; Rob Burton, BMBS, MSc, BMedSci; Sherief Elsayed, FRCS (Tr&Orth); Dominique A. Rothenfluh, MD, PhD; Hossein Mehdian, MD, MS(Orth), FRCS(Ed)
- 9:18 – 9:27 AM **Discussion**
- 9:28 – 9:32 AM **Paper #55: Problems of Growing-Rod Treatments: Results of Patients who Completed Rod Lengthening**
Kota Watanabe, MD; Morio Matsumoto, MD; Koki Uno, MD, PhD; Tepei Suzuki; Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Haruhisa Yanagida, MD; Manabu Ito, MD, PhD; Toru Hirano; Ken Yamazaki, MD; Shohei Minami; Hiroshi Taneichi, MD; Shiro Imagama, MD; Katsushi Takeshita, MD; Takuya Yamamoto; Ikuho Yonezawa, MD, PhD
- 9:32 – 9:36 AM **Paper #56: Three-Dimensional Characterization of Torsion and Asymmetry of the Intervertebral Discs versus Vertebral Bodies in Adolescent Idiopathic Scoliosis**
Tom P. Schlösser, MD; Marijn van Stralen, PhD; Rob C. Brink, Bsc; Winnie C. Chu, FRCR, FHKAM, MD; Tsz-ping Lam, MB, BS; Koen L. Vincken, PhD; Rene M. Castelein, MD, PhD; Jack C. Cheng, MD
- 9:36 – 9:40 AM **Paper #57: Two-Year Results of Anterior Vertebral Body Tethering for Immature Thoracic Idiopathic Scoliosis**
Amer F. Samdani, MD; Robert J. Ames, BA; Joshua M. Pahys, MD; Jeff S. Kimball, BS; Harsh Grewal, MD, FACS, FAAP; Glenn J. Pelletier, MD; Randal R. Betz, MD
- 9:40 – 9:48 AM **Discussion**

SCIENTIFIC PROGRAM FRIDAY, SEPTEMBER 12, 2014

9:49 – 10:09 AM Refreshment Break

ROOM: IDLUGHET 3, LEVEL 1

This break is supported, in part, by a grant from Medtronic

Session 5 Spinal Osteotomies

Session Times: 10:09 – 11:50 AM

ROOM: IDLUGHET HALL 1/2

Moderators: Christopher I. Shaffrey, MD & Qiu Yong, MD

10:09 – 10:13 AM **Paper #58: Factors Associated with Improved Long-Term Outcomes following Three-Column Osteotomies**
Kevin R. O'Neill, MD, MS; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Han Jo Kim, MD; Brian J. Neuman, MD; Kristin R. Archer, PhD, DPT

10:13 – 10:17 AM **Paper #59: Utilization Trends of Pedicle Subtraction Osteotomies Compared to Posterior Spinal Fusion for Deformity: A National Database Analysis between 2008-2011**
Jeffrey L. Gum, MD; Leah Y. Carreon, MD, MSc; Jacob M. Buchowski, MD, MS; Lawrence G. Lenke, MD; Steven D. Glassman, MD

10:17 – 10:21 AM **Paper #60: Is it the Vertebral Column Resection Procedure or the Nature of the Severe Pediatric Deformity that Creates a High Neurologic Complication Risk?**
Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Daniel J. Sucato, MD, MS; Amer F. Samdani, MD; Harry L. Shufflebarger, MD; Patrick J. Cahill, MD; Sumeet Garg, MD; Mark A. Erickson, MD; Michael P. Kelly, MD; Brenda A. Sides, MA

10:21 – 10:30 AM Discussion

10:31 – 10:35 AM **Paper #61: Analysis of Perioperative Major Non-Neurologic Complications in 105 Posterior Vertebral Column Resection (PVCR) Procedures for Severe Rigid Deformities during 10 Years: Introspection on the Balance between Patients' Risk and Benefit**
Jingming Xie; Yingsong Wang, MD; Ying Zhang; Tao Li; Zhi Zhao; Zhou Liu; Ni Bi; Leijie Chen; Zhiyue Shi

10:35 – 10:39 AM **Paper #62: Morphological Influence of Aorta and Superior Mesenteric Artery (SMA) following Posterior Vertebral Column Resection (PVCR) in Treatment of Severe Rigid Spinal Deformity (>150°)**
Ni Bi; Jingming Xie; Yong Sun; Yingsong Wang, MD; Ying Zhang; Zhou Liu; Tao Li; Zhiyue Shi; Leijie Chen; Zhi Zhao

10:39 – 10:43 AM **Paper #63: High Dose of Tranexamic Acid Reduces Intraoperative Blood Loss in Patients Undergoing Posterior Vertebral Column Resection: A Clinical Comparative Study of 89 Consecutive Patients**
Tao Li; Jingming Xie; Ying Zhang; Yingsong Wang, MD; Leijie Chen; Zhou Liu; Zhiyue Shi; Zhi Zhao; Ni Bi

10:43 – 10:52 AM Discussion

10:53 – 10:57 AM **Paper #64: The Changes of SEP/MEP following Ligating Spinal Cord Segmental Vessels in Applying Posterior Vertebral Column Resection (PVCR) to Correct Severe Rigid Spinal Deformity**
Zhi Zhao; Jingming Xie; Ni Bi; Leijie Chen; Tao Li; Yingsong Wang, MD; Ying Zhang; Zhiyue Shi; Zhou Liu

10:57 – 11:01 AM **Paper #65: Apex of Deformity for Three-Column Osteotomy: Does it Matter in the Occurrence of Complications**
Maria Cristina Sacramento-Dominguez, MD, PhD; Mitsuru Yagi, MD, PhD; Jennifer Ayamga, BA, MPhil; Oheneba Boachie-Adjei, MD

11:01 – 11:05 AM **Paper #66: Classification and Surgical Decision Making of Ankylosing Spondylitis Kyphosis**
Yan Wang, MD; Yonggang Zhang, PhD; GuoQuan Zheng

11:05 – 11:14 AM Discussion

SCIENTIFIC PROGRAM FRIDAY, SEPTEMBER 12, 2014

- 11:15 – 11:17 AM **2015 IMAST Preview**
Mun Keong Kwan, MBSS, MS(Orth) & Harwant Singh, MD, PhD
2015 IMAST Local Hosts
- 11:17 – 11:20 AM **2015 Annual Meeting Preview**
Joseph H. Perra, MD
2015 Annual Meeting Local Host
- 11:20 – 11:23 AM **Worldwide Conferences Preview**
Marinus de Kleuver, MD, PhD
Worldwide Conference Committee Chair
- 11:23 -11:30 AM **Introduction of President**
John P. Dormans, MD
President-Elect
- 11:30 – 11:50 AM **Presidential Address**
Steven D. Glassman, MD
- 11:50 – 12:00 PM **Break**

12:00 – 1:00 PM

Lunch Break

LUNCH AVAILABLE IN IDLUGHET 3, LEVEL 1

Lunchtime Symposia (see page 114)

From Study Group to Podium: Challenges and Opportunities in Multicenter/Study Group Research

ROOM: TIKAHNTU AB

Peak Performance In and Out of the OR

ROOM: IDLUGHET HALL 1/2

Research Grant Outcomes

ROOM: TIKAHNTU CF

1:00 – 1:15 PM **Walking Break**

Session 6A

Hibbs Basic Research Award Nominees

Session Times:

1:15 – 1:57 PM

ROOM: IDLUGHET HALL 1/2

Moderators: Laurel C. Blakemore, MD & S. Rajasekaran, PhD, MD, FRCS, MCh

1:15 – 1:19 PM †**Paper #67: Implementing a Dashboard Reporting Tool Improves Surgeon Performance and Patient Outcomes**
Ronald A. Lehman, MD; Harry L. Shufflebarger, MD; Michelle C. Marks, PT, MA; John M. Flynn, MD; Peter O. Newton, MD

1:19 – 1:23 PM †**Paper #68: Increasing Hospital Charges for Adolescent Idiopathic Scoliosis in the United States**
Christopher T. Martin, MD; Andrew J. Pugely, MD; Yubo Gao, PhD; Sergio A. Mendoza-Lattes, MD; John Callaghan; Ryan M. Ilgenfritz, MD; Stuart L. Weinstein, MD

1:23 – 1:27 PM †**Paper #69: Impact on Health-Related Quality of Life of Adult Spinal Deformity (ASD) Compared with Other Chronic Conditions**
Ferran Pellise, MD; Alba Vila-Casademunt; Daniela Issa; Montse Domingo-Sabat; Juan Bago, MD; Francisco J. S. Pérez-Gruoso, MD; Ahmet Alanay; Emre Acaroglu, MD; European Spine Study Group

1:27 – 1:35 PM **Discussion**

* Hibbs Award nominee for best Clinical Paper † Hibbs Award nominee for best Basic Research Paper

SCIENTIFIC PROGRAM FRIDAY, SEPTEMBER 12, 2014

- 1:36 – 1:40 PM †Paper #70: A Genome-Wide Association Study Identified a Novel Susceptibility Locus for Severe Adolescent Idiopathic Scoliosis
Atsushi Miyake; Morio Matsumoto, MD; Yohei Takahashi; Yoji Ogura, MD; Katsuki Kono; Noriaki Kawakami, MD, DMSc; Koki Uno, MD, PhD; Manabu Ito, MD, PhD; Shohei Minami; Haruhisa Yanagida, MD; Hiroshi Taneichi, MD; Kota Watanabe; Taichi Tsuji, MD; Teppei Suzuki; Hideki Sudo; Toshiaki Kotani; Ikuho Yonezawa, MD, PhD; Kazuhiro Chiba, MD, PhD; Yoshiaki Toyama; Shiro Ikegawa, MD, PhD
- 1:40 – 1:44 PM †Paper #71: 2005 and 2013 Health Survey of SRS Member Surgeons Focusing on Thyroid Cancer and Cataract Prevalence: Occupational Radiation Risk?
Theodore A. Wagner, MD; Maria A. Vanushkina, BS; Sue Min Lai, PhD; Courtney M. O'Donnell, MD; Darin J. Davidson; Mark Weidenbaum, MD
- 1:44 – 1:48 PM †Paper #72: A New Genetic Locus Increases Risk of Idiopathic Scoliosis in Females
Carol Wise, PhD; Swakar Sharma, PhD; Douglas Londono, PhD; Walter Eckalbar; Xiaochong Gao; Ikuyo Kou; Atsushi Takahashi; Morio Matsumoto, MD; John A. Herring, MD; Shiro Ikegawa, MD, PhD; Nadav Ahituv; Derek Gordon, PhD
- 1:48 – 1:57 PM Discussion

Session 6B: Hibbs Clinical Research Award Nominees

Session Times: 1:58 – 3:03 PM

ROOM: IDLUGHET HALL 1/2

Moderators: *Kenneth M. Cheung, MBBS(UK), MD, FRCS(England), FHKCOS, FHKAM(ORTH) & James O. Sanders, MD*

- 1:58 – 2:02 PM *Paper #73: Comparison of Surgical Outcomes between Anterior Fusion (ASF) and Posterior Fusion (PSF) in Patients with AIS Lenke Type 1 or 2 that Underwent Selective Thoracic Fusion: Long-Term Follow-Up Study Longer Than 10 Postoperative Years
Ayato Nohara; Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Toshiki Saito; Tetsuya Ohara; Yoshitaka Suzuki; Ryoji Tauchi, MD, PhD; Ryo Sugawara; Kosuke Takimura, MD; Kyotaro Ota; Kazuki Kawakami, BS
- 2:02 – 2:06 PM *Paper #74: Minimum 20-Year Radiographic Outcomes for Treatment of Adolescent Idiopathic Scoliosis: Preliminary Results from a Novel Cohort of US Patients
A. Noelle Larson, MD; David W. Polly, MD; William J. Shaughnessy, MD; Michael J. Yaszemski, MD, PhD
- 2:06 – 2:10 PM *Paper #75: Prediction of Outcomes in AIS: Results from BraIST
Lori A. Dolan, PhD; Stuart L. Weinstein, MD
- 2:10 – 2:19 PM Discussion
- 2:20 – 2:24 PM *Paper #76: Radiological Outcome in AIS Patients 25 Years after Treatment
Ane Simony, MD; Mikkel Andersen, MD; Steen B. Christensen, MD
- 2:24 – 2:28 PM *Paper #77: Selective Thoracic Fusion (STF) Provides Similar HRQL but Can Cause More Lumbar Disc and Facet Joint Degeneration: A Comparison of AIS Patients with Normal Population 10 Years after Surgery
Sinan Kahraman; Meric Enercan; Tunay Sanli, MA; Bahadir H. Gokcen, MD; Erden Erturer; Neron Popovski, MD; Cagatay Ozturk, MD; Ahmet Alanay; Azmi Hamzaoglu, MD
- 2:28 – 2:32 PM *Paper #78: Higher Implant Density does not Result in Increased Curve Correction or Improved Clinical Outcomes in Adolescent Idiopathic Scoliosis
Tristan Nishnianidze, MD, PhD; Kenneth J. Rogers, PhD; Blazej A. Pruszczyński; Petya Yorgova, MS; Baron S. Lonner, MD; Suken A. Shah, MD
- 2:32 – 2:41 PM Discussion

* Hibbs Award nominee for best Clinical Paper † Hibbs Award nominee for best Basic Research Paper

SCIENTIFIC PROGRAM FRIDAY, SEPTEMBER 12, 2014

- 2:42 – 2:46 PM ***Paper #79: Risk Factors for Neurological Complications in Patients Undergoing Corrective Surgery for Spinal Deformity: Results of the Scoli-Risk 1 Study International, Prospective, Multicenter Study**
Michael G. Fehlings, MD, PhD; Lawrence G. Lenke, MD; Christopher I. Shaffrey, MD; Branko Kopjar, MD, PhD, MS; Kenneth M. Cheung, MBBS(UK), MD, FRCS(England), FHKCOS, FHKAM(ORTH); Leah Y. Carreon, MD, MSc; Mark B. Dekutoski, MD; Frank J. Schwab, MD; Oheneba Boachie-Adjei, MD; Khaled Kebaish, MD; Christopher P. Ames, MD; Yong Qiu, MD; Yukihiko Matsuyama, MD; Benny Dahl, MD, PhD, DMSci; Hossein Mehdian, MD, MS(Orth), FRCS(Ed); Ferran Pellise, MD; Stephen J. Lewis, MD; Sigurd H. Berven, MD
- 2:46 – 2:50 PM ***Paper #80: Efficacy and Safety of Prophylactic Large Dose of Tranexamic Acid in Adolescent with Idiopathic Scoliosis Surgery: A Prospective, Randomized, Double-Blind, Placebo-Controlled Study**
En Xie, PhD, MD
- 2:50 – 2:54 PM ***Paper #81: Intraocular Pressure in Lumbar Spine Fusion Patients: A Prospective, Randomized Study**
Sanford E. Emery, MD, MBA; John C. France, MD; Scott D. Daffner, MD; Matthew Ellison, MD; Brian W. Grose, MD; Nina Clovis
- 2:54 – 3:03 PM **Discussion**

3:03 – 3:24 PM **Refreshment Break**
 ROOM: IDLUGHET 3, LEVEL 1

Session 7 Adult Deformity

Session Times: 3:24 – 5:13 PM

ROOM: IDLUGHET HALL 1/2

Moderators: Daniel H. Chopin, MD & Ronald A. Lehman, MD

- 3:24 – 3:28 PM **Paper #82: Outcomes of Operative and Non-Operative Treatment for Adult Spinal Deformity (ASD): A Prospective, Multicenter Matched and Unmatched Cohort Assessment with Minimum Two-Year Follow Up**
Justin S. Smith, MD, PhD; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Richard Hostin, MD; Oheneba Boachie-Adjei, MD; Behrooz A. Akbarnia, MD; Eric Klineberg, MD; Munish C. Gupta, MD; Vedat Deviren, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group
- 3:28 – 3:32 PM **Paper #83: Long-Term Outcome and Health Care Utilization following Surgical Treatment of Adult Spine Deformity**
Cody E. Bunger; Shalju Sharma, MPT
- 3:32 – 3:36 PM **Paper #84: Prevalence of Cancer in Spinal Deformity Patients Receiving High Dose (≥ 40 mg) Bone Morphogenetic Protein (rhBMP-2)**
Christine R. Baldus, RN, MHS; Jeffrey L. Gum, MD; Keith H. Bridwell, MD; Azeem Ahmad, BA, BS; Addisu Mesfin, MD; Leah Y. Carreon, MD, MSc
- 3:36 – 3:45 PM **Discussion**
- 3:46 – 3:50 PM **Paper #85: Revision Surgery in Adult Spinal Deformity Patients Achieves Similar Improvement in HRQOL Compared to Primary Surgery: Prospective, Multicenter Analysis**
Lukas P. Zebala, MD; Floreana A. Naef; Haruki Funao, MD; Virginie Lafage, PhD; Eric Klineberg, MD; Michael P. Kelly, MD; Munish C. Gupta, MD; Han Jo Kim, MD; Gregory M. Mundis, MD; Shay Bess, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Christopher P. Ames, MD; Khaled Kebaish, MD; International Spine Study Group
- 3:50 – 3:54 PM **Paper #86: Patients with Instrumented Fusions to the Ilium Report Greater Impairment of Perineal Care with Construct Extension to the Upper Thoracic versus Extension to the Thoracolumbar Junction with Two-Year Follow Up**
Daniel M. Sciubba, MD; Justin K. Scheer, BS; Justin S. Smith, MD, PhD; Virginie Lafage, PhD; Eric Klineberg, MD; Munish C. Gupta, MD; Gregory M. Mundis, MD; Themistocles S. Protopsaltis, MD; Han Jo Kim, MD; Tyler Koski, MD; D. K. Hamilton, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Robert A. Hart, MD; Christopher P. Ames, MD; International Spine Study Group

* Hibbs Award nominee for best Clinical Paper † Hibbs Award nominee for best Basic Research Paper

SCIENTIFIC PROGRAM FRIDAY, SEPTEMBER 12, 2014

- 3:54 – 3:58 PM **Paper #87: Frequency and Complication Differences in Comorbid Psychiatric Disorders in Adult Spinal Deformity versus Spinal Fusion**
Courtney Toombs, BS; Justin C. Paul, MD, PhD; Baron S. Lonner, MD
- 3:58 – 4:07 PM **Discussion**
- 4:08 – 4:12 PM **Paper #88: The Influence of Patient, Hospital and Procedural Factors on the Cost and Length of Stay following Adult Spinal Deformity Surgery**
Andrew J. Pugely, MD; Christopher T. Martin, MD; Yubo Gao, PhD; Stuart L. Weinstein, MD; Sergio A. Mendoza-Lattes, MD
- 4:12 – 4:16 PM **Paper #89: Incidence of Radiographic and Implant-Related Complications in Adult Spinal Deformity Surgery, Patient Risk Factors and Impact on HRQOL**
Alex Soroceanu, MD, CM, MPH, FRCSC; Douglas C. Burton, MD; Justin S. Smith, MD, PhD; Vedat Deviren, MD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Behrooz A. Akbarnia, MD; Christopher P. Ames, MD; Thomas J. Errico; Shay Bess, MD; Richard Hostin, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group
- 4:16 – 4:20 PM **Paper #90: Radiological Outcomes and Complications of S2 Alar-Iliac Fixation in Adult Patients with Osteoporotic Spine**
Meric Enercan; Sinan Kahraman; Bahadir H. Gokcen, MD; Ayhan Mutlu; Erden Erturer; Cagatay Ozturk, MD; Ahmet Alanay, MD; Azmi Hamzaoglu, MD
- 4:20 – 4:29 PM **Discussion**
- 4:30 – 4:34 PM **Paper #91: Unanticipated Revision Surgery in Adult Spinal Deformity: An Experience with 815 Cases**
Feng Zhu; Bao Hong-da, PhD; Xu Sun, MD, PhD; Zhen Liu; Zhu Ze-Zhang; Qiao Jun; Yong Qiu, MD
- 4:34 – 4:38 PM **Paper #92: Dynamic Sagittal Balance Evaluated by Three-Dimensional Gait Analysis in Patients with Degenerative Lumbar Kyphosis**
Yo Shiba, MD; Hiroshi Taneichi, MD; Satoshi Inami; Makoto Ohe, MD; Hiroshi Moridaira; Daisaku Takeuchi; Yutaka Nohara, MD
- 4:38 – 4:42 PM **Paper #93: Do Adult Deformity Revisions Vary by UIV Location? Two- to Ten-Year Follow Up**
Prokopis Annis, MD; Brandon Lawrence, MD; William R. Spiker, MD; Michael D. Daubs, MD; Darrel S. Brodke, MD
- 4:42 – 4:51 PM **Discussion**
- 4:52 – 4:56 PM **Paper #94: Recurrence Proximal Junctional Kyphosis following Adult Spinal Deformity Surgery: Incidence and Risk Factors**
Haruki Funao, MD; Floreana A. Naef; Jaysson T. Brooks, MD; Richard L. Skolasky, ScD; Khaled Kebaish, MD
- 4:56 – 5:00 PM **Paper #95: Chain of Compensation Related to PI-LL Mismatch: A Complete Standing Axis Investigation Including Lower Extremities**
Virginie Lafage, PhD; Emmanuelle Ferrero; Renaud Lafage, MS; Vincent Challier, MD; Barthelemy Liabaud, MD; Bassel G. Diebo, MD; Shian Liu, BS; Jean-Marc Vital; Keyvan Mazda; Themistocles S. Protopsaltis, MD; Thomas J. Errico; Frank J. Schwab, MD
- 5:00 – 5:04 PM **Paper #96: Decreasing Long Construct Pedicle Screw Reduction and Residual Forces using a Computer-Assisted Rod Bending System**
Antoine G. Tohmeh, MD; Robert E. Isaacs, MD; Zachary A. Dooley, MS; Alexander W. Turner, PhD; Gregory M. Mundis, MD
- 5:04 – 5:13 PM **Discussion**

SCIENTIFIC PROGRAM SATURDAY, SEPTEMBER 13, 2014

Session 8	Pulmonary, Circulation and Sagittal Plane Abnormalities
Session Times:	7:55 – 10:30 AM
	ROOM: IDLUGHET HALL 1/2
	<i>Moderators: Benny Dahl, MD, PhD, DMSci & Hubert Labelle, MD</i>
7:55 – 8:00 AM	Welcome
8:00 – 8:04 AM	Paper #97: Surgical Approach and its Effect on PFT in AIS Patients: Approach May Not Matter <i>Daniel J. Sucato, MD, MS; Anna M. McClung, BSN, RN</i>
8:04 – 8:08 AM	Paper #98: The Effect of Late Isolated Rib Hump Resection on the Evolution of Pulmonary Function <i>Heiko Koller, MD; Tobias L. Schulte, MD, PhD; Juliane Zenner, MD; Jens A. Schmücker; Luis Ferraris, MD; Axel Hempfing; Marc Dreimann; Oliver Meier, MD; Michael Mayer, PhD</i>
8:08 – 8:12 AM	Paper #99: Thoracic Volume and Pulmonary Function at a Minimum of 20 Years following Treatment of Adolescent Idiopathic Scoliosis: Preliminary Results <i>Kristin England, MD; A. Noelle Larson, MD; David W. Polly, MD; Charles Gerald T. Ledonio, MD; Michael J. Yaszemski, MD, PhD</i>
8:12 – 8:21 AM	Discussion
8:22 – 8:26 AM	Paper #100: The Effects of the Three-Dimensional Deformity of Adolescent Idiopathic Scoliosis on Pulmonary Function <i>Burt Yaszay, MD; Tracey Bastrom, MA; Carrie E. Bartley, MA; Stefan Parent, MD, PhD; Peter O. Newton, MD</i>
8:26 – 8:30 AM	Paper #101: 3D Analysis: The Truth About the “Hypokyphosing Effect of Pedicle Screws” in AIS <i>Peter O. Newton, MD; Takahito Fujimori, MD, MSc; Josh Doan, MEng; Fredrick G. Reighard, MPH; Diana A. Glaser, PhD; Amirhossein Misaghi, MD</i>
8:30 – 8:34 AM	Paper #102: When Does Proximal Junctional Failure Require Revision? Validation and Utility of the PJF Severity Score <i>Robert A. Hart, MD; Christopher P. Ames, MD; Jayme R. Hiratzka, MD; D. K. Hamilton, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Michael P. Kelly, MD; Marilyn L. Gates, MD; Mark D. Rahm, MD; Munish C. Gupta, MD; Justin S. Smith, MD, PhD; Richard Hostin, MD; Eric Klineberg, MD; International Spine Study Group</i>
8:34 – 8:42 AM	Discussion
8:43 – 8:47 AM	Paper #103: Pelvic Alignment Influences Disc Hydration Properties after AIS Surgery: A Prospective MRI-Based Study <i>Kariman Abelin-Genevois, MD, MSc; Erik Estivalezes, PhD; Jerome Briot; Pascal Swider, PhD; Jerome Sales de Gauzy, PhD</i>
8:47 – 8:51 AM	Paper #104: Lumbopelvic Posture: Is Pelvic Incidence the Best Indicator For Lordosis? <i>Roger P. Jackson, MD; Anne McManus, RN</i>
8:51 – 8:55 AM	Paper #105: Clinical Tolerance to Sagittal Imbalance Varies with Age <i>Ferran Pellise, MD; Alba Vila-Casademunt; Montse Domingo-Sabat; Juan Bago, MD; Ahmet Alanay; Ibrahim Obeid; Francisco J. S. Pérez-Gruoso, MD; Emre Acaroglu, MD; European Spine Study Group</i>
8:55 – 9:04 AM	Discussion
9:05 – 9:09 AM	Paper #106: 18-Year Follow Up of Surgically Treated Scheuermann Patients Deterioration of Results over Time <i>Harm C. Graat, MD, PhD; Janneke J. Schimmel, MSc; Lotte Van Hessem, MD; Roel J. Hoogendoorn, MD, PhD; Allard J. Hosman, MD, PhD; Marinus De Kleuver, MD, PhD</i>
9:09 – 9:13 AM	Paper #107: Distal Fusion Level Selection in Scheuermanns Kyphosis: A Comparison of Lordotic Disc Segment versus the Stable Sagittal Vertebrae <i>Han Jo Kim, MD; Venu M. Nemani, MD, PhD; Kevin R. O’Neill, MD, MS; Brian J. Neuman, MD; Oheneba Boachie-Adjei, MD; Matthew E. Cunningham, MD, PhD; Lawrence G. Lenke, MD</i>

SCIENTIFIC PROGRAM SATURDAY, SEPTEMBER 13, 2014

- 9:13 – 9:17 AM **Paper #108: Sagittal Spinopelvic Alignment in Skeletally Mature Patients with Scheuermann’s Disease**
Marcin Tyrakowski, MD, PhD; Steven M. Mardjetko, MD, FAAP; Kris Siemionow, MD
- 9:17 – 9:26 AM **Discussion**
- 9:27 – 9:31 AM **Paper #109: Growth Modulation Changes in Childhood Post-Tubercular Kyphosis: Long-Term Prospective Multicenter Study over 10 Years**
S. Rajasekaran, PhD
- 9:31 – 9:35 AM **Paper #110: Current Evidence Regarding the Surgical and Non-Surgical Treatment of Pediatric Lumbar Spondylolysis: A Report from the Scoliosis Research Society Evidence-Based Medicine Committee**
Charles H. Crawford, MD; Charles Gerald T. Ledonio, MD; Shay Bess, MD; Jacob M. Buchowski, MD, MS; Douglas C. Burton, MD; Serena Hu; Baron S. Lonner, MD; David W. Polly, MD; Justin S. Smith, MD, PhD; James O. Sanders, MD
- 9:35 – 9:39 AM **Paper #111: High-Grade Spondylolisthesis Surgical Management: Reduction or Arthrodesis In Situ: A Multicenter Review of 207 Cases**
Féthi Laouissat; Clément Silvestre; Gerard Bollini; Thierry Odent, MD, PhD; Jerome Sales de Gauzy, PhD; Pierre Guigui; Keyvan Mazda; Pierre Roussouly, MD
- 9:39 – 9:48 AM **Discussion**
- 9:49 – 9:53 AM **Paper #112: The Role of Athletic Activity on Lumbar Structural Abnormalities in Adolescent Patients with Symptomatic Low Back Pain**
Gregory D. Schroeder, MD; Marco Mendoza, MD; Erika Daley, BS; Cynthia LaBella, MD; Jason W. Savage, MD; Alpesh A. Patel, MD; Wellington Hsu, MD
- 9:53 – 9:57 AM **Paper #113: Inefficiency of Preoperative Donated Autologous Blood to Decrease Transfusion Requirements after Surgery in AIS Patients**
Jesús F. Burgos, PhD; Carlos Barrios, MD, PhD; Cesar Perez-Caballero; Vicente García, MD; Ignacio Sanpera, MD, PhD; Gabriel Piza Vallespir, MD, PhD; Luis Miguel Antón-Rodríguez, PhD; Pedro Domenech, MD
- 9:57 – 10:01 AM **Paper #114: Efficacy of Epoetin Beta Injection during Autologous Blood Collection before Scoliosis Surgery**
Shota Ikegami, PhD; Jun Takahashi, MD; Keijiro Mukaiyama; Shugo Kuraishi; Masayuki Shimizu; Toshimasa Futatsugi; Hiroyuki Kato, MD, PhD
- 10:01 – 10:10 AM **Discussion**
- 10:10 – 10:19 AM **Transfer of Presidency**
Steven D. Glassman, MD & John P. Dormans, MD
- 10:19 – 10:29 AM **Awards Presentation**
Russell A. Hibbs Awards
Louis A. Goldstein Awards
John H. Moe Award
James O. Sanders, MD
Program Committee Chair
- 10:30 – 10:50 AM **Refreshment Break**
ROOM: IDLUGHET 3, LEVEL 1

SCIENTIFIC PROGRAM SATURDAY, SEPTEMBER 13, 2014

Session 9 Neuromuscular Deformity, Evidence and Outcomes

Session Times: 10:50 AM – 12:39 PM

ROOM: IDLUGHET HALL 1/2

Moderators: *Sigurd H. Berven, MD & Morio Matsumoto, MD*

- 10:50 – 10:54 AM **Paper #115: Variation in Readmission for Surgical Site Infections (SSIs) and Reoperation following Spinal Fusions for Neuromuscular Scoliosis**
Lisa McLeod, MD; John M. Flynn, MD; Mark A. Erickson, MD; Nancy H. Miller, MS, MD; John P. Dormans, MD
- 10:54 – 10:58 AM **Paper #116: A Prospective Study of a Decision-Making Algorithm for Significant Neurophysiologic Intraoperative Monitoring Events in Severe Spinal Deformity Surgery**
Benjamin T. Bjerke-Kroll, MD, MS; Daniel Zuchelli, BS; Venu M. Nemani, MD, PhD; Ronald G. Emerson, MD; Jennifer Ayamga, Mphil; Oheneba Boachie-Adjei, MD; FOCOS Research Associates
- 10:58 – 11:02 AM **Paper #117: Reliability of X-Ray Based Evaluation of Pedicle Screw Misplacement in Adolescent Spinal Deformity**
Saankritya Ayan, MD; Beverly Thornhill, MD; Adam L. Wollowick, MD; Terry D. Amaral, MD; Vishal Sarwahi, MD
- 11:02 – 11:11 AM **Discussion**
- 11:12 – 11:16 AM **Paper #118: Outcomes of Patients with Syringomyelia Undergoing Spine Deformity Surgery: Do Large Syrinxes Behave Differently than Small?**
Amer F. Samdani, MD; Steven W. Hwang, MD; Anuj Singla, MD; James T. Bennett, MD; Robert J. Ames, BA; Jeff S. Kimball, BS
- 11:16 – 11:20 AM **Paper #119: Long-Term Functional Outcomes in Duchenne Muscular Dystrophy Scoliosis: Comparing the Differences between Surgery and No Surgery**
Jeong Ho Seo; Byung Ho Lee, MD, PhD; Seong-Hwan Moon, MD, PhD; Dong-Eun Shin, PhD; Joong Won Ha; KiChan An, MD, PhD; Hak-Sun Kim, MD
- 11:20 – 11:24 AM **Paper #120: Spinal Cord Monitoring in Patients with Spinal Muscular Atrophy Undergoing Spinal Fusion: A 19-Year Experience**
Ryan Miller, MD; Patricia L. Rampy, MS, REPT, CNIM; Steven Sparagana, MD; Daniel J. Sucato, MD, MS
- 11:24 – 11:33 AM **Discussion**
- 11:34 – 11:38 AM **Paper #121: Are S1 Screws a Useful Adjunct to Iliac Screws in Long Paralytic Fusions to the Sacrum**
Scott Schoenleber, MD; Harry L. Shufflebarger, MD; Jahangir Asghar, MD; Tracey Bastrom, MA; Harms Study Group
- 11:38 – 11:42 AM **Paper #122: The Pros and Cons of Operating Early versus Late in the Progression of CP Scoliosis**
Steven M. Hollenbeck; Burt Yaszay, MD; Paul D. Sponseller, MD; Suken A. Shah, MD; Jahangir Asghar, MD; Mark F. Abel, MD; Firoz Miyanji, MD, FRCSC; Peter O. Newton, MD
- 11:42 – 11:46 AM **Paper #123: Long-Term Maintenance of Spontaneous Lumbar Curve Correction following Selective Thoracic Fusion of Lenke 1 Curves in AIS: Radiographic and Clinical Results 13 Years after ASF**
Heiko Koller, MD; Manabu Ito, MD, PhD; Christian Pirkahn; Oliver Meier, MD; Susana Núñez Pereira, MD, PhD; Hideki Sudo
- 11:46 – 11:55 AM **Discussion**
- 11:56 – 12:00 PM **Paper #124: SRS7: A Valid, Reliable, Responsive and Unidimensional Functional Outcome Measure for Operatively Treated Patients with AIS**
Amit Jain, MD; Paul D. Sponseller, MD; Stefano Negrini, MD; Peter O. Newton, MD; Patrick J. Cahill, MD; Tracey Bastrom, MA; Michelle C. Marks, PT, MA; Harms Study Group
- 12:00 – 12:04 PM **Paper #125: Correlation of Pre-Operative Deformity Magnitude and Pulmonary Function Tests (PFT) Revisited: A Study of 492 Scoliosis Patients to Improve the Prediction of PFT using Radiographs**
Heiko Koller, MD; Oliver Meier, MD; Juliane Zenner, MD; Marc Dreimann

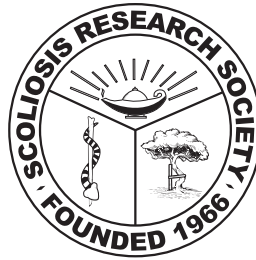
SCIENTIFIC PROGRAM SATURDAY, SEPTEMBER 13, 2014

- 12:04 – 12:08 PM **Paper #126: Relationship between Post-Operative Correction Rate and Screw Placement into Narrow Pedicles: Should We Challenge Narrow Pedicles in Adolescent Idiopathic Scoliosis?**
Tsutomu Akazawa, MD; Toshiaki Kotani; Tsuyoshi Sakuma, MD, PhD; Shohei Minami
- 12:08 – 12:17 PM **Discussion**
- 12:18 – 12:22 PM **Paper #127: Toei Study: Age Distribution and Health Related QOL of High Age Volunteers Evaluated by SRS Schwab Classification (Sagittal Modifiers)**
Daisuke Togawa, MD, PhD; Yu Yamato; Tatsuya Yasuda; Sho Kobayashi, PhD; Hideyuki Arima; Tomohiko Hasegawa; Yukihiro Matsuyama, MD
- 12:22 – 12:26 PM **Paper #128: Post-Operative Perfection: Ceiling Effects and Lack of Discrimination with Both SRS-22 and -24 in Adolescent Idiopathic Scoliosis Patients**
Tracey Bastrom, MA; Carrie E. Bartley, MA; Michelle C. Marks, PT, MA; Burt Yaszay, MD; Peter O. Newton, MD; Harms Study Group
- 12:26 – 12:30 PM **Paper #129: Observational Analysis of Changing Trends in Level of Evidence (LoE) of SRS Annual Meeting Podium Presentations in the New Millennium (2001-2013)**
Nanjundappa S. Harshavardhana, MD, MS(Orth), Dip SICOT; John P. Dormans, MD
- 12:30 – 12:39 PM **Discussion**

Case Discussion & Podium Abstracts

Case Discussion
& Podium Abstracts





The Scoliosis Research Society gratefully acknowledges
Orthofix for support of the E-Poster Kiosks,
Internet Kiosks and Annual Meeting E-News.



CASE DISCUSSION PRESENTATION ABSTRACTS

CASE DISCUSSION #1: ADOLESCENT SCOLIOSIS SURGERY

1A. Posterior Release, Temporary Internal Distraction Using the Magnetic Rod and Definitive Posterior Fusion for Severe Idiopathic Kyphoscoliosis in a 13-Year-Old AIS Patient

Heiko Koller, MD; Michael Mayer, PhD; Axel Hempling; Luis Ferraris, MD; Oliver Meier, MD
Germany

Summary: Temporary internal distraction using a magnetic rod for 2 weeks was used for correction of a severe and rigid kyphoscoliosis (Thoracic curve, TC, of 109° ; TC-flexibility of 21°) in a 13-yr-old patient. After a posterior release, daily distractions centered the corrective forces at the level of greatest TC rigidity. At 2 weeks, definitive posterior correction and fusion was accomplished. Preoperative TC improved from 109° to 41° indicating a correction of 65%. Temporary internal distraction using a magnetic rod carries the potential to replace HGT or significant 3-column osteotomies for the treatment of severe and rigid deformities.

Introduction: Treatment options for severe scoliosis ($>100^\circ$) entail anterior/posterior release, halo-gravity traction (HGT), 3-column osteotomies and posterior fusion. HGT for several weeks can be a significant burden for the patient. Distributing corrective forces with HGT at the level with greatest rigidity is difficult. We report our experience with posterior spinal release, temporary distraction and definite posterior fusion for severe kyphoscoliosis.

Methods: A 13-yr old patient presented with neglected AIS (Lenke 3C+). Radiographs revealed kyphoscoliosis with thoracic kyphosis of 76° , TC of 109° , lumbar curve (LC) of 75° , TC-flexibility of 21%, LC-flexibility of 23%, trunk height T1-L4 of 329mm and TC-apex translation of 63mm. The patient suffered from her large trunk deformity indicating surgery. We decided for staged posterior correction.

Results: During the 1st surgery, a posterior facet release T4-L4 and Ponte osteotomies T6-12 were done and pedicle screws inserted at T2-L4. Instrumentation and correction were done between T2-T5 and T12-L4 using a temporary 5.5mm diameter rod right and a magnetic 5.5mm diameter rod left. The patient underwent daily distractions using the external actuator. Immediately postop-1, the TC was 63° , LC was 46° and TC-apex translation was 44mm. After 14 days of distractions, TC was 50° , LC 46° , TC-apex translation was 19mm and trunk height was 405mm. Postop-2, the TC was 41° , LC was 10° , TC-apex translation was 10mm and trunk height was 420mm. At the 1yr follow-up, TC was 41° , LC 19° , TC-apex translation was 10mm and trunk height was 428mm. Thoracic kyphosis at follow-up was 52° . Final TC-correction was 63% and LC-correction was 75%. Postoperative body height increased from 162cm to 172cm. The patient experienced an uncomplicated course.

Conclusion: Internal temporary distraction using a magnetic rod might replace HGT in several situations. Distinct advantages are that corrective forces can be distributed at the levels of greatest rigidity. Focused distraction translates into shorter time between posterior release and definitive surgery if compared to HGT-therapy. Temporary distraction has the potential to reduce indications for HGT and the number of cases that otherwise might need significant 3-column osteotomies.



The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

1B. Tension Pneumothorax as a Complication of Inadvertent Pleural Tears during Posterior Spinal Surgery

Stephen J. Lewis, MD; Sam Keshen; Noah D. Lewis; Taylor E. Dear; Arne Mehrkens, MD; Ahtsham U. Niazi, FRCPC
Canada

Summary: Pleural tear is a common complication experienced during spinal fusion surgery. We present the clinical course of two patients that developed tension pneumothorax following inadvertent intra-operative pleural tears during posterior spinal surgery. It is important to recognize that tension pneumothorax can occur as a result of a pleural tear during spinal surgery so that proper steps can be taken towards timely recognition and treatment.

Introduction: Pneumothorax is a described complication of posterior spinal surgery. This case study investigates two separate instances of tension pneumothorax associated with spinal surgery that occurred during posterior spinal procedures with three column osteotomies using pedicle screws. These cases presented with delayed but progressive respiratory dysfunction and required subsequent management with chest tubes.

Methods: Intraoperative reports were retrospectively reviewed for two patients who underwent posterior spinal fusion and experienced pleural tear and subsequent tension pneumothorax. Surgical decisions for recognition and treatment were also reviewed.

CASE DISCUSSION PRESENTATION ABSTRACTS

Results: Unrecognized pleural tearing led to the formation of tension pneumothorax in both patients studied. Onset of respiratory signs and symptoms were delayed, occurring in the recovery room for the first patient, and intra-operatively for the second. Both patients were successfully treated with conversion to open pneumothorax and placement of chest tubes.

Conclusion: Tension pneumothorax is a complication that can arise during posterior thoracic spinal surgery as a result of an inadvertent pleural tear. Being aware of this potentially fatal complication will greatly help in the timely recognition and treatment of this condition should this situation occur. We recommend a low threshold for chest tube placement in patients with known or suspected pleural tears or in patients with undiagnosed respiratory failure undergoing posterior thoracic spine surgery.

1C. Cardiac Tamponade Following Posterior Spinal Fusion in a Patient with Severe Scoliosis

Burt Yaszay, MD; Carrie E. Bartley, MA; Peter O. Newton, MD USA

Summary: This is a case report of a 16 year old female with congenital hydrocephalus and neuromuscular scoliosis who was surgically treated for severe kyphoscoliosis. The patient had cardiac tamponade secondary to a central line that was poorly visualized on daily chest x-rays. Following extensive review, it has become policy to perform an ultrasound or echo to localize central lines obscured by severe scoliosis and/or spinal instrumentation.

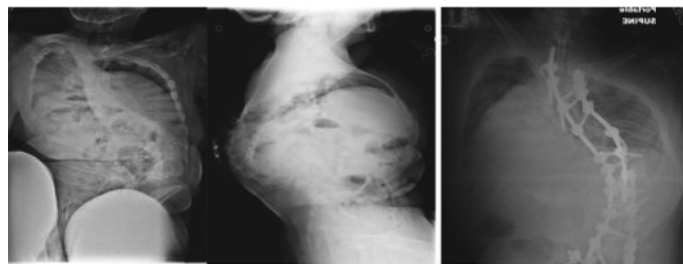
Introduction: Severe kyphoscoliosis and its associated trunk deformity have been shown to alter the relationship of the visceral anatomy, which can create challenges in visualization of normal landmarks on standard radiographs. Visualization can be made even more difficult by spinal instrumentation. The purpose of this study is to present a case of cardiac tamponade secondary to a central line that was obscured by severe scoliosis and spinal instrumentation.

Methods: A 16 year old female with congenital hydrocephalus and neuromuscular scoliosis since the age of 3 presented with 142° scoliosis and 151° kyphosis. The patient was cognitively normal and ambulated with assistance. Preop PFT was 15%. The patient underwent 6 weeks of halo traction with improvement of PFTs to 35%. A preop tracheostomy was completed per pulmonary recommendation. Following traction, the patient underwent an uneventful spinal fusion and instrumentation from T3-pelvis with T12 and L1 VCR. The patient was weaned from the ventilator on POD #5 and was mobilizing to chair. On POD #8, the patient was made NPO and given IVF through central line for anticipated bronchoscopy. During induction, the patient had a cardiac arrest.

Results: During the resuscitation, pericardiocentesis removed 250 ml of fluid with subsequent return of cardiac function. The removed fluid was consistent with infused IVF. Further evaluation determined that the central line eroded into the pericardium resulting in cardiac tamponade following routine IVF infusion. Previous chest x-rays performed daily in the ICU were unable to localize the tip of the catheter secondary to the distorted anatomy and overlying spinal instrumentation.

Conclusion: We present a case of cardiac tamponade secondary to a poorly

visualized central line in a patient with severe scoliosis. Routine chest x-rays performed daily were unable to localize the central line. Following extensive review, it has become policy to perform an ultrasound or echo to localize central lines obscured by severe scoliosis and/or spinal instrumentation.



Patient's pre-op spine x-rays (left, middle) and post-op chest x-ray (right).

1D. Modified T4 Hemivertebrectomy for Persistent High Left Shoulder following Surgery for Double Thoracic Scoliosis

Stephen J. Lewis, MD; Noah D. Lewis; Sam Keshen; Taylor E. Dear Canada

Summary: Shoulder balance is known to have a large effect on patient satisfaction following deformity correction. Previous studies have outlined guidelines for determining levels of instrumentation in order to prevent post-operative high left shoulder. However, to our knowledge, no study has provided instructions on how to correct coronal imbalance in previously fused scoliosis patients. We describe a case using a T4 unilateral pedicle subtraction osteotomy (PSO) and contralateral Smith-Petersen Osteotomy (SPO) to treat high left shoulder in a patient who had previously undergone posterior instrumented fusion for adolescent idiopathic scoliosis.

Introduction: Double thoracic curve patterns present numerous challenges to the surgeon. Despite recognizing the proximal curve and extending the constructs proximally to T2, leveling the shoulders remains a concern.

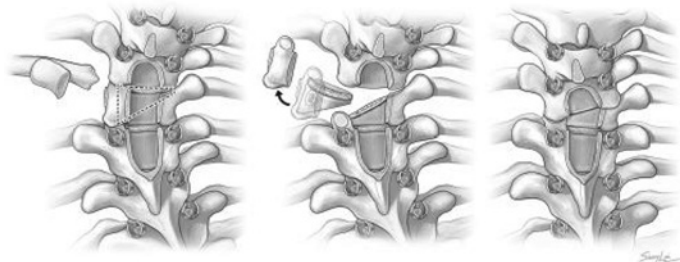
Few treatment options exist for previously fused patients with persistently imbalanced shoulders. This case study illustrates a case of revision idiopathic scoliosis correction with shoulder re-stabilization, in a previously treated double thoracic curve. An offset osteotomy was performed to balance the spine.

Methods: The radiographs and clinical charts were reviewed for a 17 year old female patient treated with a revision fusion and modified T4 hemivertebrectomy for a persistently high left shoulder following previous correction of a Lenke II idiopathic scoliosis.

Results: A reduction in the T1 tilt angle from 19.2° to 10.1° and an improvement in the coronal Cobb of the proximal thoracic curve from 37° to 17° was obtained. Shoulder balance was greatly improved.

Conclusion: A proximal thoracic partial vertebrectomy with unilateral PSO and contralateral SPO is a technique that can be used to successfully correct fixed shoulder imbalance following posterior instrumented fusion of a double thoracic adolescent idiopathic scoliosis.

CASE DISCUSSION PRESENTATION ABSTRACTS



Schematic figure demonstrating the offset osteotomy.

CASE DISCUSSION #2: CERVICAL, CONGENITAL AND NEUROMUSCULAR DEFORMITY

2A. Severe Cervical Kyphosis and Spondyloptosis in Larsen Syndrome with Progressive Myelopathy Ameliorated with Decompression and Fusion: A Report of Two Cases

Joshua M. Pahys, MD; Patrick J. Cahill, MD; Jahangir Asghar, MD; Randal R. Betz, MD; Amer F. Samdani, MD
USA

Summary: Two patients with Larsen syndrome (ages 5 and 14 years) presented with significant, progressive weakness and were diagnosed with severe congenital cervical kyphosis (patient A) and cervical spondyloptosis (patient B). Both patients underwent preoperative halo-gravity traction prior to multi-level anterior corpectomy/fusion with supplemental posterior instrumentation and fusion. Postoperatively, both patients' neurologic function returned to normal and they were able to ambulate independently. Screening radiographs of the cervical spine in Larsen syndrome patients is highly recommended.

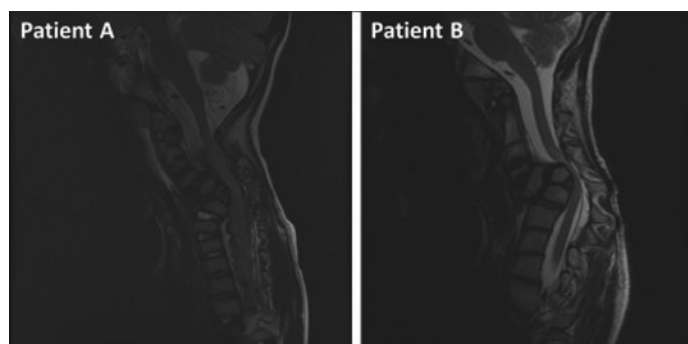
Introduction: Larsen syndrome is associated with multiple joint dislocations and joint laxity. Severe scoliosis and kyphosis have also been described. We report two cases of severe cervical kyphosis with resultant progressive myelopathy in two patients with Larsen Syndrome.

Methods: Two Larsen syndrome patients ages 5 (patient A) and 14 years (patient B) presented with progressive myelopathy. Patient A complained of progressive ataxia and paresthesias, along with upper extremity weakness. Imaging for Patient A revealed angular cervical kyphosis of 75° secondary to a hypoplastic C5 vertebra as well as spondylolysis of all levels C2 through T1. MRI of patient A demonstrated cord impingement and cord signal change. Patient B had severe progression of her myelopathy and weakness to the point where she became wheelchair bound for six months prior to presentation at our institution. Patient B was found to have spondyloptosis of C4/5 with 3mm of space available for the spinal cord. Both patients were placed in preoperative halo-gravity traction in an effort to decrease the deformity prior to formal decompression and stabilization.

Results: Both patients underwent two stage anterior multilevel corpectomy and fusion followed by supplemental posterior spinal fusion and instrumentation. Patient A reported immediate amelioration of paresthesias with return of full motor strength in all extremities and an improved gait postoperatively. Patient B, who was wheelchair bound preoperatively, had rapid relief of her paresthesias,

and significant improvement in motor strength, regaining the ability to ambulate by six months postoperative.

Conclusion: We report two patients with Larsen syndrome who presented to our institution with declining motor strength and ambulatory dysfunction. The patients were subsequently found to have severe cervical kyphosis and cord compression. Both patients' symptoms were ameliorated with anterior-posterior decompression and fusion with preoperative halo-gravity traction. Clinicians should consider obtaining screening cervical imaging in patients with Larsen syndrome in an effort to screen for cervical kyphosis prior to the onset of any neurologic changes.



Preoperative T2 weighted sagittal MRI images of Patient A and B

2B. The Role of Instrumented Fusion in the High Cervical Area in Young Children: A Mini Series

Pedro M. Fernandes, Licenciature; Dezsoe J. Jeszenszky, MD, PhD
Portugal

Summary: To describe our results for the surgical treatment of atlantoaxial instability and high cervical deformity in a pediatric patient population.

Introduction: There are no gold standards for stabilisation procedures of upper cervical pathologies in young children. The risk for pseudoarthrosis is high and the need for external support is frequently needed. Rigid instrumentation improves the fusion rate considerably and is gaining general acceptance

Methods: Four cases were retrospectively reviewed. (A 5 years old girl with 14 months old atlantoaxial dislocation, a 4 and a 7 years old children with syndromic atlantoaxial instability (Down Syndrome and Metathropic dysplasia), and finally a 2 years old male with Loeyd Dietz syndrome with major kyphotic deformity with the apex at C3 level along with a gross instability following 3 previous surgeries are described. Two patients had neurological compromise, one left hemiplegia ASIA grade 3 and the other with grade 3 tetraplegia. All cases were operated posteriorly, with full deformity reduction and rigid instrumentation with a 3,5 mm system, according to Harms technique in three and occipito-C4 lateral mass instrumentation with deformity correction in other.

Results: The patient with the old C1/C2 dislocation and severe cord compression experienced worsening postoperatively (became tetraplegic) but recovered markedly within 3 months after surgery. The patient with Downs syndrome recovered also from her neurological deficit. With a mean follow up of 22 months (min 18-max 32 months) patients are doing well with no neurological deficits and no residual instability having no complication with cervical spine fixation.

Conclusion: High cervical fixation in children is a considerable challenge especially in dysplastic and revision cases. Non-union is frequent because of

CASE DISCUSSION PRESENTATION ABSTRACTS

biomechanical reasons, poor bone stock and difficulties in achieving rigid fixation. This series is a good example of the benefits of rigid fixation in axial spine in children avoiding complications with excellent outcome.

2C. Optimal Blood Conservation Strategies can Prevent Blood Transfusion in Jehovah's Witness Myelomenigocele Patient with Severe Deformity

Preethi M. Kulkarni, MD; Marina Moquilevitch, MD; Adam L. Wollowick, MD; Vishal Sarwahi, MD; Terry D. Amaral, MD
USA

Summary: Myelomenigocele patients are at increased risk of blood loss and infection. This is even more challenging when the pt is Jehovah's witness. However, peri-operative erythropoietin, intra-op blood conservative strategies, staging of surgery and multi disciplinary approach allows for satisfactory outcomes.

Introduction: 12 yrs old with myelomenigocele, VP shunt, cognitively normal, non-ambulatory with progressive scoliosis of 63° curve. Patient is a Jehovah's witness and thus cannot receive blood transfusion. Myelomenigocele also increases the risk of infection, non-union due to absent posterior elements and challenging wound closure due to absent/atrophic posterior muscle mass.

Methods: Erythropoietin was given a week prior to surgery (dosage: 150u/Kg-3x/week). Hb 12/Hct 37, pre-erythropoietic treatment and Hb 12.5/Hct 40 post erythropoietic treatment. In Stage I anterior multi level discectomy with fusion from L1-L4 through retroperitoneal approach carried in collaboration with vascular surgery. At the same stage posterior spinal instrumentation was carried out from L1-S1 along with neurosurgical mobilization of the thecal sac. Goal oriented fluid management anesthesia protocol with cell saver and Tranexamic acid was utilized to limit blood loss. Once the Hct dropped down intraoperatively to Hct 28, surgery was abandoned in favor of second stage procedure. Post-op erythropoietin was given for 2nd stage surgery which was 2 weeks later and the Hct/Hb was adequate before surgery. Fusion was extended from T2-pelvis and a complex wound closure. Vancomycin powder was utilized at the time of wound closure.

Results: Patient underwent complex stage lengthy anterior and posterior spinal procedure without need for any blood transfusion.

Conclusion: In complex cases combination of erythropoietin, goal directed fluid management protocol and multidisciplinary team approach can result in ideal outcome.



2D. Case of Early Distal Junctional Kyphosis in a Neuromuscular Scoliosis Patient Treated with Posterior Spinal Fusion Associated with Postural Habits

Elias C. Papadopoulos, MD; Francisco J. S. Pérez-Gruoso, MD
Greece

Summary: A 14 yo girl with severe epilepsy and NM scoliosis was successfully treated with posterior spinal fusion. She returned for the first follow up visit with a fracture through both L4 pedicles and kyphosis in the lumbar spine. The assumed mechanism of fracture was her preference of laying in bed in a prone position with her hips in her chest. She underwent posterior extension of the fusion to the sacrum-iliac with TLIF at the L5-S1 level. Reduction of the fracture was achieved with removal of the callous with the use of curettes at the fracture site and the sagittal alignment was restored. At 1 year follow-up patient is ambulating with excellent alignment in both planes.

Introduction: Distal Junctional degeneration is an uncommon cause of reoperation in young scoliotic patients. This case is unique because a) the horizontal type of fracture through the pedicles and b) because of the possible mechanism of injury.

Methods: A 14 year old girl with severe epilepsy and NM scoliosis underwent a posterior spinal fusion from T4 to L4. She returned for the 3-month of follow up visit with a fracture through the pedicles of L4 and lumbar kyphosis. Because of her inability to communicate, parents weren't aware of any symptoms. The only possible causative factor was the preference of the patient to spend most of her bed time in a knees-on-chest prone position, a habit present before and after the first surgery.

Results: Patient underwent posterior extension of the fusion to the sacrum-iliac with TLIF at the L5-S1 level. Reduction of the fracture and restoration of the sagittal alignment was achieved with curettage and cleaning of the callous at the fracture site. Postoperatively, patient was strictly supervised in order to avoid the knees on chest posture.

Conclusion: This is a unique DJK case that could possibly have been avoided if the harmful habit was early identified and corrected. Reduction of the fracture was feasible because of the relatively early intervention. nevertheless a pedicle subtraction osteotomy should always be anticipated in similar delayed cases.



CASE DISCUSSION PRESENTATION ABSTRACTS

2E. Safety and Efficacy of One-Stage Spinal Osteotomy for Severe and Rigid Congenital Scoliosis (CS) Associated with Split Spinal Cord Malformation (SSCM)

Huiren Tao, MD, PhD; Michael S. Chang, MD

China

Summary: The present study was performed to evaluate the safety and efficacy of one stage spinal osteotomies for 29 consecutive patients who had severe and rigid CS associated with SSCM.

Introduction: Congenital scoliosis (CS) and SSCM is often encountered concurrently in clinical settings. Conventional practice for CS associated with SSCM is neurosurgical intervention for the SSCM itself as a first stage followed by scoliosis correction 3 to 6 months later in a second stage. More recently, one stage posterior and/or anterior instrumentation has been proposed for moderate CS associated with SSCM. However, information is still lacking regarding the application of one stage spinal osteotomy for severe CS (The major curve more than 80° with flexibility less than 30%) associated with SSCM.

Methods: Patients were treated by one-stage spinal osteotomy between September 2007 and June 2011 in our hospital. The clinical records were reviewed for demographic data, radiographic data, operative time, intraoperative blood loss and blood transfusion, perioperative complications, and functional outcomes.

Results: There were 18 females and 11 males with an average age of 15.5±3.6 years (range, 12-28 years). Eleven patients had type I SSCM and 18 had Type II SSCM. Patients were observed for a minimum of 24 months after initial surgical treatment with an average follow-up of 43.0±17.1 months (range 24-68 months) from September 2007 and June 2013. The mean operative time and average blood loss of type I SSCM was significantly greater than those of type II SSCM (P<0.05). The major curve was corrected from an average of 97.2°±17.8° to 35.7°±15.9°, a mean correction rate of 64.3%±11.0%. The average loss of correction at final follow-up was 2.9% for major curves. The overall complication rate was 24.1%, including transient neurological deterioration in 3 patients, cerebrospinal fluid leakage in 2 patients, urinary tract infection in 1 patient and pleural rupture in 1 patient.

Conclusion: One-stage spinal osteotomy is effective for the correction of severe CS and SSCM without increasing the rate of surgical complications. However, surgical treatment of type I SSCM does require more operating time and blood loss, which mandates the surgeon to adopt flexible.



An 15-year-old female patient with Congenital scoliosis (CS) associated with split spinal cord Malformation (SSCM). She underwent bony spur resection, posterior instrumentation, Posterior Vertebral Column Resection at T6-7 vertebrae, and correction and fusion Simultaneously. (a,b) Preoperative anteroposterior and lateral radiographs show the mean major coronal curves 92°, The trunk imbalance was 1.2 cm in the coronal plane and 0.4 cm in the sagittal plane. (c,d,e) Preoperative computed tomographic, magnetic resonance imaging sections show type I SSCM at T3-4 and intraoperative findings. (f,g) Preoperative photograph showed obvious kyphoscoliosis. (h,i) Postoperative anteroposterior and lateral radiographs show the mean major coronal curves 35°, The trunk imbalance was 0.8cm in the coronal plane and 0.5 cm in the sagittal plane. (j,k) Intraoperative, bony spur resection and posterior instrumentation was performed. (l,m) The trunk balance was well and no found decompensation phenomenon.

CASE DISCUSSION #3: NEUROLOGIC DETERIORATION AND OTHER MAJOR COMPLICATIONS

3A. Severe Kyphoscoliosis Surgery, Staged Due to TcMEP Loss with Prolonged Delay of Second Stage from Severe Nutritional Deterioration

Terry D. Amaral, MD; Saankriya Ayan, MD; Adam L. Wallowick, MD; Vishal Sarwahi, MD

USA

Summary: 17 years old male with prior history of neuroblastoma excision from the spine reviewed for severe kyphoscoliosis. Surgery had to be aborted after motor evoked potential loss following peri-apical pedicle screw insertion. Post-operative course was complicated with severe nutritional decompensation and multi organ dysfunction delaying the second stage surgery.

Introduction: 17 years old male who had a prior history of neuroblastoma excision from spine at 14 months of age evaluated for severe kyphoscoliosis with a T4-L1 curve of 79 degrees and multiple mid thoracic spine and rib fusion. He was planned for a combined anterior release and posterior instrumentation surgery.

Methods: Intra operatively the surgery had to be abandoned due to loss of motor evoked potential during final pedicle screw instrumentation in the peri-apical segment of the curve after anterior release of T5-T10 disc spaces. The wake up test demonstrated full motor function.

Post-operative course was complicated by MRSA septicemia, respiratory distress in the setting of suspected pulmonary embolism requiring respiratory support. Also nutritional deterioration marked by 14 pound weight loss over 3 weeks, nausea, vomiting diarrhea and difficulty tolerating PO feeds, complicated issues further. Combined multimodal teamwork led him to fitness to undergo second stage surgery one month later.

Results: His spine was stabilized without sequelae, though ideal correction expected was not achieved due to stiffness despite anterior release and osteotomy. Post operative recovery was slow though progressive.

Conclusion: Vigilante postop management is paramount for preparation for subsequent stages of surgery. Delays from lack of nutritional support after the first step had led to premature healing of the anterior release thus limiting

CASE DISCUSSION PRESENTATION ABSTRACTS

the ultimate expected correction. This case illustrates the importance of communication and inter disciplinary team management.



3B. Implant Failures in Neurologically Intact Syndromic Kyphoscoliotic Growing Spine with Significant Spinal Cord Abnormalities

Terry D. Amaral, MD; Preethi M. Kulkarni, MD; Aviva G. Dworkin, BS; Adam L. Wollowick, MD; Vishal Sarwahi, MD

USA

Summary: Proximal implant failure in 5 yr old female with severe scoliosis, VACTERL syndrome and menigomyelocele.

Introduction: 5 year old female with sever infantile scoliosis, sacral agenesis, VACTERL syndrome, menigomyelocele, Cloacal malformation with colostomy, failed conservative treatment. Growing rod from T2-L4 with apical fusion at T9-T10, no complications. 3 months post-op patient had implant failure at proximal segment with loss of correction. Second revision was for loose pedicle screws, hooks causing implant irritation. Multiple revision done to maintain correction.

Methods: First revision for proximal implant failure consisted of removal of proximal rod and screws with wound debridement. Fracture at T2 with loose screw, loose sublaminar hooks at T3 noted. Bigger screws placed at T4 on both sides. Second revision due to implant irritation, loose pedicle screw and hooks. Loose screws and hooks removed with proximal rod removal. Third revision, hooks pulled out. Hence, translaminar wire and hooks were introduced. The translaminar wire and hooks failed to maintain correction. Seven revisions leading finally to a complete removal due to implant irritation and MRSA treated with iv vancomycin.

Results: Multiple implant failure and infection led to Risser type casting to prevent progression of curve until skeletal maturity. Presently curve still progressing through cast treatment. Decision to wait for skeletal maturity may cause severe pulmonary morbidity. Evaluation of MRI of her spine by neurosurgeon showed multiple cord abnormalities which would lead to paralysis with just decompression and no correction.

Conclusion: Poor bone quality from chronic malnutrition and nutritional wasting from the colostomy with progressive severe kyphoscoliosis deformity led to instrumentation pull out. Progressive severe kyphoscoliosis may lead to severe pulmonary complications and potential morbidity but surgical correction may result in paralysis due to multiple spinal abnormalities. This has lead to a quandary for treatment options.



3C. Malignant Hyperthermia during Scoliosis Surgery: A Sentinel, Near Fatal Event

Jahangir Asghar, MD; Joshua M. Pahys, MD; Patrick J. Cahill, MD; Amer F. Samdani, MD; Harry L. Shufflebarger, MD
USA

Summary: Malignant Hyperthermia (MH) is an exceedingly rare and potentially fatal complication. The only proven treatment is Dantrolene, which can lead to profound muscle weakness and diminish MEPs.

Introduction: Malignant Hyperthermia (MH) is an exceedingly rare (1:50,000) and potentially fatal complication. This case reports discusses the events surrounding a case of MH during spinal deformity surgery and its subsequent repercussions.

Methods: A 13-year-old male with Mobius syndrome and a 67° right thoracic curve underwent an elective posterior spinal fusion from T2-L2. During the procedure, total intravenous anesthesia with Propofol and Fentanyl was utilized. No issues were noted during induction and intubation. The surgical procedure was started without significant event and intraoperative neuromonitoring signals were initially strong. Exposure, posterior releases, screws and the first rod were placed without event. At 290 minutes and 800 cc blood loss into the operation, a large rise in the end tidal CO₂, increase in blood pressure, and EKG changes were noted. The anesthetist suspected MH and emergent treatment was started. This included the bolus administration of dantrolene, a muscle relaxant that acts by abolishing excitation-contraction coupling in muscle cells. 10 minutes after bolus administration of Dantrolene there was a loss of motor evoked potentials (MEP). The patient was emergently closed and remained intubated. Initial neurologic exam, revealed 1 to 2 out of five strength to all motor distributions with intact sensation. This slowly improved over a couple of hours and would acutely worsen every six hours with the re-administration of dantrolene. Once stabilized CT and MRI were obtained. There was no evidence of mal placed hardware or extrinsic compression.

Results: The patient remained intubated for 10 days and eventually received a tracheostomy secondary to associated respiratory failure. He recovered over a course 8 weeks and was subsequently decannulated. The patient returned to normal motor function after discontinuation of the dantrolene, and remains intact at five years postop.

Conclusion: MH is a rare and potentially fatal condition. Although associated, primarily, with inhalational anesthetics, there are case reports of MH with propofol and other IV administered agents. The only proven treatment is Dantrolene, which can lead to profound muscle weakness and diminish MEPs.

CASE DISCUSSION PRESENTATION ABSTRACTS

3D. Lower Extremity Paralysis Presenting 36 Hours after Attempted Posterior Spinal Fusion for Severe Scoliosis in an Adolescent

Joshua M. Pahys, MD; Patrick J. Cahill, MD; Amer F. Samdani, MD; Jahangir Asghar, MD; Randal R. Betz, MD
USA

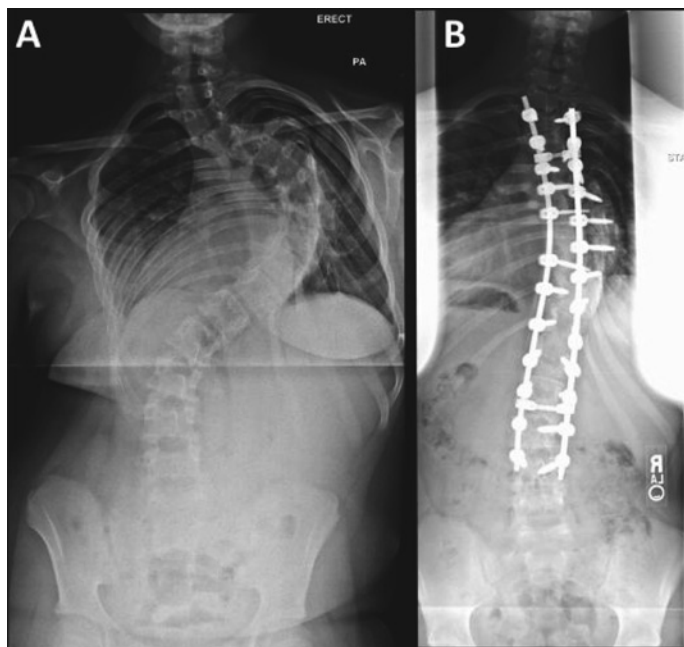
Summary: A 13 year old female with severe scoliosis of 125° underwent attempted PSF with multiple Ponte osteotomies complicated by transient loss of TCMEP. The patient awoke with a normal neurologic examination, but 36 hours postoperative developed near complete paraplegia after a brief drop in MAP. The patient's strength returned to normal after emergent laminectomy and apical pedicle excision. Perioperative temporary spinal stabilization across osteotomies and strict postoperative MAP monitoring should be considered for severe scoliosis after transient intraoperative TCMEP loss.

Introduction: Cases of delayed neurologic deficits after posterior spinal fusion (PSF) for scoliosis have been sparsely reported. We report a case of significant postop paraplegia presenting 36 hours after attempted correction of severe scoliosis in an adolescent.

Methods: A 13 year old female presented with a severe scoliosis of 125°, stable Chiari I malformation, and an otherwise normal MRI and neurologic examination. The patient underwent screw instrumentation from T2-L2 with Ponte osteotomies T4-T12. There was a transient drop in transcranial motor evoked potentials (TCMEP) during apical Ponte osteotomies which returned rapidly with an increase in mean arterial pressure (MAP). A second, transient decrease in TCMEP occurred with attempted rod implantation and curve correction and TCMEP returned immediately after the corrective forces were removed. The case was then aborted and she awoke with a normal neurologic exam. On postop day (POD) #2, the patient had a brief MAP drop to 70mmHg overnight. The patient awoke with complete paralysis of her bilateral lower extremities and altered sensation. MAP was elevated >90mmHg with a slight motor improvement. CT scan/myelogram revealed appropriate placement of instrumentation with lack of dye at the apex of the deformity. Emergent laminectomy and concave pediclectomy were performed. No epidural hematoma was identified, but the cord was draped over the apical pedicles.

Results: The patient's motor strength improved to 5/5 by POD #3 with the patient's MAP kept >90mmHg for 72 hours. The patient subsequently underwent successful PSF without complications one week later. One year postop, the patient has a normal exam and maintenance of curve correction of 40°.

Conclusion: A patient with severe scoliosis developed complete paraplegia 36 hours after attempted PSF. The paraplegia was reversed after immediate increase in MAP to ≥ 90 mmHg and return to the OR for laminectomy with apical concave pediclectomy. After loss of TCMEP signals strict maintenance of MAP ≥ 90 during the periop period is paramount. Consideration may be given to stabilization of the spine during pone osteotomies in severe curves similar to stabilization during vertebral body resections.



A) Preop radiograph B) One year postop radiograph

CASE DISCUSSION #4: ADULT DEFORMITY

4A. Non-Contiguous Two Level VCR for Severe Thoracic Kyphosis in an Osteoporotic Patient

Floreana A. Naef; Khaled Kebaish, MD
USA

Summary: We present a case of severe thoracic kyphosis in a 72 year old male diagnosed with multiple myeloma in 4/08 and subsequently underwent bone marrow transplantation. The patient suffered multiple osteoporotic fractures in the thoracic spine leading to a severe kyphosis, breathing difficulty and pain.

Introduction: Surgical treatment of adult deformities in the osteoporotic spine in patients with a severe deformity is a challenging problem and is associated with a high rate of failure and complications. Indications of surgery in this patient were significant pain and limitation of the patient's walking distance and breathing difficulty secondary to his deformity. Pulmonary function testing revealed a FVC suggestive of a restrictive ventilatory defect. Compared to his prior measurement the patient lost 10 inches of height from 66.5 to 56.5 inches

Methods: DEXA scan revealed severe osteoporosis with a T-score of -4.8 in both hips. Radiographs showed multiple compression fractures in the thoracic and lumbar spine. Thoracic kyphosis measured 130 degrees and SVA was 13.8 cm of positive balance.

The patient underwent posterior spinal fusion from T2 to the sacrum which was staged into 2 settings. Correction was achieved by posterior vertebral column resection of T9 and T12. Vertebroplasty was performed at all instrumented levels down to L3 due to the severe osteoporotic nature of his bone.

Results: Postoperative radiographs showed correction of thoracic kyphosis to 47 degrees.

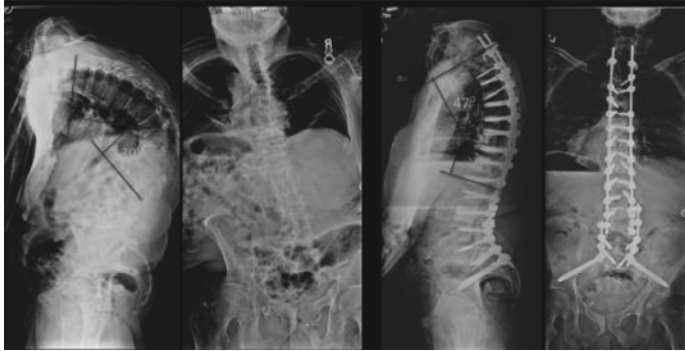
Combined focal correction at the osteotomy sites was 65 degrees.

CASE DISCUSSION PRESENTATION ABSTRACTS

ODI score showed an improvement from 60 preoperative to 28 at six weeks postoperative and to 14 at one year follow up. SRS-22 score showed similar improvement as well.

Complications included a dural tear and Non ST segment elevation myocardial infarction and right leg weakness with a weak TA and EHL 2/5 which partially recovered over the following 6 months.

Conclusion: Posterior vertebral column resection and cement augmentation is an effective strategy for treatment of severe spinal deformity in an osteoporotic patient. However, it is a technically demanding procedure with a potential high risks and serious complications



4B. Severe PJK with Previous Anterior and Posterior Instrumentation in an Osteoporotic Patient Requiring Additional Revision and Extended PSO in Thoracic Spine

Floreana A. Naef; Khaled Kebaish, MD
USA

Summary: We present a 67 year old female who developed severe proximal junctional kyphosis with sagittal as well as coronal imbalance. She has a complex history of three prior spine surgeries. Her initial surgery in 2002 was performed for spinal canal stenosis with laminectomy from L2 to sacrum. Her second surgery followed in 2004 with PSF T11-S1 with anterior instrumentation and interbody fusions from L2-S1 for correction of flat back. One year later she had revision of the PSF as well as the ASF through a lateral approach for nonunion and failed instrumentation.

She presented with severe PJK at T10-T11 measuring 60° with positive sagittal balance of 25 cm and coronal imbalance of 6.3 cm to the left. She also had severe back pain and difficulty walking and relied on using a walker for ambulation.

Surgical treatment was performed and her deformity was corrected through an extended PSO of T11.

Introduction: Proximal Junctional Kyphosis continues to be a challenge for spine surgeons. Revision strategies are tailored for each individual patient according to the levels involved, previous instrumentation and the degree of the focal deformity. A 65 degree PJK at the T10-T11 with severe sagittal and coronal imbalance is a very challenging problem. The following issues added more complexity to the case: Complicated history of previous spine surgeries, presence of anterior instrumentation and Interbody fusion across the kyphotic level, history of radiation therapy for renal cell carcinoma to the affected region and the severe

osteoporosis with a T-score of -2.5. In this case VCR is usually needed to correct the deformity. This meant staging of the procedure with removal of the proximal anterior instrumentation first to allow for reduction of the deformity through a second posterior approach. At the same time an anterior approach would be risky given the history of nephrectomy and radiation at the affected level.

Methods: The patient underwent extension of instrumentation to T4 with an asymmetric PSO at T11. The posterior screws at T11 and T12 were revised and connected to the previous construct at L1, TP hooks were used at the most proximal level to provide a softer landing. Correction of the deformity was achieved through an en mass reduction technique that allowed for reduction without cantilevering on the screws. A cage was placed across the osteotomy site to achieve interbody fusion and prevent loss of correction. OR time was around 415 min and EBL 1750 cc. The patient spent 3 days in the ICU. Her post-operative course was complicated by a UTI.

Results: Postoperative radiographs showed correction of the sagittal and coronal imbalance and reduction of the kyphosis at T10-T11 to 5°. Focal correction at the osteotomy sites was 55°. At 6 weeks postop the patient was doing well in spite of developing a compression fracture at T5 with minimal loss of sagittal correction with 2.5 cm +ve balance

Conclusion: Asymmetric PSO allows for correction of severe kyphotic deformities as well as coronal imbalance. En mass reduction is an effective technique for correction of angular deformities without compromising the fixation anchors.



4C. Adult Idiopathic Scoliosis with Iatrogenic Flat Back Presenting with Coronal and Sagittal Decompensation after Scoliosis Surgery

Vishal Sarwahi, MD; Saankritya Ayan, MD; Terry D. Amaral, MD; Preethi M. Kulkarni, MD; Adam L. Wollowick, MD
USA

Summary: 49 years old morbidly obese female with adult idiopathic scoliosis and low back pain underwent L1-5 laminectomy and fusion for back pain. She presented with iatrogenic flat back and uncorrected scoliosis. She continues to have gross coronal decompensation even after combined anterior and posterior scoliosis surgery due to under correction of the L4-S1 fractional curve.

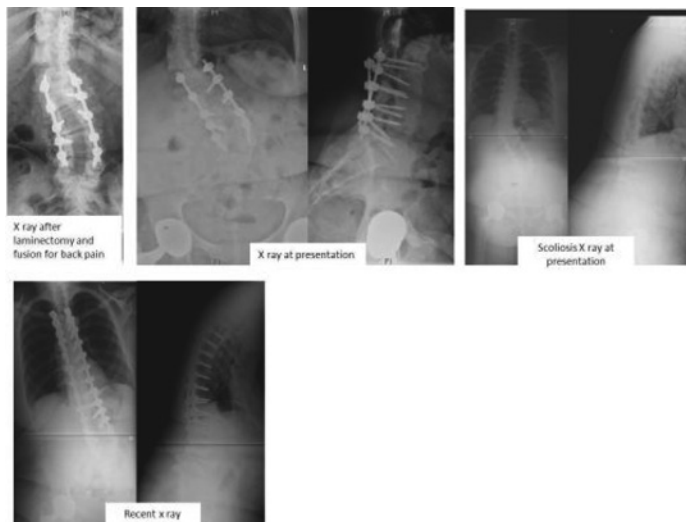
Introduction: 49 years old morbidly obese female with adult idiopathic scoliosis and low back pain underwent L1-5 laminectomy and fusion for back pain. She presented with iatrogenic flat back and further decompensation of scoliosis on post-surgery films with solid fusion from L1-5.

CASE DISCUSSION PRESENTATION ABSTRACTS

Methods: She was indicated for two stage anterior and posterior surgery. First stage involved anterior release and ALIF cage from L1-5. A week later multiple level thoracic Smith Petersen osteotomy and fusion was done from T4-S1. Intra operative difficulty in assessing the spino pelvic alignment was encountered due to morbid obesity. Post operatively she was still pitching forward and obliquely. The sagittal balance was restored on sitting films but coronal plane was marked by an oblique take off of the whole spine at the L5-S1 junction and gross coronal imbalance.

Results: Patient is being indicated for asymmetric PSO of L3 for correction of deformities.

Conclusion: Deformity surgery in a fused spine is largely dependent on adequate anterior and posterior release with or without osteotomies for adequate mobilization of the spine. Failure to assess the mobility and spinopelvic alignment intraoperatively is difficult and often challenging especially in obese patients. Our failure is largely consequent to our underestimation of L4-S1 fractional curve.



4D. Severe Kyphosis in Adult Patient with Significant Cardiopulmonary Compromise: Safety, Work-Up and Treatment Options

Preethi M. Kulkarni, MD; Terry D. Amaral, MD; Adam L. Wollowick, MD; Vishal Sarwahi, MD

USA

Summary: A 59 year old male patient with severe kyphosis, severe restrictive lung disease and non-ischemic cardiomyopathy.

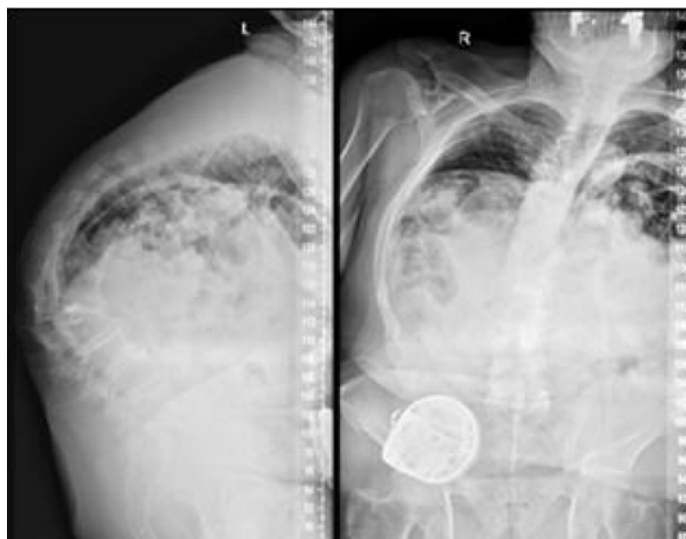
Introduction: 59 year old male patient with severe kyphosis and progressively deteriorating respiratory impairment leading to chronic hypoxemia and chronic daytime hypercapnia. He has obstructive sleep apnea with need for BiPAP with oxygen. He also has history of non-ischemic cardiomyopathy with palpitation due to premature ventricular contractions (PVCs).

Methods: Severe kyphosis (105° T3-T12) in patient with restrictive pulmonary disease and non-ischemic cardiomyopathy, further complicated with sleep apnea and obesity. The patient has significant sagittal imbalance, is unable to stand upright, and uses a walker for ambulation. Patient is grossly neurologically intact. He has undergone vertebroplasty in the past at another institution. Patient is

high risk from cardiac and pulmonary standpoint. No angina, CHF and normal coronary arteries on cardiac catheterization. The LVEF was 55%. Pulmonary function test showed vital capacity decreased from 2.6L in 2009 to 1.6 L 2012, FEV1 reduced from 2.1 in 2009 to 1.33 in 2012. Hence, suggesting a progressively deteriorating respiratory impairment. This would pose a prohibitive respiratory risk for surgery. Bone marrow density is within normal limits.

Results: Treatment options-non-surgical versus correction. Is there any role of Preoperative halo gravity traction? Option of Vertebral column resection versus multiple posterior Chevron osteotomies or anterior release.

Conclusion: Severe kyphosis with co-morbid conditions like non-ischemic cardiomyopathy, restrictive pulmonary condition has severely increased the high risk nature of the surgery. Patient is grossly neurologically intact and is able to ambulate with a walker. Case is being presented for discussion of treatment options and management.



4E. Choosing Fusion Levels in Adult Idiopathic Scoliosis with Significant Degeneration and Kyphosis

Vishal Sarwahi, MD; Saankritya Ayan, MD; Etan P. Sugarman, MD; Terry D. Amaral, MD; Adam L. Wollowick, MD

USA

Summary: 62 years female was operated for kyphoscoliosis with severe sagittal and coronal imbalance. Posterior spinal fusion from T1-L4 was carried out. Post operative course was complicated with fall leading to L4 fracture, distal pedicle screw failure and reappearance of sagittal and coronal deformity.

Introduction: 62 years female who had past history of scoliosis diagnosed at 13 years of age reviewed for worsening deformity, dyspnea on exertion and significant back pain. Radiographs revealed a right sided 90 degree thoracolumbar curve from T8-L2 with 7cms of positive sagittal imbalance and significant proximal thoracic kyphosis measuring 68 degrees. MRI revealed degenerative changes at L4-5 disc and well hydrated L5-S1 disc.

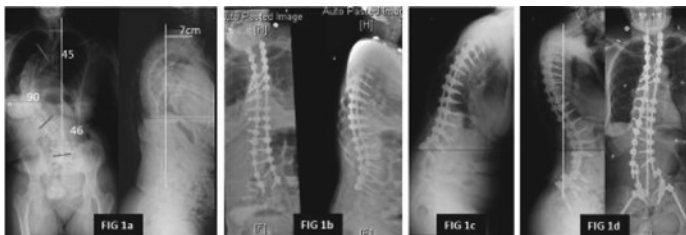
Methods: Multiple level Smith Petersen osteotomy and fusion from T1-L4 was carried out correcting the sagittal and coronal imbalance. Postoperative course was complicated with fall leading to fracture of L4 body, failure of distal L3

CASE DISCUSSION PRESENTATION ABSTRACTS

pedicle screws and appearance of list and positive sagittal imbalance. Fusion was further extended to the illeosacrum with L5-S1 TLIF.

Results: Patient is doing well with excellent correction of scoliosis and restoration of lumbar lordosis.

Conclusion: AIS presenting late into adulthood with degenerative changes pose significant challenges to the surgeon in choosing the fusion levels. Our patient had a significant proximal thoracic kyphosis and distal lumbar degeneration. Pertinent questions related to the level of upper instrumented vertebrae (UIV) and the lower instrumented vertebra(LIV) to be answered are 1) UIV: T1 vs T4: stopping at T4 could have led to PJK and 2) LIV: L4 vs S1 : was fusing through S1 a reasonable option in presence of healthy L5-S1 disc?



PODIUM PRESENTATION ABSTRACTS

*Hibbs Award Nominee for Best Clinical Paper

† Hibbs Award Nominee for Best Basic Science Paper

The Russell A. Hibbs Awards are presented to both the best clinical and basic science papers presented at the 49th Annual Meeting and Course. The top podium presentations accepted in each category are invited to submit manuscripts for consideration. Winners are selected on the basis of manuscripts and podium presentations.

1. A Preliminary Validation of a Severity Index for Early Detection of Progressive Adolescent Idiopathic Scoliosis

Claudio Vergari, PhD; Kariman Abelin-Genevois, MD, MSc; Remi Kohler; Xavier Drevelle; Eric Ebermeyer; Isabelle Courtois; Jean Dubouset; Wafa Skalli, PhD France

Summary: The aim was to assess the relevance of a severity index based on 3D reconstruction from biplanar X-Rays, for early detection of progressive adolescent idiopathic scoliosis. 56 patients were enrolled at their first exam. They were followed until end of growth (non-progressive) or brace decision (progressive). 95% of early predictions regarding progression vs non-progression were consistent with the actual clinical outcome. Although still requiring large scale validation, results are promising for early detection of progressive curves.

Introduction: AIS risk of progression is routinely estimated according to multiple clinical factors including skeletal maturity, menarchal status, curve pattern and amplitude. However careful follow up is still the gold standard method to assess the deformity progression and to decide whether or not to treat. The present study describes a predictive severity index for early detection of progressive AIS patients based on 3D geometrical criteria of the deformity obtained from EOS spine acquisitions.

Methods: Inclusion criteria followed the SRS guidelines for AIS diagnosis (curve $> 10^\circ$, Risser 0-2). All patients were followed until skeletal maturation (Risser > 3 , stable scoliosis) or decision for bracing (progressive scoliosis). A set of parameters describing the major curve (Cobb angle, kyphosis, vertebral axial rotations, torsion) were obtained from bi-planar x-rays and 3D reconstructions of the spine (EOS, EOS Imaging). A severity index (normalized between 0 and 1) was calculated with a discriminant analysis algorithm by comparison with a database of 45 progressive scoliosis (Cobb Angle $> 25^\circ$) and 48 non-scoliotic subjects. A severity index lower than 0.4 was associated with stable scoliosis, while an index higher than 0.6 with progressive scoliosis.

Results: Fifty-six AIS patients were enrolled prospectively in this study (15 boys and 41 girls, 12 ± 2 years old, mean Cobb angle $15.5 \pm 4.8^\circ$, range $11-26^\circ$). Fifty-three out of 56 patients (95 %) were adequately classified by the severity index (results are detailed in Table 1). Two cases were false negatives and one false positive, corresponding to a sensibility of 97 % and a specificity of 91 %.

Conclusion: Our preliminary results suggest that this severity index is a promising prognostic tool for scoliosis in skeletally immature patients. Recommendations to optimize the performance of the prognostic index are discussed regarding patient positioning, 3D reconstruction uncertainty and curve type. A large multi-centric study is in progress to validate the proposed severity index and investigate its robustness.

2. Integrated Multi-Dimensional Maturity Assessments Predicting the High-Risk Occurrence of Peak Angle Velocity during Puberty in Progressive Female Idiopathic Scoliosis

Shi Benlong; Saihu Mao, MD; Xu Sun, MD, PhD; Zhu Ze-zhang; Bangping Qian, MD; Zhen Liu; Yong Qiu China

Summary: Curve progression during adolescence is associated with the skeletal maturity in IS. Multiple indicators for growth potential have been proposed to predict the curve progression. To date, there is no consensus on which factors could most precisely predict the high risk of curve progression, especially PAV.

Introduction: To identify the peak angle velocity (PAV) during puberty in a group of progressive female idiopathic scoliosis (IS), and to look for the multiple dimensional maturity indicators predicting the high risk of occurrence of PAV.

Methods: IS girls with open triradiate cartilage were initially recruited, and were followed up at 6-month regular intervals. At each visit, the following data were collected and recorded: chronologic age, stage of menses, standing height, Cobb angle of the main curve, spine length, status of triradiate cartilage, Risser sign and digital skeletal age (DSA) scores. The height velocity (HV) and spine length velocity (SLV), as well as the angle velocity (AV) of each visit were calculated.

Finally, those with main curve progression of 5° or more during brace treatment and with a minimum of 2 years follow up covering the closure of the triradiate cartilage were recruited in this analysis, and their PAV was defined as the peak of AV curves during the whole follow-up period in puberty. Logistic regression analysis was used to identify the independent predictors of occurrence of PAV.

Results: Thirty-six IS girls were finally recruited in the study. The average DSA score, spine length, standing height and Cobb angle of main curve at PAV were 479.5, 326.7 mm, 150.8 cm, and 26.5° , respectively. The average HV, AV and SLV at PAV were 8.3 cm, 7.8° and 28.2 mm per year, respectively. According to the logistic regression model, chronologic age between 11 and 13 years (OR=4.055), Risser 0 (OR=8.745), closed triradiate cartilage (OR=6.887), DSA scores between 400 and 500 (OR=6.883), HV > 6 cm/year (OR=22.090), Cobb angle of main curve $> 30^\circ$ (OR=6.233) and SLV > 20 mm/year (OR=4.493) were independent factors predictive of occurrence of PAV.

Conclusion: Multiple dimensional maturity assessments, defined as chronologic age between 11 and 13 years, modified Risser 0, DSA scores between 400 and 500, HV > 6 cm per year, and SLV > 20 mm per year, combined with pre-existing scoliotic curve $> 30^\circ$, were good predictors of the occurrence of PAV in IS girls.

3. Health, Function, Quality of Life and Self-Esteem in AIS: Preliminary Results from BraIST

Lori A. Dolan, PhD; Stuart L. Weinstein, MD USA

Summary: Conflicting reports have been published concerning the effect of adolescent idiopathic scoliosis (AIS) and its treatment on patient physical and psychosocial function and overall quality of life. Results from BraIST suggest that curve progression despite brace wear is associated with lower scores than those of patients with successful treatment. Patients who wear a brace require not

PODIUM PRESENTATION ABSTRACTS

only orthopaedic support, but also psychosocial support, especially in the face of significant curve progression.

Introduction: Conflicting reports have been published concerning the effect of AIS and its treatment on physical and psychosocial function and overall quality of life. This study compared the physical and psychosocial function and quality of life over time in treated and untreated patients and in comparison to school-based populations.

Methods: BrAIST, a multi-center, partially randomized prospective study, enrolled 383 subjects with AIS and followed them until skeletal maturity (success) or until the curve exceeded 50 degrees (failure). Patients completed the Child Health Questionnaire (CHQ) and the PedsQL (QOL) prior to treatment and then every 6 months. Baseline and final follow-up scores were ranked and compared using ANOVA techniques. Scores were also compared to published norms.

Results: Baseline, final scores and final outcome were available for 237 subjects. 61% were braced. The success rate was 49% in the untreated group compared to 72% in the braced group. There were no statistically significant differences between the braced and untreated groups on any of the subscales at baseline. At final follow-up, there is some evidence that patients who were braced yet had treatment failure ranked lower than braced patients with a successful outcome, on the self-esteem ($p<0.07$), behavior ($p<0.07$), physical functioning ($p<0.09$) and role functioning ($p<0.05$) CHQ subscales. This pattern was also noted in QOL scores ($p<0.04$). Overall, subject QOL and CHQ scores were not different than those published for school-based populations.

Conclusion: Overall, patients in this study scored similarly to those in a school-based population, indicating little effect of the diagnosis of AIS on their physical and psychosocial function or overall quality of life. However, there were differences within the study cohort. Developing a curve of 50 degrees or greater despite bracing was associated with lower-ranked self-esteem, behavior, physical and role functioning and overall QOL. These findings suggest that patients who wear a brace require not only orthopaedic support, but also psychosocial support, especially in the face of significant curve progression.

4. Does It Make a Difference to Stop Fusion at L3 versus L4 in Terms of Disc and Facet Joint Degeneration: An MRI Study with Minimum Five-Year Follow Up

Meric Enercan; Sinan Kahraman; Mustafa F. Seckin; Tunay Sanli, MA Management; Mesut Kilic, MD; Cagatay Ozturk, MD; Onur Levent Ulusoy; Ahmet Alanay; Azmi Hamzaoglu, MD
Turkey

Summary: A retrospective analysis of 37 pts operated for AIS with structural lumbar curves (SLC) and had minimum 5 years of f/up was performed. Pts fused to L3 vs L4 were compared to each other and to a healthy population in terms of disc (DD) and facet joint degeneration (FJD) grades and sagittal parameters (SP). There were no differences between L3 vs L4 groups in terms of adjacent segment (AS) degeneration, however the control group had more healthy discs and facets than the fused groups

Introduction: Selection of LIV for SLC (L3 vs L4) is often difficult. Saving L4 is believed to be beneficial for preserving motion and preventing AS degeneration. The purpose of the study was to evaluate the DD and FJD of caudal ASs and

clinical outcomes after at least 5 years and compare with a healthy group
Methods: Group A included 21 pts (18f, 3m) with av age 21.4 ± 2.0 and LIV at L3. Group B included 16 pts (12f, 4m) with av age 22.9 ± 3.9 and LIV at L4. All pts had SLC. Both groups were similar in terms of age, gender, type, magnitude and flexibility of curves. Group C included (27f, 3m) age and gender matched healthy individuals with no spinal deformities (av age 23.8 ± 2.2). Pre and postoperative and f/up X-rays in all groups were analyzed in terms of SP, and lumbar MRIs were evaluated in operated and healthy groups in terms of DD and FJD. Clinical outcome was evaluated by using SRS22r, ODI, NRS

Results: Av f/up period was 7 (5-10) y in group A, 9 (5-17) y in group B. Av correction rates in SLC magnitudes were 78% in group A and 79% in group B with no significant correction loss at final f/up. There was no significant difference between groups A and B in terms of SP (except T10-L2 angle), FJD, DD and LIV tilt. FJD was significantly greater in both group A and group B compared to the control group (Table 1). Although DD in these groups were also greater than the control, it was not statistically significant. Clinical outcome scores were similar between all three groups

Conclusion: AIS pts who underwent fusion with LIV L3 vs. L4 had similar severity of FJD, DD at caudal AS degeneration and similar HRQL after 5 years f/up. This information may be helpful in decision making for fusion to L3 vs L4

5. Radiographic Results of Selecting the Touched Vertebra as the Lowest Instrumented Vertebra in Lenke 1A AIS Curves at a Minimum Five-Year Follow Up

Lawrence G. Lenke, MD; Peter O. Newton, MD; Ronald A. Lehman, MD; Michael P. Kelly, MD; David H. Clements, MD; Thomas J. Errico; Amer F. Samdani, MD; Randal R. Betz, MD; Kathy Blanke, RN
USA

Summary: Using the TV, defined as the most cephalad vertebra "touched" by the CSVL, as the LIV determinant for Lenke 1A AIS curves produced excellent LIV positioning at a minimum 5-year follow-up. It also resulted in significantly better LIV positioning than those cases where the LIV selected was 1 level short of the TV (TV-1).

Introduction: Selecting the Lowest Instrumented Vertebra (LIV) in AIS is a crucial decision that has many different rules utilized by scoliosis surgeons. The Touched Vertebra (TV), defined as the most cephalad thoracolumbar/lumbar (TL/L) vertebra touched by the Center Sacral Vertical Line (CSVL), has been used as a method of LIV selection. Whether cases are fused to the TV or not, long-term results of LIV position when applying the TV rule has not been reported.

Methods: 65 cases of Lenke 1A AIS curves treated with PSF using an all pedicle screw construct with minimum 5-year radiographic follow-up were evaluated from a prospective multicenter AIS database. On each preop AP x-ray, the TV was selected by 2 reviewers drawing the CSVL and noting its position on the TV: "A"-between the pedicles; "B"-touching the pedicle; & "B'"-touching the corner of the TV lateral to the pedicle border. The LIV was then compared to the TV as TV-1 (LIV 1 level short of TV); TV (LIV=TV); and TV+1 (LIV 1 level distal to TV). LIV position relative to the CSVL (cm) and LIV tilt (degrees) was compared among the 3 LIV groups at minimum 5 years postoperative.

PODIUM PRESENTATION ABSTRACTS

Results: Skeletal maturity ranged from Risser 0 to 5, with 45/65 being \geq Risser 3. There was a statistically significant increase in final CSVL-LIV distance for those cases fused 1 level short of the TV or TV-1 (Table 1). In addition, for those fused to TV-1, there was a statistical increase in CSVL-LIV distance for those cases fused to the "B-" position vs those fused to the "A" or "B" positions. There was no difference in those patients fused to the TV or TV+1 ($p>0.05$).

Conclusion: Selecting the TV as the LIV in the Lenke 1A main thoracic pattern, prevented an increase in final CSVL-LIV distance without any "adding-on" or angulation/tilt at a minimum 5-year follow-up, and resulted in a significantly better LIV position than when fusing to the TV-1 level. This confirms the use of the TV as an excellent method of LIV selection in the Lenke 1A curve pattern.

6. 15 to 25 Year Functional Outcomes of Patients Treated with Posterior Cotrel-Dubousset (CD) Instrumentation

Andy A. Beltran, MS; Stephen Albanese, MD; Allen L. Carl, MD; Khalid Hesham, MD; William Lavelle, MD

USA

Summary: Long-term outcomes of patients undergoing extensive fusions for AIS have been examined with conflicting results. We examined patients' long-term functional outcomes treated with posterior CD instrumentation. Most appeared to do well long-term with minimal back pain and the lowest instrumented segment did not appear to be associated with increased back pain.

Introduction: Moskowitz found un-instrumented scoliosis fusion patients had similar back pain as normal age matched population. A single center Harrington rod study had like functional outcome scores as non-scoliosis patients, but a trend was seen toward worse outcomes when fusions extended to L4. We examined long-term outcomes of patients treated with posterior CD instrumentation.

Methods: Retrospective review of scoliosis surgeries between 1986-1996 was completed. Patients were contacted and complete a series of functional outcome questions. Statistical analysis was done using ANOVA technique categorically comparing outcome scores to the most distal levels of fusion. Linear regression compared patient reported outcomes to time elapsed since surgery. Statistical significance was $p<0.05$.

Results: Of 112 patients identified, 50 were contacted via a telephone interview. 22 agreed to complete the full assessment of outcome scores. Follow-up time since surgery ranged from 15-26 years (mean 20) and age ranged from 30-43 years old (mean 35). 6 reported daily back pain of >5 , but mean VAS Back Pain was 2.5 and not associated with distal level fusion. ODI was 15.36 with 6 patients ODI >20 and no relationship with distal level of fusion. SF-36 and SRS 22 values were not related to distal level of instrumentation. (Table 1) VAS back pain, ODI, SF-36 and SRS-22 scores were not worse in patients with longer follow-up.

Conclusion: Most patients who had multisegment spinal fixation appeared to do well long-term with minimal back pain. The lowest instrumented segment did not appear to be associated with increased back pain. Patient reported back pain scores were not worse in patients with longer follow-up. VAS back pain, SF-36 and SRS-22 trended toward better scores in patients further out from surgery.

7. Spontaneous Derotation of Compensatory Lumbar Curve after Selective Thoracic Fusion in Adolescent Idiopathic Scoliosis

Noriaki Yokogawa; Hideki Murakami; Katsuhito Yoshioka, MD; Satoshi Kato, MD; Hiroyuki Hayashi; Hiroyuki Tsuchiya; Satoru Demura
Japan

Summary: Spontaneous derotation of lumbar curve following selective thoracic fusion was investigated in adolescent idiopathic scoliosis. A greater spontaneous axial correction of the lumbar curve could be achieved with maximizing axial correction of the thoracic spine following segmental screw fixation.

Introduction: With increasing use of posterior segmental screw fixation and attempts at vertebral derotation, excellent coronal and axial correction can be achieved in adolescent idiopathic scoliosis (AIS). The purpose of this study was to investigate the extent of spontaneous derotation of lumbar curve following selective thoracic fusion.

Methods: A consecutive single center series of AIS patients with thoracic curves (Lenke 1 and 2) who underwent selective thoracic fusion with the use of posterior segmental screw fixation were evaluated. Angle of vertebral rotation was defined as the difference between the axial rotation angles of the apical vertebra using the method of Aaro and S1 vertebra on reconstructed axial CT images. Radiographic measurements included major thoracic curve, thoracolumbar/lumbar curve (preop and postop), and side bending curve. The relationships between the axial rotation of the lumbar spine and radiographic measurements were also analyzed.

Results: Twenty-three patients (all females) were included (mean age 15.9 years). Preoperative thoracic Cobb measured $63^{\circ}\pm 10^{\circ}$, which improved to $20^{\circ}\pm 6^{\circ}$ at 2-year, resulting in 68% correction. Preoperative lumbar Cobb measured $39^{\circ}\pm 10^{\circ}$, which spontaneously improved to $20^{\circ}\pm 6^{\circ}$ (49% correction). Preoperatively, the axial rotation of apical lumbar vertebra was $9.7^{\circ}\pm 6.2^{\circ}$, which changed to $6.7^{\circ}\pm 5.5^{\circ}$ (31% spontaneous correction, $p<0.01$). Comparing the correction between the axial rotation of the lumbar spine and other parameters, postoperative angle of axial rotation correlated well with preoperative ($r = 0.78$, $p < 0.05$) and postoperative ($r = 0.75$, $p < 0.05$) lumbar Cobb angle. Meanwhile, the improvement rate of axial rotation showed negative correlation with postoperative angle of axial rotation of apical thoracic vertebra ($r = -0.43$, $p < 0.05$).

Conclusion: In AIS patients with major thoracic curves, spontaneous axial derotation of lumbar curves occurred with a mean correction rate of 31% after selective thoracic fusion. A greater spontaneous axial correction of the lumbar curve could be achieved with maximizing axial correction of the thoracic spine following segmental screw fixation.

PODIUM PRESENTATION ABSTRACTS

8. Factors Predicting When L3 is Not Distal Enough for an “Ideal” Result in Lenke 5 Curves

Lee Phillips; *Burt Yaszay, MD; Tracey Bastrom, MA; Suken A. Shah, MD; Baron S. Lonner, MD; Firoz Miyajni, MD, FRCSC; Amer F. Samdani, MD; Stefan Parent, MD, PhD; Jahangir Asghar, MD; Patrick J. Cahill, MD; Peter O. Newton, MD USA*

Summary: Choosing between L3 or L4 for a Lenke 5 curve can be difficult. Multiple variables are important in this process; however, preop L3 translation was the most important predictor of success, with a L3 translation less than 3.5 cm being a potential threshold for selecting L3 as the end instrumented vertebra.

Introduction: Determining whether to end distally at L3 or L4 for a Lenke 5 curve is often a difficult decision. The purpose of this study was to determine the preop variables that predict either an “ideal” or “less than ideal” outcome for Lenke 5 curves instrumented to L3 (i.e. Should they have been used to L4?).

Methods: The minimum 2 yr f/u radiographs of 139 surgically treated Lenke 5 curves with an LIV of L3 were evaluated by 5 seasoned AIS surgeons and rated as either “ideal” or “less than ideal” with respect to the correction and alignment. 23 were considered “less than ideal” by 3 or more surgeons. 81 were considered unanimously “ideal”. Preop and postop radiographic variables were compared and a multivariate regression analysis was performed to determine the variables most predictive of a “less than ideal” outcome.

Results: At 2yrs f/u, the “less than ideal” group had significantly larger lumbar curves (26 vs. 15o, $p < 0.001$), EIV angulation (11 vs 5o, $p < 0.001$), EIV translation (2.6 vs 1.4 cm, $p < 0.001$) as well as lower self image SRS-22 scores (4.19 vs. 4.5, $p = 0.01$). Preop, the “less than ideal” group was significantly stiffer, had greater apical translation with an EIV that was more angulated and more translated (Table). Multivariate regression found that L3 translation ($p = 0.009$) was the single most important predictor of a “less than ideal” outcome. Specifically, a preop L3 translation < 3.5 cm consistently resulted in an “ideal” outcome, while a translation > 3.5 cm risked a “less than ideal” result.

Conclusion: The goal of surgery in Lenke 5 curves is to get an “ideal” clinical and radiographic outcome with the shortest fusion. Frequently, the decision is whether to instrument to L3 or L4 distally. While multiple variables are important in this process, this study found preop L3 translation was the most important predictor of success with a L3 translation less than 3.5cm being a potential threshold for selecting L3 as the end instrumented vertebra.

9. What is Different about Patients with Lenke 5 Curves Who Achieve a Minimal Clinically Important Difference (MCID) in Appearance?

Amer F. Samdani, MD; Robert J. Ames, BA; Tracey Bastrom, MA; Firoz Miyajni, MD, FRCSC; Joshua M. Pahys, MD; Michelle C. Marks, PT, MA; Baron S. Lonner, MD; Peter O. Newton, MD; Harry L. Shufflebarger, MD; Randal R. Betz, MD; Patrick J. Cahill, MD USA

Summary: The purpose of this study was to identify factors associated with an SRS-22 Appearance domain score increase greater than the MCID in surgically treated patients with Lenke 5 curves. 166 patients were identified and 60.8%

attained the MCID. Factors associated with attaining the MCID included starting with the lowest SRS Appearance domain score and the lowest postoperative lumbar prominence. The anterior scar appeared to have a negative impact.

Introduction: Previous work has determined the MCID for the appearance domain of the SRS-22 questionnaire to be an increase of ≥ 1.0 . Those patients with a Lenke 5 curve type are least likely to achieve this increase (Sanders Spine 2010, Samdani SRS 2013). The purpose of this study was to identify factors associated with an SRS-22 appearance domain score increase greater than the MCID.

Methods: A prospectively collected multicenter database was retrospectively reviewed to identify surgically treated Lenke 5 patients with minimum 2 year follow-up. 166 patients were divided into two cohorts: “I”= improved after surgery (Δ Appearance ≥ 1.0) and “NI”= not improved after surgery (Δ Appearance < 1.0). The two cohorts were compared using clinical and radiographic measures. Univariate regression was used to find a significant difference between the cohorts for individual measures. Multivariate logistic regression was used to find continuous predictors.

Results: Overall, 101 patients (60.8%) were improved greater than the MCID and 65 (39.2%) were not improved. Both groups were similar with respect preoperative major Cobb angle (I=47°, NI=48°, $p=0.7$), % correction (I=62%, NI=60%, $p=0.4$), postoperative trunk shift (I=1.0 cm, NI=0.8 cm, $p=0.3$) and coronal balance (I=1.2 cm, NI=1.0 cm, $p=0.07$). The improved cohort was comprised of older patients (I=15.6 years, NI=14.8 years, $p=0.01$); they also had a lower pre-op SRS Appearance score (I=3.1, NI=3.6, $p<0.01$), more postoperative T5-12 kyphosis (I=28°, NI=25°, $p=0.05$), higher preoperative weight (I=58 kg, NI=53 kg, $p=0.02$), and smaller pre-op and post-op lumbar prominence (pre-op I=10.7°, NI=12.9°, $p=0.03$, post-op I=2.8°, NI=4.1°, $p=0.003$). Of those patients approached anteriorly, 53% attained the MCID compared to 65% of those treated posteriorly ($p=0.17$). Multivariate analysis identified preoperative SRS Appearance domain scores as an independent predictor of achieving an MCID.

Conclusion: Our results imply that patients with Lenke 5 curves most likely to demonstrate a clinically significant improvement in the SRS Appearance domain are those who start with the lowest pre-op scores and with the smallest postoperative lumbar prominences. In addition, the visible anterior scar may have some negative impact.

10. Cervical Spine Compensation in Adolescent Idiopathic Scoliosis

Elizabeth P. Norheim, MD; Leah Y. Carreon, MD, MSc; Daniel J. Sucato, MD MS; Lawrence G. Lenke, MD; Aygul Dankowski, PhD; Steven D. Glassman, MD USA

Summary: AIS patients compensate for abnormal thoracic sagittal alignment with changes in cervical spine sagittal alignment. Although intuitive for Lenke 1 and 2 curves, where restoration of thoracic kyphosis improves cervical alignment, cervical kyphosis was also noted in Lenke 5 and 6 curves, suggesting a need to consider compensatory thoracic and cervical sagittal alignment during surgical planning. Lenke 3 and 4 curves had more normal cervical alignment, suggesting that multiple curves may preserve sagittal as well as coronal balance.

PODIUM PRESENTATION ABSTRACTS

Introduction: The purpose of this study is to determine associations between radiographic cervical spine alignment and Lenke type for AIS. A better understanding of cervical spine alignment may influence selection of fusion levels, correction strategies and counseling with regard to long term outcome.

Methods: In order to obtain a representative sample from all Lenke types (1 to 6) and thoracic curve modifiers (1: 10° of kyphosis, 2: 10-40° of kyphosis; 3: >40° of kyphosis); stratified random sampling was done from 3654 available 36-inch pre-op lateral films of patients enrolled in a multicenter database of surgically treated AIS. The C2-C7 Sagittal Cobb and C2-C7 Sagittal Vertical Axis (SVA) distance were measured by reviewers unaware of the patient's Lenke classification. C2-C7 Sagittal Cobb and C2-C7 SVA differences among the different curve types and thoracic modifiers were determined using ANOVA.

Results: There were 387 females and 84 males among the 471 randomly selected preoperative films; mean age at surgery was 14.8±2.0 years. There was a statistically significant difference in C2-C7 Sagittal Cobb among the Lenke types (p=0.001). Less cervical kyphosis was seen in patients with double major-main thoracic structural (Lenke 3) or triple major (Lenke 4) curves (p=0.001); and greater cervical kyphosis seen in patients with single curves or double thoracic curves (Lenke 1, 2, 5 and 6). No statistically significant differences in C2-C7 SVA were seen.

Conclusion: Patients with AIS appear to compensate for abnormal thoracic sagittal alignment with changes in cervical spine sagittal alignment. This seems intuitive for Lenke 1 and 2 curves where surgical restoration of thoracic kyphosis is a recognized goal and has been shown to improve cervical alignment. Cervical kyphosis was also noted in Lenke 5 and 6 curves, suggesting a need to consider compensatory thoracic and cervical sagittal alignment as part of the surgical planning process. Patients with Lenke 3 and 4 curves had more normal cervical alignment, suggesting that multiple curves may preserve balance in the sagittal plane as much as in the coronal plane. Surgeons should consider reduction strategies and restoration of thoracic kyphosis in patients with substantial cervical kyphosis prior to surgery.

11. Quantitative Analysis of the Three-Dimensional Morphology of Adolescent Idiopathic Scoliosis (AIS) with Implications for Surgical Strategy

Tom P. Schlösser, MD; Marijn van Stralen, PhD; Winnie C. Chu, FRCR, FHKAM, MD; Tsz-ping Lam, MB, BS; Bobby K. Ng, MD; Koen L. Vincken, PhD; Jack C. Cheng, MD; Rene M. Castelein, MD, PhD
Netherlands

Summary: This is the first quantitative estimation of three-dimensional (3-D) morphology of different types of adolescent idiopathic scoliosis (AIS), using high-resolution CT scans. The 3-D morphology of AIS consist of three separate, rotated, lordotic curves and two straight junctional segments. This is important for understanding the true nature of the problem and for harmonious 3-D surgical correction to avoid complications such as thoracic hypokyphosis and junctional kyphosis.

Introduction: AIS is a spinal deformity, characterized by lateral deviation, axial rotation and apical lordosis of three individual curves. The 3-D morphology of the different areas of the scoliotic spine has not been quantified so far. This is the first study to accurately define the 3-D morphology of AIS and compare it to normal anatomy.

Methods: A unique series of high-resolution CT scans of 77 AIS patients and 22 matched controls was used for this study. Non-idiopathic curves were excluded. Scans were obtained in prone position for navigation purposes. True transverse sections were reconstructed taking rotation, and coronal and sagittal tilt into account. Using semi-automatic analysis software, 'endplate-vectors' were calculated and complete 3-D spine reconstructions were acquired. Coronal deviation, axial rotation and the exact anterior-posterior length discrepancy, as defined per vertebra and disc in 3-D, were measured for each curvature and for the junctional segments, semi-automatically. Intraclass correlation coefficients for intraobserver reliability were 0.98-1.00.

Results: All thoracic and (thoraco)lumbar curves were longer anteriorly (+3.8% and +9.4%, respectively), while the proximal and distal junctional segments between the scoliotic curves were straight, with a tendency to slight kyphosis in the proximal junctional segment. The same thoracic segments in the controls were shorter anteriorly (-4.1%; P<0.001). Linear relations were observed between the upright radiographic Cobb angles, axial rotation and the anterior-posterior length discrepancy on the CT scans in thoracic curves (>0.729; P<0.001) and (thoraco)lumbar curves (>0.485; P<0.001). Lateral radiographs had no value for prediction of the 3-D morphology of AIS.

Conclusion: AIS consists of three separate, rotated, lordotic curves and two straight junctional segments. Anterior overgrowth is regional rather than global, and the disc contributes more than the vertebral body. This study provides guidelines for the amount of posterior lengthening and/or anterior shortening that is necessary for true harmonious 3-D realignment.



From left to right: 3-D CT reconstructions of an AIS patient from an anterior view and from true lateral to the thoracic apex, distal junctional segment and lumbar apex. Percentages indicate the anterior-posterior length discrepancy of the individual curves.

PODIUM PRESENTATION ABSTRACTS

12. Breast Asymmetry in Idiopathic Scoliosis

Atsushi Ono; Kanichiro Wada; Toshihiro Tanaka; Taito Itabashi; Gentaro Kumagai; Shugo Maeda; Yasuyuki Ishibashi

Japan

Summary: The relations between breast asymmetry in idiopathic scoliosis and age, Cobb angle of thoracic and lumbar curve, Lenke classification, thoracic and lumbar hump, apex vertebrae, shoulder imbalance, and SRS 22 score were investigated. There were correlations between breast asymmetry and age, Cobb angle of thoracic curve and SRS 22 self-image domain. The breast asymmetry in idiopathic scoliosis is one of the problems of body surface deformity and has a psychologically adverse effect on patients.

Introduction: Thoracic and lumbar hump, shoulder imbalance and waist asymmetry are deformities of the body surface in idiopathic scoliosis. Recently, breast asymmetry has also drawn attention as a deformity of the body surface. The purpose of this study was to investigate the breast asymmetry in idiopathic scoliosis.

Methods: Sixty females (12-15 years old, ave. age 16.7 years) with idiopathic scoliosis and 60 females (12-15 years old, ave. age 16.6 years) without scoliosis, who filled in a questionnaire, were included. The questionnaire asked how much they worried about thoracic hump, shoulder imbalance, waist asymmetry and breast asymmetry using the visual analogue scale (VAS; 0-100mm). The relations between breast asymmetry and age, Cobb angle of thoracic and lumbar curve, Lenke classification, thoracic and lumbar hump, apex vertebrae, shoulder imbalance, and SRS 22 score were investigated.

Results: Positive rates of questionnaire responses about deformities of the body surface in females without scoliosis were 10.0% in thoracic hump, 35.0% in shoulder imbalance, 16.7% in waist asymmetry and 21.7% in breast asymmetry. Positive rates of questionnaire responses about deformities of the body surface in females with idiopathic scoliosis were 68.3% in thoracic hump, 70.0% in shoulder imbalance, 61.7% in waist asymmetry and 61.7% in breast asymmetry. Mean VAS scores in females without scoliosis were 3.3 in thoracic hump, 8.2 in shoulder imbalance, 4.9 in waist asymmetry and 7.3 in breast asymmetry. Mean VAS scores in females with idiopathic scoliosis were 27.0 in thoracic hump, 24.1 in shoulder imbalance, 29.8 in waist asymmetry and 24.5 in breast asymmetry. There were correlations between breast asymmetry and age ($r=0.28$), Cobb angle of thoracic curve ($r=0.30$) and SRS 22 self-image domain ($r=0.37$).

Conclusion: Even females without scoliosis mind breast asymmetry to some extent. But, the breast asymmetry in idiopathic scoliosis is one of the problems of body surface deformity and has a psychologically adverse effect on patients.

13. Do Crosslinks Improve Clinical or Radiographic Outcomes of Posterior Spinal Fusion with Pedicle Screws in Adolescent Idiopathic Scoliosis? A Multicenter Cohort Study

Sumeet Garg, MD; Cameron Niswander; Zhaoxing Pan, PhD; Mark A. Erickson, MD

USA

Summary: A comparative analysis found similar outcomes between adolescent idiopathic scoliosis (AIS) patients who underwent posterior spinal fusion (PSF) with pedicle screws with and without crosslinks.

Introduction: Crosslinks are frequently utilized during PSF for AIS. It is unclear if they provide any advantages for patients with all pedicle screw constructs.

Methods: A prospectively collected multicenter database of patients with AIS undergoing spinal fusion was retrospectively queried. Study inclusion criteria were: primary PSF with all pedicle screw fixation (>90% fixation points) and minimum two years follow up. Collected data included demographics, radiographic measures, complications, SRS-22r scores, and SAQ scores.

Results: 500 patients were included in the cohort (377 crosslink, 123 no crosslink). Age, BMI, gender, and pre-operative major Cobb angle were not different between the groups. With the exception of slightly decreased lumbar Cobb angle (2.7 degrees) in the crosslink group at two year follow-up, no other radiographic measures were different at two year follow-up. Complications were not significantly different between groups; 21/377 (6%) crosslink, and 9/123 (7%) no crosslink. Infection occurred in one patient in the crosslink group and none in the no crosslink group. Reoperation occurred in 4 patients, all with crosslinks (3 implant removal at patient request, 1 for distal adding-on). The total and individual domain SRS-22r scores improved by a similar amount in both groups. At two year follow-up, the parent and patient SAQ appearance scores were not significantly different between groups. The SAQ expectations domain scores were similar for all visits and improved for both patients and parents.

Conclusion: There do not appear to be any significant clinical or radiographic outcome differences in patients with AIS undergoing PSF based on use of crosslinks at 2 years follow-up. Surgeons should consider eliminating use of crosslinks in patients with AIS having PSF with all pedicle screw constructs. This may have substantial cost savings without affecting patient outcome.

14. Spinal Deformity Surgery: In Cases of Intraoperative Monitoring Alert, the use of a Flexible Epidural Spinal Electrode Allows the Determination of a Lesional Level

Jean-Luc Jouve, MD; Sebastien Pesenti; Elie Choufani; Isabelle Suprano; Gérard Bollini; Martine Gavaret, MD, PhD

France

Summary: Analysis of a prospective series of 800 consecutive cases (2004-2014) undergoing intraoperative monitoring in paediatric orthopaedic spinal surgery.

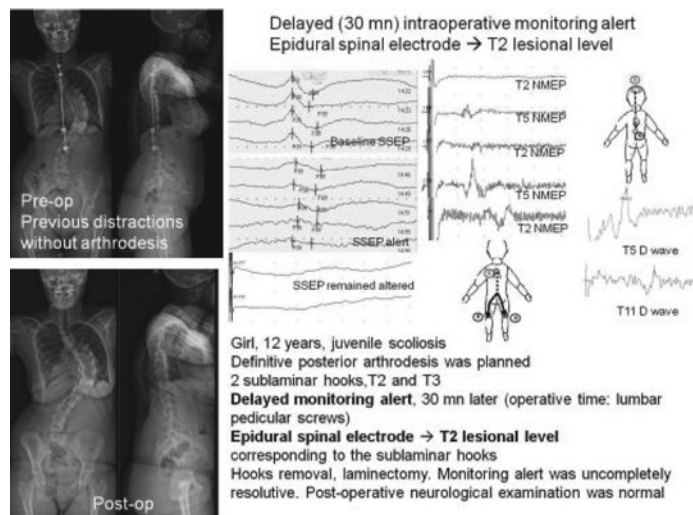
Introduction: The objective of this study was to demonstrate that in case of monitoring alert, the use of a spinal electrode allows the determination of a lesional level.

PODIUM PRESENTATION ABSTRACTS

Methods: Methods consist in: 1/ somatosensory evoked potentials (SSEP), 2/ neurogenic mixed evoked potentials (NMEP) with a spinal electrode, 3/ D waves were practised with the same spinal electrode, in order to assess selectively corticospinal tracts 4/ testing of pedicular screws. A uniform total intravenous anaesthesia was practised. In case of monitoring alert that remained during few minutes, the lesional level was diagnosed either with NMEP either with D waves, by displacing the spinal electrode along the inter-vertebral spaces.

Results: 60 monitoring alerts considered as true positive occurred (7.5%). Pathologic values (<10 mA) of pedicular screws testing were not considered here in spinal monitoring alerts. Several monitoring alerts with determination of a lesional level are presented. We particularly illustrate (Fig) the case of a girl, 12 years old who had previous distractions without arthrodesis. Two sublaminar hooks were positioned at the levels T2 and T3. The monitoring alert occurred half an hour later, while surgeons positioned the lumbar pedicular screws. Displacement of the epidural electrode allowed the determination of a lesional level T2, corresponding to sublaminar hooks positions. Monitoring alert was uncompletely resolutive after hooks removal and laminectomy T2. After removal of the instrumentation, her spine was subsequently bone graft and closed. Post-operative neurological examination was normal.

Conclusion: In case of monitoring alert, it is usually considered that the surgeon has to evaluate what he/she was doing 1-10 minutes earlier. The identification of a lesional level appears to be particularly important when the alert of the monitoring is delayed with regard to the surgical act which was harmful. We report, with different monitoring alerts examples, that determination of a lesional level, with NMEP (or D waves), moving the flexible epidural spinal electrode along open inter-vertebral spaces, helps the surgical team to identify the monitoring alert etiology and thus to react in the most informed and appropriate way.



Delayed monitoring alert, 30 mn after the positionnement of two sublaminar hooks T2-T3. A lesional level T2 was diagnosed with an epidural spinal electrode. Normal post-operative neurological examination.

15. Biomechanical Comparison of Posterior Ponte Osteotomy versus Anterior Discectomy for Spinal Deformity

Patrick Bosch, MD; Kevin Bell, PhD; Ozgur Dede, MD; James W. Roach, MD; Cheng Wang USA

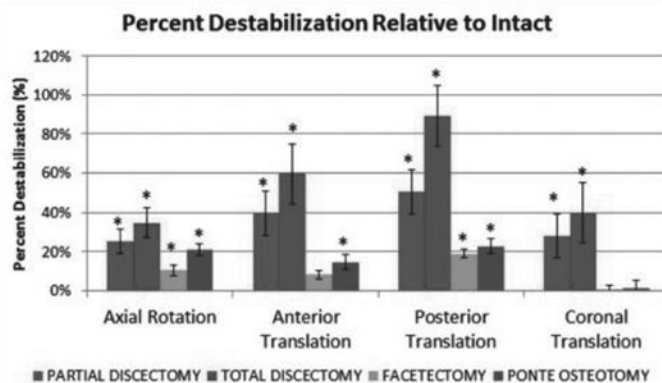
Summary: The relative destabilizing effect of Ponte osteotomies was compared to discectomy in an in vitro thoracic spinal column model. Ponte osteotomies destabilized the spine well for axial rotation but not for coronal correction.

Introduction: Posterior spinal releases, such as the Ponte osteotomy, are recommended to improve correction during instrumented spinal fusion. Biomechanical data supporting the effectiveness of these releases is limited. We present a biomechanical analysis of posterior release versus discectomy using in vitro thoracic model.

Methods: 12 fresh frozen thoracic human specimens anchored at T2 and T10 were tested by application of force with a robot arm (Staubli RX90) by applying force through pedicle screws at T6. The specimens were randomized into posterior or anterior release groups. Releases were done at six levels (T3/4 through T8/9). The posterior group was tested intact, after standard facetectomy, and after Ponte. The anterior group was tested intact, after partial discectomy (disc anterior to rib head), and after complete discectomy.

Results: Data is presented as a percent destabilization of the intact specimen (Figure 1). The force required to produce axial rotation is decreased with Ponte osteotomy by 21% compared to 35% for full discectomy. Posterior releases have the greatest comparative effect in the axial plane, 60% of the effect of a full discectomy. To produce lordosis, Ponte was roughly one third as effective as discectomy. Ponte osteotomy was one quarter as effective as discectomy in producing kyphosis. In coronal force application the Ponte osteotomy had virtually no effect (2%) compared to 40% destabilization by discectomy.

Conclusion: Ponte releases produced more motion than facetectomy alone in axial rotation and sagittal correction maneuvers, but had no effect on coronal correction. Pedicle screws have enabled surgeons to apply far greater corrective forces to the spine and largely obviated the need for anterior surgery. Despite ample clinical experience demonstrating effectiveness of posterior only surgery, posterior releases produce only modest destabilization of the spinal column. This data allows surgeons to compare the biomechanical effect of Ponte osteotomy to the more familiar effect of discectomy.



PODIUM PRESENTATION ABSTRACTS

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

16. Results of the SRS M&M Database 2009-2012: A Report from the Morbidity & Mortality Committee

Douglas C. Burton, MD; Brandon B. Carlson, MD, MPH; Howard M. Place, MD; Jonathan E. Fuller, MD; Kathy Blanke, RN; Robert H. Cho, MD; Kai-Ming Fu, MD, PhD; Robert F. Heary, MD; Aruna Ganju, MD; Jose A. Herrera-Soto, MD; A. Noelle Larson, MD; William Lavelle, MD; Ian W. Nelson, MB, BS, MCh (Orth), FRCS; Karl E. Rathjen, MD; Alejo Vernengo-Lezica, MD; Joseph M. Verska, MD USA

Summary: The number of submitted M&M cases has steadily increased. Overall 2012 rates were as follows: mortality - 0.11%, infection - 1.25%, neurologic deficit - 1.17%, and blindness - 0.004%.

Introduction: Members of the Scoliosis Research Society are required to annually submit complication data regarding deaths, visual acuity loss, neurological deficit and infection (2012-1st year for this measure) for all deformity operations performed. The purpose of this study is to report the 2012 results and the changes in complication rates from 2009-2012.

Methods: The SRS M&M database is a self-reported registry of complications of deformity operations performed by the members. The data from 2009-2012, inclusive, was tabulated and analyzed. Differences in frequency distribution between years were analyzed with Fisher's exact test. Significance set at $\alpha=0.05$.

Results: The total number of cases reported increased from 34,332 in 2009 to 47,775 in 2012. The overall mortality ranged from 0.07% in 2011 to 0.16% in 2009. The Neuromuscular scoliosis group had the highest mortality rate (0.44%) in 2010. The combined groups' neurological deficit rate increased yearly from 0.58% in 2009 to 1.17% in 2012. Neurological deficits were significantly lower in 2009 compared to other years for Idiopathic scoliosis >18yrs, Congenital scoliosis, Other scoliosis, Degenerative spondylolisthesis and Other groups. There were significantly higher neurological deficit rates for Idiopathic Scoliosis 10-18yrs and Isthmic Spondylolisthesis groups during 2011 and 2012, respectively. Each year, the groups with the highest neurological deficit rates were Dysplastic spondylolisthesis and Congenital kyphosis. There were no differences in the rates of vision loss between the years. The overall 2012 infection rate was 1.25% with Neuromuscular scoliosis having the highest rate at 3.19%.

Conclusion: Neuromuscular scoliosis has the highest complication rates of mortality and infection. The neurological deficit rates of all groups combined have increased slightly from 2009 to 2012 with the highest rates consistently being in the Dysplastic Spondylolisthesis and Congenital Kyphosis groups. This could be due to a number of factors, including more rigorous reporting.

17. Association between Surgeon Experience and Complication Rates in Adult Scoliosis Surgery: A Review of 5,117 Cases from the Scoliosis Research Society Database 2004-2007

Branko Skovrlj, MD; Samuel K. Cho, MD; John Caridi, MD; Motasem Al Maaiheh; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Yongjung J. Kim, MD USA

Summary: We demonstrate that overall complication rates were similar between active and candidate members. However, there was significantly more wound infections and a trend toward higher spinal cord deficits in the candidate group.

Introduction: Surgeon training and experience play an important role in patient outcomes following spinal surgery. The Scoliosis Research Society Morbidity and Mortality (SRS M&M) data allow membership status (active vs. candidate) to serve as a proxy for the level of surgeon experience. No study to date has evaluated surgeon experience as a risk factor for perioperative complications for adult scoliosis.

Methods: SRS M&M database was queried for patients aged >18 years who underwent spinal fusion for scoliosis from 2004-2007. Patient demographics, surgical characteristics, and complications were analyzed. Two-tailed t test and chi-square test were performed.

Results: A total of 5,117 cases (avg. age 51.8 years, 21.7% revisions) were identified between 2004 and 2007. Active members performed 3,836 (75%) and candidate members performed 1,281 (25%) surgeries. There were a total of 681 (13.3%) complications: 498 (13.0%) for active; 183 (14.3%) for candidate, $p=0.24$. Mortality rate was 0.29% (15): 12 for active; 3 for candidate, $p=0.88$. There were a total of 173 (3.4%) wound infections: 114 (3.0%) for active; 59 (4.6%) for candidate, $p=0.01$. Spinal cord complications (35) accounted for 0.68%: 21 (0.55%) for active; 14 (1.1%) for candidate, $p=0.07$.

Conclusion: Overall complication rates were similar regardless of surgeon experience. However, there were significantly more wound infections and a trend toward higher spinal cord deficits in candidate member cases.

18. What is the Frequency of Intraoperative Alerts using Current Neuromonitoring Methodology?

Arvydas A. Tamkus, MD, PhD, DABNM; David W. Polly, MD USA

Summary: There is variability in neuromonitoring, anesthetic, and surgical techniques for the treatment of pediatric spinal deformity. This study evaluates a series of patients treated at multiple centers utilizing TCMEP, SSEP and EMG. The frequency of alerts and the intraoperative follow-up is reported.

Introduction: Intra-operative neuromonitoring (IONM) has become an accepted standard in the US when surgically treating pediatric spinal deformity. We report on the frequency of IONM alerts and their results.

Methods: A 2 month cohort (Jun-Jul 2013) of pediatric (1-18 y.o.) spine deformity cases were evaluated. Standard patient demographics and IONM data were collected.

Results: Data was from 46 facilities and 72 surgeons. 218 patients were included (153F/65M) with average age 13.7 (3-18), weight 54.3 kg (9.5-

PODIUM PRESENTATION ABSTRACTS

118), BMI 22.0 (11.1-48.8). Diagnoses were 178 adolescent idiopathic scoliosis, 13 congenital scoliosis, and 27 neuromuscular. 27 had preoperative lower extremity deficits. Anesthesia technique was balanced (IV + inhalational) in 186 (131 < 0.5MAC, 55 >0.5 but <1 MAC); 30 had IV only; and 2 inhalational only >1 MAC (both lost TCMEP).

Baseline upper TCMEP data was achieved in 205/212 and absent 7/212. Lower TCMEPs \geq 1 muscle group were present bilaterally in 199/212, absent in 11. Baseline SSEP data were present in upper extremities 216/217, lower extremities 207/217.

Surgical TCMEP alerts occurred in 19 (8.7%). 11 were during translation, 5 placement of instrumentation, 2 decompression, and 1 closing. 9/19 had TCMEP recovery intra-op, 8/19 had partial recovery, and 2/19 did not. There were 26 non-surgical alerts: 16 (7.3%) due to positioning, 4 inhalational agent change, 4 global physiological change, and 2 due to technical reasons.

2164 pedicle screws were tested during 134 (61.5%) surgeries, average 16.1 screws/case. 1940 (89.6%) >10 mA, 197 (9.1%) 6-9 mA. Of these, 171 (65.4%) left unchanged, 10 (5.1%) removed, 8 (4.1%) repositioned improved, 8 repositioned not improved. 26 screws <5 mA. 17 (65.4%) left unchanged, 5 (19.2%) removed, 2 (7.7%) repositioned improved, 2 (7.7%) repositioned not improved.

Conclusion: IONM provides data that causes re-evaluation in about 10% of cases. LE TCMEP was achievable in 93.9%, SSEP in 95.4% of patients. TCMEP surgical alerts occurred in 19/212 (7.8%) and 9 recovered intra-operatively. Non-surgical alerts occurred in 26. Screw stimulation was used in 61.5%; 10.4% of screws tested <10 mA.

19. Revision Rate in Adult Spinal Deformity Surgery

Steven D. Glassman, MD; Leah Y. Carreon, MD, MSc; John R. Dimar, MD USA

Summary: Revision procedures following adult deformity surgery remain a persistent and inadequately defined problem. This national database study of patients between ages 45 and 85 demonstrates a cumulative 18% revision rate at 4 years post-op. Revisions tended to occur earlier in younger patients, but overall revision rate was not related to age. The value of an intervention depends upon efficacy, safety and durability. This study establishes a benchmark for the critical effort to reduce revision rate in adult spinal deformity surgery.

Introduction: Historically, surgical treatment of adult spinal deformity was limited by inadequate deformity correction and high complication rates. Improved intra-operative techniques including neuromonitoring, complex osteotomies and effective pelvic fixation have produced more consistent clinical benefit. However, the need for revision surgery remains a persistent and inadequately defined problem. Reported revision rates have varied widely. The purpose of this study is to establish a benchmark for future efforts to address this substantial problem.

Methods: Patients who had multi-level spinal fusion for adult spinal deformity were identified from a national insurance database containing private payor and Medicare records using ICD-9 or CPT codes from 2005 to 2011. Revision procedures were identified based on codes for spinal instrumentation and fusion. Procedures two weeks within the index surgery were excluded to differentiate revisions from planned staged procedures.

Results: The 5% Medicare sample included 1879 patients (1329 females, 550 males) who had adult deformity surgery. Revision rate in this cohort was 6% in yr-1 post-op, 6% in yr-2, 4% in yr-3 and 3% in yr-4, for a cumulative 19% revision rate. In the private payor database, 803 patients (559 females, 244 males) had adult spinal deformity procedures. Revision rate was 10% in yr-1 post-op, 3% in yr-2, 2% in yr-3 and 1% in yr-4, for a cumulative 16% revision rate. Pooling the databases yielded an overall 18% revision rate at 4 years post-op.

The timing of revision surgery was influenced by the patient's age. Fewer revisions were noted in yr-1 post-op in the Medicare sample, and yr-1 revision rate was inversely proportional to age across the entire cohort. Revision rate equalized across age groups over time such that no differences were seen at 4 years post-op.

Conclusion: The value of an intervention depends upon efficacy, safety and durability. Despite improvements in surgical technique and clinical outcome, an 18% revision rate at 4 years post-op is not realistically sustainable from either a clinical or economic standpoint. This study establishes a benchmark for the critical effort that is needed to reduce revision rate in adult spinal deformity surgery.

20. Incidence and Risk Factors for Early Wound Complications after Spinal Arthrodesis in Children

Christopher T. Martin, MD; Andrew J. Pugely, MD; Yubo Gao, PhD; Ryan M. Ilgenfritz, MD; Stuart L. Weinstein, MD USA

Summary: In a prospectively collected multicenter cohort of 1,915 pediatric patients undergoing spinal arthrodesis the 30-day incidence of wound complications was 3.5%. Patients with a fusion extending to the pelvis, obese patients, and patients with significant cardiac conditions were independently associated with higher risk.

Introduction: While multiple prior studies have reported on wound complications in pediatric spine surgery, the majority have been single center retrospective case series.

Methods: The National Surgical Quality Improvement Program (NSQIP) employs onsite personnel to prospectively collect 30-day morbidity data from 50 pediatric hospitals in the United States. 2012 was the first year of data collection and 1,915 cases of pediatric thoracic or lumbar spinal fusion were enrolled. Patients were divided into cohorts of those with without a wound complication. A univariate analysis was used to identify associations between risk factors and the incidence of complication. A multivariate logistic regression analysis was used in an attempt to identify independent risk factors for complication. A $p < 0.05$ was considered significant.

Results: There were 78 wound complications in 67 patients (3.5%). The incidence was significantly higher in patients with congenital (4.35%) or neuromuscular (4.67%) diagnoses, as opposed to idiopathic (2.7%) or infantile (1.61%). Procedures with fusions extending to the pelvis (9.91%) or an osteotomy (4.99%) were associated with significantly higher risk. In the univariate analysis, patients requiring nutritional support, an increased American Society of Anesthesia (ASA) class, longer hospital lengths of stay, increased operative time, central nervous system abnormalities, increased patient BMI, and patients with cardiac, gastrointestinal, or pulmonary comorbidities were also

PODIUM PRESENTATION ABSTRACTS

associated with a higher risk of infection. In the multivariate analysis, a BMI over 30 kg/m², patients with cardiac risk factors, and fusions extending to the pelvis were independent risk factors for wound complication.

Conclusion: Data from this large prospective multicenter study confirms that the incidence of early wound complications in pediatric spine surgery is low. Patients with a fusion extending to the pelvis, obese patients, and patients with significant cardiac conditions were independently associated with higher risk for this complication. This data should be useful for patient counseling and for pre-operative risk stratification. Interventions for minimizing infection risk may be most applicable to the high risk groups identified here.

21. Efficacy and Safety of Intrawound Vancomycin for Reducing Surgical Site Infection (SSI) in Spine Surgery

Thomas Cheriyan, Carl B. Paulino, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Jeffrey A. Goldstein, MD; Thomas J. Errico USA

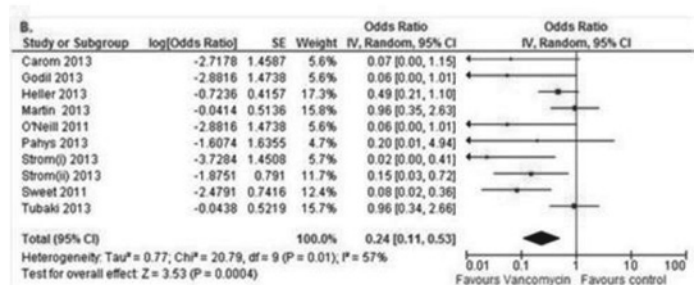
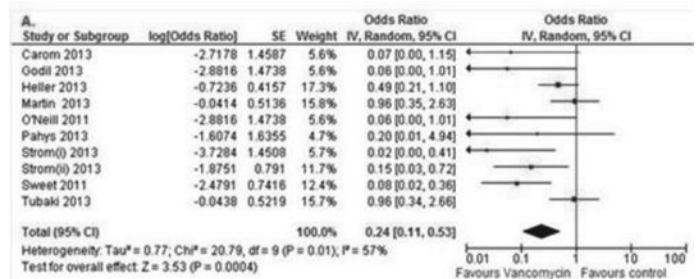
Summary: Various studies have investigated the benefit of application of intrawound vancomycin powder on SSI rates with conflicting results. This meta-analysis of consolidated studies appears to be effective in reducing SSI. There does not seem to be any increased risk of adverse events.

Introduction: Despite improvements with prophylactic intravenous antibiotics, surgical site infection (SSI) remains a significant concern in spine surgery, and is associated with significant morbidity and costs. Studies have investigated the benefit of application of intrawound vancomycin powder on SSI rates. However, these studies have resulted in conflicting evidence. The purpose of this meta-analysis is to consolidate studies and evaluate the efficacy of intrawound application of vancomycin in reducing SSI.

Methods: Studies published before January 2014 that investigated the effectiveness of intrawound vancomycin powder, compared to a control group in spine surgery were included. Generic inverse variance of pooled risk estimate meta-analysis was performed using rev-man5. Pooled odds ratio with 95% confidence interval (CI) was used to assess the efficacy. A modified Newcastle-Ottawa Quality assessment scale and Jadad score was employed for observational and RCTs study quality assessment.

Results: Ten published studies were included in the analysis. Nine were retrospective and one prospective, totaling 4902 patients with 2565 and 2337 in the vancomycin and control group, respectively. Pooled effects showed that intrawound vancomycin powder is effective in reducing SSI (pOR = 0.24; 95% CI [-0.69, -0.31]; p=0.004) and *S. aureus* SSI (pOR = 0.19; 95% CI [0.08, 0.43]; p<0.0001). (Figure 1), when compared to controls. There was no apparent increased risk of adverse events or pseudoarthrosis with the application of vancomycin powder. Quality assessment of studies showed low-medium risk of bias, though there was control group selection bias in 7 studies. Even though the prospective study was adequately powered, there was a medium risk of bias.

Conclusion: There is medium-evidence to support the intrawound application of vancomycin powder to reduce SSI. There does not seem to be any increased risk of adverse events. However, there is a paucity of high-quality studies and further prospective studies are required to evaluate the efficacy and safety of vancomycin powder.



Forest plot of comparison of intrawound vancomycin and control on SSI (A) overall infections (B) staph aureus infections

22. Long-Term Cost-Effectiveness of Adult Spinal Deformity Surgery (ASD)

Ian McCarthy, PhD; Chessie Robinson, MA; Michael F. O'Brien, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Virginie Lafage, PhD; Robert A. Hart, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Gregory M. Mundis, MD; Frank J. Schwab, MD; Khaled Kebaish, MD; Justin S. Smith, MD, PhD; Richard Hostin, MD; International Spine Study Group USA

Summary: This is a cost-effectiveness analysis of surgical treatment for ASD. Using estimates from literature and observed data on costs and health-related quality-of-life (HRQOL) outcomes, we simulate costs and outcomes for surgical and nonsurgical treatment to estimate incremental cost-effectiveness ratios (ICERs) after 10 and 20 year follow-up. Through 10-year follow-up, the average quality adjusted life-year (QALY) gained per dollar was \$144,000 for ASD surgery compared to nonsurgical treatment. Over 20-year follow-up, the ICER improved to \$115,000 per QALY gained from surgery.

Introduction: There is a lack of long term outcomes in the existing cost-effectiveness literature. The current study examines the long term cost-effectiveness of surgical treatment of ASD with a Markov model populated by estimates from literature and observed data on hospital costs and outcomes.

Methods: We develop a robust Markov model with parameter uncertainty, incorporating costs and outcome distributions from published literature and observed patient data. Summary statistics on mortality rates, revision rates, and nonsurgical costs are taken from literature, while statistics for surgical costs and QALYs are taken from a single-center, retrospective administrative dataset and a multi-center prospective dataset. Costs of surgery are measured as total hospital costs from administrative records. QALYs were calculated from the SF-6D. We projected costs and QALYs for the surgical and nonsurgical populations

PODIUM PRESENTATION ABSTRACTS

allowing varied readmission, cost, and QALY outcomes over 10 and 20 year follow-up. Costs for surgical and nonsurgical patients are intended to reflect the full spectrum of services incurred for surgical or nonsurgical care (e.g., physical therapy, pain management, etc.). Our results are based on 1,000 simulated patients, each proceeding through 6-month cycles over a 10 and 20 year follow-up periods.

Results: Surgical costs averaged \$170,523 over 10-year follow-up, with average QALYs of 6.3. Nonsurgical costs averaged \$40,046 over 10-year follow-up with average QALYs of 5.4. This resulted in an average ICER from surgical treatment of \$144,000 per QALY gained. Over 20 year follow-up, the ICER decreased (became more cost-effective) to \$115,000 per QALY gained.

Conclusion: Our results illustrate the potential for surgical treatment for ASD to be cost-effective over extended follow-up compared to nonsurgical treatment. These findings argue in favor of longer follow-up in ASD studies for accurate cost-effectiveness comparison. Future research should also pursue measurement of indirect costs/benefits resulting from changes in absenteeism or productivity.

23. Post-Operative Blood Salvage and Autotransfusion following Surgery for Adult Spinal Deformity: A Randomized Controlled Trial

Venu M. Nemani, MD, PhD; Han Jo Kim, MD; Curtis A. Mina, MD; Thomas Ross, MS, RN; Matthew E. Cunningham, MD, PhD; Bernard A. Rawlins, MD; Oheneba Boachie-Adjei, MD

USA

Summary: The collection and reinfusion of blood collected via a surgical drain after surgery for adult spinal deformity has not been routinely used due to increased cost and questionable clinical benefit. In a randomized controlled trial, use of post-operative blood salvage and autotransfusion compared to standard closed suction drainage resulted in higher hemoglobin levels on POD 2 and 3, but did not significantly affect the rate of homologous blood transfusion post-operatively.

Introduction: Use of intra-operative blood salvage has become commonplace in spine surgery; however, the collection and reinfusion of blood drained from the wound post-operatively has not been employed routinely due to increased cost and questionable benefit. We investigated whether the collection and reinfusion of autologous blood post-operatively would decrease the need for homologous blood transfusion.

Methods: A randomized controlled trial (RCT) was performed on a consecutive series of patients (pts) undergoing long posterior fusions for spinal deformity. Pts were randomized just prior to wound closure to either (a blood salvage and reinfusion system) or a standard subfascial closed suction drain (Group 2). Blood collected was reinfused according to the manufacturer's protocol. Blood salvage and reinfusion system was converted to a standard closed suction drain when their output was less than 50cc over 4 hours, and drains removed when their output was minimal. Pts received autologous or homologous blood transfusions when Hg < 8 g/dL or they had symptomatic anemia.

Results: 24 pts each were randomized into Group 1 and Group 2. There were no differences in pre-operative or intra-operative parameters (Table 1). Patients in Group 1 had higher hemoglobin levels on POD #2 and POD #3 compared to those in Group 2. However, there was no significant difference in the percentage

of patients requiring homologous blood transfusion between the two groups (42% Group 1 vs. 63% Group 2, $p = 0.15$). Similarly a subgroup analysis in patients with EBL > 2000cc also showed no difference in homologous blood transfusion rates (64% Group 1 vs. 82% Group 2, $p = 0.36$). There were no differences in the rate or type of post-operative complications.

Conclusion: Post-operative blood salvage and reinfusion results in a higher hemoglobin level in the early post-operative period, but does not significantly reduce the need for homologous blood transfusion. The increased cost associated with the use of these drains in patients undergoing correction of spinal deformity can thus be avoided given the lack of clinical benefit.

24. Perioperative Use of Adjunctive Medications for Pain Management Improves Outcomes after Posterior Spinal Fusion for AIS

Suken A. Shah, MD; Karen Sacks, MSN; Kenneth J. Rogers, PhD; Dinesh K. Choudhry, MD

USA

Summary: Perioperative gabapentin and pregabalin are effective adjuncts to improve pain control, reduce opioid consumption and increase mobility in the early stages of recovery in pediatric patients undergoing spinal fusion for idiopathic scoliosis.

Introduction: Adjunctive medications (gabapentinoids) have opioid-sparing effects in adult surgical patients, but few reports exist for the pediatric population. Our purpose was to assess the efficacy of gabapentin and pregabalin use in the perioperative period in pediatric patients with AIS undergoing posterior spinal fusion (PSF).

Methods: 132 consecutive patients had a PSF by a single surgeon for idiopathic scoliosis (AIS) and were prospectively assigned to one of three pain management regimens in this cohort study (Group 1 - morphine PCA, Group 2 - morphine PCA and gabapentin, or Group 3 - morphine PCA and pregabalin). Postoperatively, opioid use was calculated in mg/kg/time intervals. Pain scores and opioid side effects were recorded. Achievement of physical therapy (PT) goals and length of stay were assessed.

Results: 132 patients (44 morphine PCA, 44 morphine PCA and gabapentin, and 44 morphine PCA and pregabalin) did not differ in demographics, operative blood loss, surgical time, fusion levels or in coronal and sagittal plane curve corrections. Inpatient visual analog pain scores did not differ significantly between groups. Morphine consumption (mg/kg/h \pm SD) was significantly lower in the gabapentin and pregabalin groups on the first postoperative day (POD) (0.042 ± 0.014 Group 1 vs. 0.027 ± 0.011 Group 2 vs. 0.028 ± 0.008 ; $p < 0.001$). Also, a greater percentage of patients who received gabapentin and pregabalin were converted to oral pain medications on the first POD (0% Group 1 vs. 25% Group 2 vs. 45% Group 3; $p = 0.005$). There were no significant differences in opioid-related side effects or length of stay (mean 4.85 days). More patients who received gabapentin tolerated ambulation with PT on the first POD (26% Group 1, 50% Group 2, 52% Group 3; $p = 0.058$). There were no adverse effects noted with the use of the adjunctive medications.

Conclusion: Perioperative gabapentin and pregabalin reduced morphine consumption and facilitated transition to oral pain medication on the first POD after PSF for AIS. There was also a tendency towards early ambulation.

PODIUM PRESENTATION ABSTRACTS

Although the results of the adjunctive medications between the two groups were essentially equivalent, pregabalin is 44 times more expensive than gabapentin (total therapy cost \$96.46 vs. \$2.19).

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

25. The Use of Chewing Gum Post-Operatively in Pediatric Scoliosis Patients Facilitates an Earlier Return to Normal Bowel Function

*Joseph Khoury, MD; Jonathan K. Jennings, MD; Shawn R. Gilbert, MD; John S. Doyle, MD
USA*

Summary: This is a prospective, randomized study showing that the use of chewing gum in pediatric patients after scoliosis surgery facilitates an earlier return to normal bowel function. Specifically, first bowel movement occurred 30.9 hours earlier in the gum group. There were no complications associated with the chewing of gum in the early post-operative period.

Introduction: In surgical correction of scoliosis in pediatric patients, gastrointestinal complications, including postoperative ileus, can result in extended hospital stays, poorer pain management, slower progression with physical therapy, and overall decreased patient satisfaction. In patients undergoing colorectal, gynecological, and urological surgery, gum chewing has been shown to reduce time to flatus and passage of feces. We hypothesized that chewing gum could also speed return to normal bowel function in pediatric patients undergoing surgical correction of scoliosis.

Methods: IRB approval was obtained for a prospective randomized controlled trial. Eligible patients included all adolescent idiopathic scoliosis patients undergoing posterior spinal fusion. Exclusion criteria included previous gastrointestinal surgery or pre-existing gastrointestinal disease. Patients were randomized by coin flip. The treatment group chewed sugar-free bubble gum five times a day for twenty to thirty minutes beginning on post-operative day one, and the control group did not chew gum. Patients were asked a series of questions regarding subjective gastrointestinal symptoms each day. Time to flatus and first passage of feces were recorded as indicators of return to normal bowel function. Normality of data was assessed using normal probability plots.

Results: 83 patients completed the study (69 females, 14 males, mean age 14.4 years). Of the 42 patients in the chewing gum group, eight patients elected to stop chewing gum regularly prior to discharge due to a variety of reasons. Patients who chewed gum experienced first bowel movement on average 145.5 hours after surgery, 30.9 hours before those who did not chew gum ($p=0.04$). Gum-chewing patients first experienced flatus at an average of 54.7 hours after surgery compared with 61.8 hours for controls. This trend did not reach statistical significance ($p=0.11$). No difference was noted in duration of hospital stay or subjective complaints.

Conclusion: Chewing gum following posterior spinal fusion for scoliosis is safe and efficacious for speeding return of normal bowel function.

26. Is MRI Necessary for Adolescent Idiopathic Scoliosis When Patients Present with Curves Over 80 Degrees?

*Daniel J. Sucato, MD, MS; Dong-Phuong Tran, MS; Lawrence G. Lenke, MD
USA*

Summary: In a large cohort of 1138 AIS patients, the likelihood of obtaining a preoperative MRI is higher for those patients with curves $\geq 80^\circ$ (63 vs 39%), however, the incidence of neural axis abnormalities (15.6 vs 11.1%) and the likelihood of neurosurgical intervention was the same. These data call into question the greater need to obtain an MRI for large AIS curves.

Introduction: The well-accepted published criteria for obtaining an MRI for patients with adolescent idiopathic scoliosis (AIS) do not include an indication based on curve magnitude. There are no studies which have studied the indications for MRI in patients who have AIS with curves greater than 80 degrees.

Methods: This is retrospective review of a prospective series of AIS operative patients from a single institution from 2002-2013. All data was analyzed and patients were compared based on a preoperative curve ≥ 80 degrees (group ≥ 80) and those who were < 80 degrees (group < 80).

Results: There were 1138 patients who underwent fusion and instrumentation for AIS. The average age was 14.6 years; 920 were female and 221 were male. Overall, 471 (41.6%) patients had a preoperative MRI. There were 102 (8.9%) in the ≥ 80 group and 1036 (91.0%) in the < 80 group. There was a greater incidence of obtaining an MRI for the ≥ 80 group compared to the < 80 group (62.7 vs 39.3%) ($p<0.001$). However, the incidence of having an abnormality was not different between the two groups (15.6 vs 11.1%). The overall distribution of having a Chiari, syrinx, Chiari/syrinx and tethered cord was similar between groups ($P=0.10$). There were differences between the ≥ 80 group and the < 80 group for syrinx (70 vs. 33%), Chiari/syrinx (10 vs 33%) and tethered cord (0 vs 17.8%) ($P=0.032$), while the incidence of a Chiari alone was the same (20 vs 15.6%). There were no differences in the likelihood of having neurosurgical intervention between the ≥ 80 group and < 80 group (40% vs 53.3%). There were no permanent neurologic deficits in this series of patients.

Conclusion: Surgeons obtain a preoperative MRI significantly more often for patients with large curves in AIS, however, the incidence of neural axis abnormalities and the need for neurosurgical intervention are the same. These data call into question the need for obtaining an MRI more often for larger curves. The indications for a preoperative MRI for AIS should not include large curve magnitude and the indications for those patients with curves < 80 degrees could be safely applied to all patients.

27. How Quantity and Quality of Brace Wear Affect the Brace Treatment Outcomes for AIS Patients

*Edmond H. Lou, PhD; Douglas L. Hill, MBA; James V. Raso, MASc; Marc J. Moreau, MD; Douglas Hedden, MD
Canada*

Summary: The positive effects of bracing in patients with AIS have been validated: longer hour of brace wear is associated with better outcomes.

PODIUM PRESENTATION ABSTRACTS

However, the effect of the quality of the brace wear has not been well documented. This study reports a curve progression model for AIS patients treated with full time TLSO. The model demonstrated that both quantity and quality of brace wear affect treatment outcomes. This model can be used to counsel patients to improve treatment effectiveness.

Introduction: A multicenter study demonstrated that bracing significantly decreased the progression of high-risk curves. Full time brace wear, at least 13 hours/day was associated with higher success rates. In a previous study, we showed that brace treatment outcome was related to the risk of progression, curve flexibility, quantity and quality of brace wear. then, a prognostic model of curve progression has been developed. The goal of this study was to determine the reliability of this model in terms of the role of the quantity and quality of brace wear.

Methods: To develop the model, 20 subjects, (17F;3M), age 13.4 ± 1.8 years, prescribed a full-time TLSO (22hr/day) were monitored and followed for 2 years. All subjects met the SRS Brace Study inclusion criteria. The brace usage was logged in terms of quantity (% of wear time relative to the prescribed wear) and quality (% of wear tightness relative to the prescribed tightness level) with a force compliance monitors during the first 6 months. Peterson's risk of progression at brace prescription was calculated. In-brace curve correction (flexibility) was calculated as: (Initial Cobb - best in-brace Cobb)/Initial Cobb. The curve progression model is: Curve Progression (degrees) = $33 + 0.12 * \text{Peterson Risk}(\%) - 0.48 * \text{Quality}(\%) - 0.52 * \text{Quantity}(\%) + 0.66 * \text{Quantity} * \text{Quality} * 100$. To test the model, 40 new subjects, (35F, 5M), age 12.4 ± 2.2 years, who met the same inclusion criteria, used the same type of monitors and followed for 2 years after bracing.

Results: For the test subjects, the average in-brace correction was $40 \pm 22\%$. The average quantity and quality of the brace wear were $56 \pm 19\%$ and $55 \pm 17\%$, respectively. Twelve subjects (30%) progressed in which 10 subjects (25%) required surgery and 28 subjects (70%) showed no progression. Table 1 shows the results from the curve progression model and the actual outcomes. The accuracy of the prediction model was 88% (35/40) which was better than the Peterson's risk model (68%;26/40) alone. The mean absolute difference of the predicted model was 4.2 ± 2.9 . Patients who had the combined quantity times the quality over a threshold 43% had a success rate of 95%.

Conclusion: This study shows that quality in addition to quantity is an important factor in treatment outcomes.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

28. Risk of Development of New Onset Post-Operative Cervical Deformity (CD) in Thoracolumbar Adult Spinal Deformity (ASD) and Effect on Clinical Outcomes at Two-Year Follow Up

Alex Soroceanu, MD, CM, MPH, FRCSC; Peter G. Passias, MD; Anthony J. Boniello, BS; Justin K. Scheer, BS; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Munish C. Gupta, MD; Eric Klineberg, MD; Virginie Lafage, PhD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; International Spine Study Group USA

Summary: This study quantifies the incidence of new onset CD after ASD surgery, identifies predictors of development and determines the impact on patient outcomes and satisfaction. Independent predictors of new onset CD at 2 years include diabetes, higher pre-operative TS-CL, and ending instrumentation above T4.

Introduction: A high prevalence of residual cervical deformity (CD) has been identified following surgical treatment of adult spinal deformity (ASD). Development of new onset CD is less understood and its clinical impact unclear. This study quantifies the incidence of new onset CD after ASD surgery, identifies predictors of development and determines the impact outcomes.

Methods: Retrospective review of prospective multi-center database yielded 215 patients (pts) with complete 2yr follow-up and full length xrays including the cervical spine. CD was defined by: T1S-CL $>20^\circ$, C2C7 SVA $>40\text{mm}$, or C2C7 kyphosis $>10^\circ$. Univariate analysis was performed using t-tests or tests of proportion. Multivariate logistic regression was used to determine independent predictors of new CD. The impact of CD on Health Related Quality of Life (HRQL) and satisfaction was measured using repeated measures mixed models or logistic regression as appropriate, accounting for potential confounders.

Results: 88/215 ASD pts did not have CD at baseline and 42 of them (47.7%) developed CD at 2 years postop. Univariate analysis revealed that pts who developed new cervical deformity in the post op period had a higher incidence of diabetes (14.29%vs2.17%, $p=0.036$) increased pre-op C2C7 SVA ($p=0.04$) and C2 slope ($p=0.038$) and smaller diameter rods used at surgery ($p=0.0328$). Independent predictors of new CD at 2yrs included: diabetes (OR 10.49, $p=0.046$) and increased pre-op TS-CL (OR 1.08/deg, $p=0.027$). Ending instrumentation below T4 was a negative predictor of CD (OR 0.31, $p=0.019$). Pts with and without CD experienced improvements in 2yr SF-36 ($p=0.0001$), ODI ($p=0.0001$) and SRS ($p=0.0001$). Rates and overall improvement were similar. CD was not associated with decreased satisfaction ($p=0.28$).

Conclusion: 47.7% of pts without preop cervical deformity develop new post op cervical deformity after ASD surgery. Independent predictors of new onset CD at 2yrs include diabetes, higher preop TS-CL, and ending instrumentation above T4. Significant improvements in HRQL scores occurred despite the development of postoperative CD.

PODIUM PRESENTATION ABSTRACTS

29. The Presence of Pre-Operative Cervical Deformity in Adult Spinal Deformity Patients is a Strong Predictor of Inferior Outcomes and Failure to Reach MCID at Two-Year Follow Up: Analysis of 235 Patients

Christopher P. Ames, MD; Peter G. Passias, MD; Alex Soroceanu, MD, CM, MPH, FRCSC; Anthony J. Boniello, BS; Justin K. Scheer, BS; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Munish C. Gupta, MD; Eric Klineberg, MD; Virginie Lafage, PhD; Justin S. Smith, MD, PhD; International Spine Study Group USA

Summary: This study aims to quantify the difference in patient-reported outcomes among adult spinal deformity (ASD) patients based on presence of cervical deformity (CD) prior to treatment. Pre-op CD in ASD patients is a strong predictor of inferior outcomes and failure to reach MCID at 2 years (OR for C2C7 SVA>4cm: 0.39 for ODI, 0.34 for PCS, 0.29 SRS activity, 0.41 SRS pain).

Introduction: A high prevalence of cervical deformity (CD) has been identified among adult spinal deformity (ASD) patients undergoing surgical treatment. The clinical impact of this is uncertain. This study aims to quantify the difference in patient-reported outcomes among ASD patients based on presence of CD prior to treatment.

Methods: Retrospective review of a multicenter prospective database of surgical ASD patients with 2-year follow-up. CD was defined as: C2C7 SVA>4cm, cervical kyphosis (CK) C2C7 angle>0. Univariate testing was performed using t-tests, or tests of proportion. Multivariate models determined impact of pre-op CD on Health Related Quality of Life (HRQL) scores (SF-36, ODI, SRS) and obtaining Minimally Clinically Important Difference (MCID) at 2 years.

Results: 235 patients met criteria, of which 65 with pre-op C2C7 SVA>4cm, 57 with CK. Patients with and without CD saw improvements in 2-year HRQL scores ($p<0.001$). Overall, patients with pre-op CD had inferior post-op HRQL and were less likely to achieve MCID for HRQL at 2-years. Those with pre-op SVA>4cm had worse ODI, PCS, SRS activity, appearance, pain, and total, and were less likely to meet MCID for ODI, PCS, SRS activity and pain scores (odds ratio 0.39 for ODI CI 0.19:0.81 $p<0.05$), (0.34 for PCS CI 0.16:0.72 $p<0.05$), (0.29 CI 0.14:0.62 $p<0.05$ SRS activity) (0.41 CI 0.20:0.86 $p<0.05$ SRS pain). Similarly, patients with CK had inferior 2-year HRQL scores. Patients without any CD were 4x more likely to reach 2-year SRS activity MCID (OR 0.40 CI 0.19:0.86 $p<0.05$).

Conclusion: Despite experiencing significant improvements in HRQL scores, pre-op CD in ASD patients is a strong predictor of inferior outcomes and failure to reach MCID at 2 year follow up. This information will help surgeons educate patients at risk for inferior outcomes and direct future research to improve patient outcomes.

30. What is the Best Construct Across the Cervicothoracic Junction?

Justin S. Yang, MD; Jacob M. Buchowski, MD, MS; Vivek Verma, MD USA

Summary: No study to date has objectively compared the outcome of various constructs across the cervicothoracic junction. The present study sought to assess fusion with two types of constructs commonly used: small rods (3.2mm/3.5mm

rods) or transitional constructs. Overall pseudoarthrosis rate were similar between small rods and transitional constructs. There was higher complications rate, blood loss and operating time associated with transitional constructs. Pseudoarthrosis risk factors at the cervicothoracic junction include tobacco use, lack of an anterior construct, and longer constructs.

Introduction: Several constructs over the years have been used to stabilize across the cervicothoracic junction; however no study to date has objectively compared their outcome. The present study sought to assess fusion at the cervicothoracic junction as a function of two types of constructs commonly used: small rods (3.2mm/3.5mm rods) or transitional constructs, and to assess risk factors for pseudoarthrosis at the cervicothoracic junction. Our hypothesis is that both constructs would have similar fusion and complication rates.

Methods: A retrospective review of a prospectively collected database revealed 135 patients with the above mentioned constructs, and having followed-up with imaging at 6 months, 12 months, and 24 months. Initial primary diagnoses were as follows: spondylosis (116), kyphosis/scoliosis (16), fracture (7), and tumor involvement (6). Univariate analysis comparing the two different construct groups was performed. Multivariate analysis for risk factors of pseudoarthrosis was also performed.

Results: There were a total of ten patients with pseudoarthrosis at two year follow-up. There was no difference in pseudoarthrosis rate between the small rods (7%) and transitional constructs (8.6%). The overall construct lengths were similar (5.8 levels in small rods, 6.7 levels in transitional construct). Blood loss was higher in transitional constructs (574ml) than small rods (236ml). Transitional constructs also had longer operating times (249min) than small rods (207min). Overall complication rate was overall higher in the transitional constructs. Tobacco use, lack of an anterior construct, and construct length were all risk factors for cervicothoracic junction pseudoarthrosis in the multivariate analysis.

Conclusion: Overall pseudoarthrosis rate were similar between small rods and transitional constructs. There was higher complications rate, blood loss and operating time associated with transitional constructs. Pseudoarthrosis risk factors at the cervicothoracic junction include tobacco use, lack of an anterior construct, and longer constructs.

31. More than 10-Year Follow Up after Total En Bloc Spondylectomy for Spinal Tumors

Satoshi Kato, MD; Hideki Murakami; Satoru Demura, MD; Katsuhito Yoshioka, MD; Hiroyuki Hayashi; Noriaki Yokogawa; Takayoshi Ishii; Hiroyuki Tsuchiya Japan

Summary: We reviewed 29 patients who had survived for more than 10 years total en bloc spondylectomy (TES) for primary and metastatic tumors. The 10-year survivals after surgery for metastatic tumors were 33% with metastases from kidney cancer, and 25% with metastases from thyroid cancer. There were no tumor recurrences in any of the 23 patients who underwent TES as the primary surgery. TES played an important role in the treatment strategy for spinal tumors including metastases.

Introduction: Total en bloc spondylectomy (TES) is a surgical procedure designed to achieve complete resection en bloc of an aggressive benign spinal tumor or

PODIUM PRESENTATION ABSTRACTS

a malignant spinal tumor. Using this procedure can result in a decrease in the rate of local recurrence plus longer survival. Hitherto, there are many reports of en bloc resection for primary and metastatic spinal tumors. However, no studies have evaluated the clinical outcomes with follow-up exceeding 10 years. The purpose of this study was to examine the clinical outcomes of patients surviving for more than 10 years after TES.

Methods: We reviewed 82 patients who had undergone TES for spinal tumors in our institute before January 2002 and identified 29 patients (19 with primary tumors and 10 with metastatic tumors) who had survived for more than 10 years (mean 164 months) after surgery. Fifty-one patients died within 10 years after surgery and 2 others were lost to follow-up. We evaluated the clinical outcomes including patient-based outcomes using a questionnaire. The questionnaire included subjective assessment of the results of surgery and SF-36. **Results:** The percentage of patients with metastatic tumors who survived for more than 10 years after surgery were 33% with metastases from kidney cancer, and 25% with metastases from thyroid cancer. Four patients with metastatic tumors had no evidence of disease at the time of survey. There were no tumor recurrences in any of the 23 patients who underwent TES as the primary surgery. There was one tumor recurrence in the 6 patients who underwent TES as the revision procedure after the initial surgery in another hospital. No revision surgeries have been required owing to instrumentation failure in any of the 29 patients. About 90% of the patients were satisfied or very satisfied with the results of TES. The SF-36 results demonstrated that the both physical and mental health of patients with primary tumors was equivalent to those of healthy individuals, and the mental health of patients with metastatic tumors was almost similar to those of healthy individuals.

Conclusion: This study clearly showed the long-term clinical outcomes after TES to be favorable. TES played an important role in the treatment strategy for spinal tumors including metastases.

32. The Use of Intraoperative Cell Salvage in Metastatic Spine Tumor Surgery

Naresh S. Kumar, MBBS, FRCS (Orth&Tr), DM; Yongsheng Chen, MBBS, MRCS; Aye Sandar Zaw, MBBS, MPH; Hee-Kit Wong
Singapore

Summary: Metastatic spine tumour surgery (MSTS) is associated with significant blood loss, which is presently replenished by allogeneic blood transfusion (ABT). Using cell saver can reduce ABT requirements but it is contraindicated in tumour surgery due to risk of tumour dissemination. Our study found that cell saver in combination with leucocyte depletion filter could remove tumour cells from blood salvaged during MSTS and this result is consistent with results from previous similar studies in other oncological specialties.

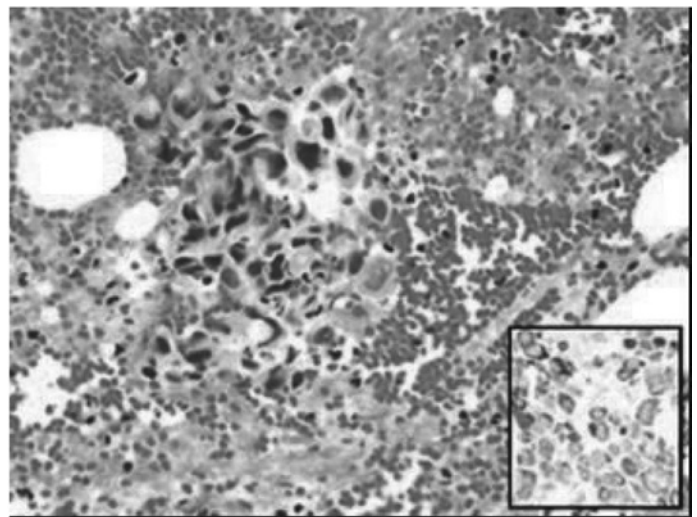
Introduction: Catastrophic bleeding is a significant problem in metastatic spine tumor surgery (MSTS). Currently, allogeneic blood transfusion (ABT) is the mainstay for replenishing blood loss, placing an undue strain on limited blood bank resources and exposing patients to ABT associated side effects. Despite using cell saver (CS) can reduce ABT requirements, CS have traditionally been avoided in tumour surgery because of the theoretical concern of promoting tumour dissemination by re-infusing tumour cells into the circulation. Although CS

has been extensively investigated in patients undergoing surgery for a number of oncological specialties, there is no prior report of the use of CS in MSTS.

Methods: After Institutional Review Board approval, 35 consecutive patients with metastatic spinal tumours from a known epithelial primary and scheduled for MSTS were recruited with informed consent. During surgery, 15-ml samples of blood were taken from each of three consecutive stages: Stage A - from the operative field prior to CS processing; Stage B - from the transfusion bag post-CS processing; Stage C - from the filtered blood after passage through both CS and LDF. Samples were examined using one of the immunohistochemical monoclonal antibodies, AE1/3, MNF 116 and CAM 5.2 which are highly sensitive and specific markers to identify tumour cells of epithelial origin.

Results: Four cases were excluded when final diagnosis concluded it as an infection. Of the remaining cases, 11 out of 31 cases tested positive for tumour cells in Stage A, 3 out of 31 cases tested positive in Stage B. No sample tested positive for tumour cells in Stage C which were the samples taken after both CS and LDF processing.

Conclusion: In this first-ever report of cell saver use in MSTS, we have proved that LDF can effectively remove tumour cells from blood salvaged during MSTS. Our results are consistent with published results of similar studies performed on CS and LDF use in various oncological surgeries outside the field of Orthopaedic surgery. Our results support the fact that CS-LDF combination can be a simple and safe method in reducing ABT in cancer patients undergoing oncological surgeries.



Epithelial tumour cells noted in the hematoxylin-eosin stain, original magnification x400 (Inset: Cytokeratin AE1/3 positivity in tumour cells, original magnification x400)

33. META: An MRI-Based Scoring System Differentiating Metastatic from Osteoporotic Vertebral Fractures

So Kato, MD; Takahiro Hozumi; Kiyofumi Yamakawa; Takahiro Goto, MD
Japan

Summary: This is the retrospective study to create a scoring system to differentiate metastatic vertebral fractures from osteoporotic vertebral fractures by integrating several magnetic resonance imaging (MRI) findings. Our scoring

PODIUM PRESENTATION ABSTRACTS

system "META" was created by discriminant analysis and its accuracy was calculated to be 96.6%.

Introduction: MRI is useful for the differential diagnosis of osteoporotic vertebral fractures (OVFs) and metastatic vertebral fractures (MVF), but no single finding is absolutely conclusive. The objective of the present study was to create a scoring system to facilitate the correct diagnosis of MVFs by integrating several magnetic resonance imaging (MRI) findings.

Methods: We reviewed MRI images of thoracolumbar vertebral fractures that were obtained within 60 days from fractures. One hundred OVFs and 100 MVFs were included. Seven known key MRI findings of these fractures were analyzed to evaluate their sensitivity and specificity. Discriminant analysis was performed using 140 fractures as a training set, and the classification accuracy was calculated in the remaining 60 fractures as a test set. Additionally, the images of these 60 fractures were reviewed by another blinded reviewer to investigate the interobserver reliability of each finding.

Results: All findings were useful, with either sensitivity or specificity of greater than 75.0%. Eight variables were selected in the final discriminant function. A simpler scoring system (META: MRI Evaluation Totalizing Assessment) was created by approximating the coefficients and the constant term by integral numbers. The classification accuracy was calculated to be 96.6% in the test set. The interobserver reliability of the key findings varied, but the final discrimination conducted by META had the high agreement between the two reviewers ($\kappa = 0.93$).

Conclusion: This novel scoring system, META, could be a useful tool for the differential diagnosis of OVFs and MVFs. It is simple and physician-friendly, yet highly accurate.

34. The Cellular and Biological Profile of Autologous Bone from Various Graft Sites

Brandon Lawrence, MD; Sarina Sinclair, PhD; William R. Spiker, MD; Darrel S. Brodke, MD
USA

Summary: The cellular and biologic profiles of 5 autograft sources from 15 patients were evaluated. The mesenchymal stem cell (MSC) numbers were highest in iliac crest bone graft (ICBG), iliac crest aspirate (ICA) and vertebral body aspirate (VBA) when compared to local laminectomy bone (LLB) and local morselized bone fragments (MBF). Growth factor concentrations were higher in the bone graft sites when compared to the aspirates, and LLB had the highest concentration of BMP-2.

Introduction: Due to patient dissatisfaction and donor site morbidity associated with ICBG, many surgeons have come to rely on local bone graft or aspirates in an attempt to circumvent these complications. The biological potential of these alternatives have not been fully elucidated.

Methods: Patients undergoing spinal decompression and fusion had cells isolated from five different sites: ICBG, LLB, MBF, ICA and VBA. The cells were evaluated using four parameters: a nucleated cell count, colony forming unit (CFU) assay, alkaline phosphatase (ALP), and evaluation of the growth factor environment using ELISA for VEGF, PDGF, BMP-2 and BMP-7.

Results: 15 patients, average age 67 (42-80), had MSC's successfully isolated from all 5 sites. A comparison of the median values of cell numbers based on a skewed data distribution showed no significant differences. The CFU assay suggests more MSCs were isolated from ICBG, ICA and VBA compared to LLB and MBF. Cells from all 5 sites exhibited osteogenic potential based on expression of ALP with ICBG having significantly higher levels. Growth factor analysis showed no significant difference in the concentrations of VEGF, PDGF, BMP-2 or BMP-7 between the bone tissue graft sites (ICBG, LLF, MBF), though LLB had the highest concentration of BMP-2. These three sites had significantly higher concentrations than the aspirates.

Conclusion: This study is the first to rigorously evaluate the cellular and biologic properties of the available graft sites utilized in spine surgery. While the initial goal of this work was to identify one optimal graft site, a combination of LLB/MBF and VBA may provide a synergistic effect that rivals ICBG.

35. Local versus Systemic Antibiotics for Surgical Infection Prophylaxis in a Rat Model

Fred A. Sweet, MD
USA

Summary: Implant infection prophylaxis with a variety of local antimicrobial agents were compared to intravenous antibiotics in a rat model. Local antimicrobials were significantly better than intravenous antibiotics in preventing implant infections.

Introduction: Recent clinical studies have demonstrated efficacy of local application of vancomycin powder in surgical wounds to reduce implant related infections. Clinical studies have also been done on Tobramycin powder and dilute betadine as local prophylactic agents. Our purpose was to compare local application of a variety of antimicrobial agents compared to intravenous antibiotics for infection prophylaxis in a rat model.

Methods: A total of sixty adult male Sprague-Dawley rats were implanted with a GORE-TEX vascular graft in a dorsal subcutaneous position challenged with 10^6 methicillin sensitive staph aureus (MSSA). Ten rats received pre-treatment with IV cefazolin, ten rats were pretreated with IV vancomycin. The forty remaining rats all had application of local antimicrobials in the surgical site at the conclusion of the procedure including: ten rats received vancomycin powder, ten rats received cefazolin powder, ten rats received tobramycin powder, and ten rats underwent dilute 0.35% betadine lavage for 3 minutes. One week after surgery the vascular grafts were retrieved and cultured.

Results: Ten of ten (100%; 95% confidence interval (CI), 77% to 100%) rats in each of the IV cefazolin, IV vancomycin, and dilute betadine lavage had grossly positive cultures for MSSA.

Eight of ten (80%; 95% CI, 60% to 99%) rats in the cefazolin local powder group demonstrated positive cultures. Three of ten (30%; 95% CI, 7% to 53%) rats in the tobramycin local powder group demonstrated positive cultures. Zero of ten (0%; 95% CI, 0 to 22%) rats in the local vancomycin powder group demonstrated positive cultures for MSSA. The infection rates for local application of vancomycin and tobramycin powder were statistically significant compared to Betadine lavage, IV vancomycin, IV cephalosporin, and local cephalosporin powder ($P < 0.05$).

PODIUM PRESENTATION ABSTRACTS

Conclusion: Local antimicrobial prophylaxis for infections with vancomycin and tobramycin powder in this rat model was statistically superior to systemic prophylaxis with IV antibiotics, local cefazolin powder and Betadine lavage. The superiority of local antibiotic surgical prophylaxis in this model suggests systemic prophylaxis with IV antibiotics may not be necessary for surgical procedures.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

36. The Type of Metal, Local Antibiotics or Prophylactic IV Antibiotics; What Influences Postoperative Spine Infections with MRSA the Most?

Sachin Gupta, Sukanta Maitra, Blythe Durbin-Johnson, PhD; Maria das Gracas C. Pereira, DVM, PhD; Pumbal Wetpiriyakul, MD; Munish C. Gupta, MD; Kavita Gupta
USA

Summary: Post-operative infections can be devastating. We studied the efficacy of Vancomycin powder in eradicating MRSA. Vancomycin powder was effective in eradicating MRSA. CoCr had more residual infection than Ti and SS.

Introduction: The purpose of this study was to determine the efficacy of Vancomycin powder and IV prophylactic Vancomycin in treatment of spine infection with MRSA in presence of different metals.

Methods: 42 rabbits underwent a posterior L5-L6 approach. A 4 cm wire was placed around the L5 and L6 spinous processes. The implant was inoculated with 100 μ L MRSA containing 106 colonies. 40 mg of Powder Vancomycin was placed in the wound prior to closure. The dose of IV Vancomycin was 15mg/kg. Proportions of infected rabbits were compared using chi-square tests, and compared between groups adjusting for confounding factors using Cochran-Mantel-Haenszel tests. CFU counts for the tissue and implant were compared between groups using Wilcoxon rank sum tests.

Results: The proportions of rabbits with infection were significantly higher in rabbits who received no Vancomycin compared ones that received powdered Vancomycin ($p < 0.001$ for tissue-oxy, tissue-blood, implant-oxy, and implant-blood). CoCr had higher rates of residual infection despite the use of Vancomycin powder than Ti and SS ($p = 0.040$). In rabbits with SS, the proportions of infection differed significantly among Vancomycin types (non, powdered, or IV) ($p = 0.015$ for tissue-oxy, $p = 0.020$ for tissue-blood, $p = 0.025$ for implant-oxy, $p = 0.023$ for implant-blood), with a significantly lower proportion infected among those with powdered Vancomycin. Rabbits with SS implants treated with Vancomycin powder had a lower infection rate than those treated with IV Vancomycin, although this difference was not statistically significant ($p=0.557$).

Conclusion: The Vancomycin powder is very successful in eradicating infection. CoCr had more residual infection in tissues when compared to SS and Ti. SS had a similar outcome than portrayed in the literature when compared to Ti. Local vancomycin powder appears better in eliminating infection than Prophylactic IV Vancomycin.

37. Intermediate Dosing of Recombinant Human Bone Morphogenetic Protein-2 (rhBMP-2) Improves Fusion Rates with No Increase in Major Complications but does not Improve Health Related Quality of Life for Adult Spinal Deformity (ASD) at Minimum Two Years: A Prospective, Multicenter Analysis

Shay Bess, MD; Breton Line, BSME; Virginie Lafage, PhD; Christopher P. Ames, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Munish C. Gupta, MD; Eric Klineberg, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group
USA

Summary: Prospective, multi-center analysis of complications and outcomes in 199 consecutive ASD patients minimum 2 year follow up demonstrated patients treated with rhBMP-2 (BMP) had lower incidence of pseudarthrosis and higher fusion grades than NOBMP ($p<0.05$). Total major complications and return to surgery were similar between groups, but were more common at 6-12 months for NOBMP vs. BMP. BMP receiving 5-10mg/level had higher fusion rates and grades than NOBMP. HRQOL outcomes were similar BMP vs. NOBMP.

Introduction: Controversy persists regarding rhBMP-2 use in spine surgery. Purpose: compare minimum 2 year complications, fusion rates and clinical outcomes for BMP and NOBMP patients in a prospective, multi-center consecutive cohort.

Methods: Multicenter, prospective analysis of complications, spine fusion (Lenke grade) and health related quality of life (HRQOL; SRS-22r, ODI, SF-36) for consecutive ASD patients receiving rhBMP-2 (BMP) or no BMP (NOBMP). Inclusion criteria: ASD, age ≥ 18 years, spinal fusion ≥ 4 levels, minimum 2 years follow up. Type and timing of complications evaluated and multivariate analysis (MARS) performed. BMP divided into posterolateral dose used; <5 , 5-10, and >10 mg/level.

Results: 199 patients, mean follow up 44.3 months (range 23.3-60.3), met inclusion criteria. BMP ($n=130$; mean posterolateral dose/level 3.1 mg, mean interbody dose/level 1.8 mg) had had similar preoperative deformity and total fusion levels as NOBMP ($n= 69$). BMP had greater Charleson comorbidity index, operative time, and anteroposterior surgery than NOBMP; NOBMP had more 3 column osteotomies than BMP ($p<0.05$). Early minor complications (< 3 and 3-6 months) were greater for BMP vs. NOBMP ($p<0.05$). Total major complications were similar BMP vs. NOBMP, however NOBMP had greater return to surgery rates at 6-12 months, greater pseudarthrosis rates, and deep infection and implant failures constituted a greater proportion of complications for NOBMP vs. BMP ($p<0.05$). BMP had greater interbody and posterior fusion grades and rates than NOBMP ($p<0.05$). BMP dosed at 5-10mg demonstrated greater fusion grades and rates vs. NOBMP, while BMP dosed at <5 mg group did not. HRQOL values were similar BMP vs. NOBMP at all time points.

Conclusion: RhBMP-2 at intermediate dosing may improve fusion rates with no increase in major complications in ASD surgery, however HRQOL measures were similar between groups. Longer follow up is needed to assess if fusion rates correlate with HRQOL and revision surgery.

PODIUM PRESENTATION ABSTRACTS

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

38. Bone Morphogenetic Protein (BMP-2) Usage and Cancer Correlation: An Analysis of 10,416 Spine Fusion Patients from a Multicenter Spine Registry
Lance K. Mitsunaga, MD; Yuexin Chen, BS; Kamran Majid, MD; Kern H. Guppy, MD, PhD; Jessica Harris, MS, RD; Julie L. Alvarez, MPH; Liz W. Paxton; Ravi S. Bains, MD
USA

Summary: Concern exists over the potential association between bone morphogenetic protein (BMP-2) use and increased cancer risk. We present data from a large spine registry that includes 10,416 patients who underwent spine fusion. BMP-2 was used in 5,987 of these patients while 4,429 patients underwent fusion without BMP-2. De novo cancer occurred in 1.2% of the BMP-2 group compared to 1.1% in the non-BMP group. With our 2-year follow-up data, we did not find an association between BMP-2 and increased cancer risk.

Introduction: Questions have been raised about the possible increased risk of cancer from the use of BMP-2 in spine fusion surgery. Existing literature on this topic is conflicting and relies on animal studies or human studies with limited sample sizes. The purpose of our study—one of the first independent, non-industry supported analyses—is to compare the risk of developing cancer in patients who underwent spine fusion with and without the use of BMP-2 using data from a large, multi-center spine registry.

Methods: An integrated health system's spine registry was used to retrospectively identify patients who underwent spine fusion surgery between 1/09 and 6/12. Using this data, patient characteristics, BMP-2 dosage (if used), region of the spine fused, and number of levels fused were extracted. Data was also cross-matched with our institution's Cancer Registry to identify any de novo diagnoses of cancer in these patients. Using logistic regression analysis, the risk of malignancy following spine surgery with and without BMP-2 administration was determined.

Results: In our cohort of 10,416 patients, 5,987 patients underwent a fusion procedure with BMP-2 while 4,429 patients underwent fusion without BMP-2. De novo cancer diagnoses were found in 73 patients in the BMP-2 group (1.2%), compared to 47 patients in the non-BMP group (1.1%, $p=0.454$). Average length of follow-up for patients in the BMP-2 group was 2.2 years, compared to 1.9 years for the non-BMP group. After adjusting for age, gender, BMI, ASA score, and smoking status, we did not identify a significant effect of BMP-2 on the development of cancer (OR 1.06, 95% CI 0.58-1.92).

Conclusion: In this retrospective analysis of data collected from a large spine registry over a 3.5-year period, we found no evidence that the use of BMP-2 (in dosages ranging from less than 1.05 mg to 12 mg) conferred an increased risk of developing cancer. This serves as a preliminary report. Longer follow-up is needed to conclusively determine that BMP-2 does not cause cancer.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

39. Use of Recombinant Bone Morphogenetic Protein (BMP) is Associated with Reduced Risk of Reoperation after Spine Fusion for Scoliosis
Justin C. Paul, MD, PhD; Baron S. Lonner, MD; Thomas J. Errico
USA

Summary: By improving fusion rates, use of BMP is expected to reduce the need for subsequent revision surgery, but this has not been shown for adolescent idiopathic scoliosis (AIS), adult spine deformity surgery (ASDS), or neuromuscular scoliosis (NMS). Large administrative databases provide sufficient sample size to monitor relatively rare reoperation events. Using the New York State Inpatient Database, we found that BMP is associated with a reduced risk for reoperation in all three patient populations.

Introduction: Randomized controlled trials have suggested that BMP may increase the likelihood of solid fusion for spine arthrodesis. This would imply fewer reoperations for pseudarthrosis, but small cohort sizes are inadequate to monitor these events. This study follows the inpatient stay administrative data collected for a cohort of thousands of patients who had spine fusion surgery in the state of New York. We sought to examine adult, adolescent idiopathic, and neuromuscular scoliosis for reoperation events with and without the use of BMP.

Methods: The 2008-2011 New York State Inpatient Database was queried using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. Patients age 10 and older with a diagnosis of scoliosis and an index fusion of greater than 2 disk levels were included. Patient identifiers and linkage variables were used to identify revisits. The relative risk of reoperation was calculated. The use of BMP at the initial inpatient stay was used to define the two cohorts for relative risk assessment.

Results: A total of 2,301 adolescent (age 10-21) and 3,749 adult (age over 21) relevant patient records were identified. The rate of reoperation for a pseudarthrosis was 0.9% in AIS, 4.2% in ASDS, and 17.2% in NMS. The use of BMP at the initial visit was performed at a rate of 5.5% for AIS, 37.6% for ASDS, and 21.4% for NMS fusion surgery and was associated with decreased risk of reoperation, especially for fusions longer than 8 levels (see Table). Adult idiopathic scoliosis showed a relative risk for reoperation of 0.134, $p<0.001$, while adolescents showed 0.460, $p<0.001$. Adolescent patients with neuromuscular scoliosis showed a similar result (RR 0.252, $p<0.001$).

Conclusion: Using relevant in-hospital patient records from the New York State Inpatient Sample, we found a 7.5-fold decrease in the risk of reoperation with the use of BMP in the case of ASDS, with similar trends noted in AIS and NMS. If subsequent unnecessary hospital stays can be avoided, the economics of BMP use should be re-examined.

40. Risk of Neurological Injuries in Spinal Deformity Surgery
Julian J. Leong, MA, FRCS, PhD; Mary R. Curtis, BSc; Emma V. Carter, MSc; Joseph Cowan, MB, ChB, FRCP; Jan Lehovsky
United Kingdom

Summary: Risk of neurological injuries was examined in patients who had spinal deformity correction surgery in a single institution. Over 2000 prospectively entered records were analysed over a 7 year period, and quantification of risk

PODIUM PRESENTATION ABSTRACTS

was made for anterior versus posterior surgery, and also for operations for different subtypes of spinal deformity.

Introduction: There is a wide range of reports on the prevalence of neurological injuries during scoliosis surgery, however this should depend on the subtypes and severity of the deformity. Furthermore, anterior versus posterior corrections pose different stresses to the spine, further quantifications of neurological risks are presented.

Methods: Neuromonitoring data was prospectively entered, and the database between 2006 and 2012 was interrogated. All deformity cases under the age of 21 were included. Tumour, fracture, infection and revision cases were excluded. All “red alerts” were identified and detailed examinations of the neuromonitoring records, clinical notes and radiographs were made. Diagnosis, deformity severity and operative details were recorded.

Results: 2291 deformity operations were performed: 2121 scoliosis (1627 idiopathic, 204 neuromuscular, 216 syndromic, 52 congenital, and 21 others), 89 kyphosis, 54 growing rod procedures, and 27 operations for hemivertebra. 719 anterior and 1393 posterior operations were performed for scoliosis (9 not recorded), and 39 anterior and 50 posterior kyphosis correction.

68 “red alerts” were identified, there were 14 transient and 9 permanent neurological injuries. 63 were during posterior stage (24 idiopathic, 20 neuromuscular, 16 syndromic (4 kyphosis), 1 growing rod procedure, 2 others), and 5 were during anterior stage (4 idiopathic scoliosis and 1 syndromic kyphosis). Average Cobb angle was 90°. 3 permanent injuries were during correction for kyphosis (1 anterior and 2 posterior), and 6 were for scoliosis (4 syndromic, 1 neuromuscular, and 1 anterior idiopathic).

Common reactions after “red alerts” were surgical pause with anaesthetic interventions (n=39) and the Stagnara wake-up test (n=22). Metalwork was partially removed in 19, revised in 12 and completely removed in 9. 13 procedures were abandoned.

Conclusion: The overall risk of permanent neurological injuries was 0.4%, the highest risk groups were posterior kyphosis corrections (4%) and syndromic scoliosis (3%). 4% of all posterior deformity corrections had “red alerts”, and 0.5% resulted in permanent injuries; compared to 0.7% “red alerts” and 0.3% permanent injuries for anterior surgery. The overall risk for idiopathic scoliosis was 0.06%.

41. Improvement of Motor Evoked Potential Responses Using Novel Transcranial Electrical Stimulation Technique in Intraoperative Neurophysiologic Monitoring during Spinal Deformity Surgery: Multi-Train Stimulation

Shunji Tsutsui, MD, PhD; Hiroshi Iwasaki, MD; Hiroshi Yamada, MD, PhD; Hiroshi Hashizume, MD, PhD; Akihito Minamide, MD, PhD; Yukihiko Nakagawa; Hideto Nishi, MD; Munehito Yoshida, MD

Japan

Summary: Transcranial motor evoked potentials (TcMEPs) are too small and variable to reliably interpret the critical changes of responses in anesthetized patients. A novel technique of multi-train stimulation was introduced to improve TcMEPs during spinal deformity surgery. A multipulse (train) stimulus was delivered repeatedly. Although TcMEP amplitudes increased with the number of

train stimuli and variability in amplitude was significantly reduced, no adverse event was observed. Changing methodology from conventional single-train to multi-train stimulation has greatly improved TcMEP responses.

Introduction: Transcranial motor evoked potentials (TcMEPs) are widely used to monitor motor function during spinal deformity surgery. However, reliable interpretation of the critical change of TcMEPs remains cumbersome since TcMEPs are small and variable in amplitude in anesthetized patients. A novel technique of multi-train stimulation (MTS) was introduced to improve TcMEP responses.

Methods: In 53 patients undergoing surgical correction of spinal deformities (8 males and 45 females with normal motor status; age range, 11-80 years), TcMEPs from abductor hallucis (AH) and quadriceps femoris (QF) were prospectively collected and analyzed. A multipulse (train) stimulus with an individual pulse width of 0.5ms and an inter-pulse interval of 2ms was delivered repeatedly (2-7 times) at different rates (2, 5, and 10Hz).

Results: TcMEP amplitudes increased with the number of train stimuli for both of AH and QF and the strongest facilitation was observed at 5 Hz. When compared to conventional single-train stimulation (STS), the response amplitude increased 6.1 and 8.0 times on average respectively, and coefficient of variation (SD/mean) in amplitude during surgery was also significantly reduced for both muscles (p=0.026 and 0.016, respectively). No adverse event (e.g., seizures) was observed in any of the cases.

Conclusion: Changing methodology from conventional STS to MTS has greatly enhanced TcMEP responses and reduced variability in amplitude.

42. The Importance of “Time to Surgery” for Traumatic Spinal Cord Injured Patients: Results from an Ambispective Canadian Cohort of 949 Patients

Marcel F. Dvorak, MD, FRCSC; Charles G. Fisher, MD, MHSc, FRCSC; Brian K. Kwon; Brian M. Drew, MD; Michael G. Fehlings, MD, PhD; Jerome Paquet; Henry Ahn, MD, PhD, FRCSC; Najmedden Attabib, MD, FRCSC; Chris S. Bailey, MD; Sean Christie; Neil Duggal, MD, MSc, FRCSC, FACS; Joel Finkelstein, MSc, MD, FRCSC; Daryl R. Fourney, MD, FRCSC, FACS; R. John Hurlbert, MD, PhD, FRCSC, FACS; Michael G. Johnson; Jean-Marc Mac-Thiong, MD, PhD; Stefan Parent, MD, PhD; Eve C. Tsai, MD, PhD; Nader Fallah; Vanessa Noonan, PhD, PT; Carly S. Rivers, PhD

Canada

Summary: The timing of surgery for Traumatic spinal cord injury (tSCI) is controversial. Although some recent studies highlight the benefit of surgery within 24h of injury, this is not definitive.

Introduction: The timing of surgery for Traumatic spinal cord injury (tSCI) is controversial. Although some recent studies highlight the benefit of surgery within 24h of injury, this is not definitive. The objective of this study was to determine current surgical timing for tSCI in Canada and to ascertain whether the timing of surgery influences neurological outcome in tSCI patients.

Methods: Ambispective cohort design of tSCI patients who underwent spine surgery within 30d of injury, recruited to the Rick Hansen National Spinal Cord Injury Registry (RHSCIR). between 2004-2013, Patient demographics, admitting and post-operative neurology, timing of surgery were collected. Multiple linear and gamma regression were used to determine correlations between times of arrival at the first acute hospital, initial neurologic examination, and surgery, as

PODIUM PRESENTATION ABSTRACTS

well as to determine if there were differential patterns of recovery dependent on time to surgery and admission neurology (ASIA Injury Scale (AIS) A, B, C, or D). Possible reasons for neurologic deterioration over time were also examined.

Results: 949 patients were included in this analysis. The mean/median/range time to surgery for all participants were 60h/32h/2-705h. Participants with AIS A at admission did not demonstrate an effect of time of surgery on change in motor score; however, surgery within 24 hours on AIS B, C, or D increased motor score by almost 7 points.

Conclusion: In tSCI participants who present with AIS A injuries; the timing of surgery does not appear to influence motor recovery. When the AIS is B, C, and D at admission, surgery within 24 hour from injury is correlated with improved motor score recovery.

43. Comparison of Early Spinal Fusion with Late Spinal Fusion in Pediatric Patients with Congenital Spinal Deformity: Long-Term Follow-Up Study

Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Toshiki Saito; Toshiaki Kotani; Shohei Minami; Koki Uno, MD, PhD; Teppei Suzuki; Toru Hirano; Haruhisa Yanagida, MD; Toru Yamaguchi, MD; Manabu Ito, MD, PhD

Japan

Summary: This long-term follow-up (FU) study compared early fusion (EF, ≤ 10 ys of age at surgery) in pediatric patients with congenital spinal deformity (p-CSD) with late fusion (LF, ≥ 11 ys of age at surgery). The clinical data from 171 patients (87 in EF, 84 in LF, FU ≥ 10 years) were analyzed retrospectively. Those that underwent EF did not exhibit deterioration of their thoracic height (TH) if shorter fusion was performed. Lower correction following EF was a risk factor for reoperation due to postop. progression of spinal curvatures.

Introduction: To compare the clinical outcomes of EF with that of LF in p-CSD, in order to clarify problems associated with EF during long-term F/U periods.

Methods: Clinical data of p-CSD that underwent SF was obtained from 6 institutions and retrospectively analyzed. Inclusion criteria were: 1) p-CSD, 2) SF at the age ≤ 20 ys, 3) a minimum FU period ≥ 10 ys. Patients with CSD treated with growth sparing surgery were excluded in this study. 171 patients were divided into two groups based on their age at the time of SF (≤ 10 , > 11). The EF group included 87 patients (42 male, 45 female, age at SF 5.7 ys, FU 14.7 ys). The LF group included 84 patients (29 male, 55 female, age at SF 13.8 ys, FU 15.8 ys).

Results: There were no significant differences in the types and locations of the vertebral anomalies between the two groups. 28% of the patients in EF group underwent SF without any instrumentation while 2.6% in the LF group had no instrumentation. Scoliosis of the EF and the LF group were corrected from 50.7°, 64.9° preoperatively to 36.6°, 40.0° at 2 years after surgery and 43.6°, 44.8° at 10 years after surgery, respectively. There was no significant difference between the preop. angles and those at the time of postop. 2 years. A comparison of the TH between the EF group and LF group revealed that the TH in patients who underwent longer SF in the EF group was significantly shorter (18.7cm) than those that underwent shorter SF in the EF group (23.7cm) and SF in the LF group (22.7 cm). 35 of 87 patients in the EF group required additional surgery with an interval of 4.8 years from the initial SF because of progression of the spinal deformity while 7 of 84 of the patients in the LF

group required a reoperation within a period of 2.1 years. The main reason for reoperation in both groups was the progression of the spinal deformities. The risk factors for reoperation were an earlier SF, a larger preop. and postop. magnitude of scoliosis, and SF without spinal instrumentation.

Conclusion: This study showed that EF in p-CSD was not associated with deterioration of the TH if shorter SF was chosen, and that lower correction in EF caused a relatively higher rate of reoperation than in LF, due to postop. progression as a result of further growth of the spinal column.

44. Long-Term Quality of Life after Early Fusion Surgery in Congenital Scoliosis Patients 10 Years of Age or Younger Assessed after a Minimum of 10 Years: A Multicenter Study

Toshiaki Kotani; Shohei Minami; Tsutomu Akazawa, MD; Tsuyoshi Sakuma, MD, PhD; Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Koki Uno, MD, PhD; Teppei Suzuki

Japan

Summary: We investigated the long-term quality of life in a group of young (≤ 10 years old) patients with congenital scoliosis who underwent early fusion. In a multicenter study, follow-up assessment carried out in 45 patients after a minimum of 10 years revealed that surgery had beneficial long-term effects on pain and mental health.

Introduction: Several long-term follow-up studies of surgically-treated adolescent patients with idiopathic scoliosis have been reported. However, the long-term clinical outcomes of early fusion in congenital scoliosis are unknown. The purpose of this multicenter study was to investigate the clinical outcomes of surgery for congenital scoliosis.

Methods: Eighty-six patients with congenital scoliosis underwent surgery between 1978 and 2002, and 45 (52.3%) of the patients (26 females, 19 males; mean age 22.0 (range 16-39) years) answered a questionnaire. Mean age at the initial operation was 6.0 (range 2-10) years; mean follow-up period was 15.9 (range 10-32) years. Fifty-one age- and sex-matched healthy individuals (29 females, 22 males; mean age 22.7 (range 20-31) years) were selected as a control group. The SRS-22 Patient Questionnaire and Roland-Morris Disability Questionnaire (RDQ) were used to evaluate long-term clinical outcomes.

Results: Responses to the SRS-22 showed that patients with congenital scoliosis had a significantly decreased functioning (patients, 4.6 ± 0.5 vs. controls, 4.9 ± 0.2 ; $p < 0.01$) and self-image (patients, 3.4 ± 1.0 vs. controls, 3.9 ± 0.6 ; $p < 0.01$). However, patients had significantly increased mental health (patients, 4.2 ± 0.7 vs. controls, 3.9 ± 0.7 ; $p < 0.01$). There were no significant differences in pain between the two groups. RDQ responses were 1.2 ± 2.6 in patients and 0.4 ± 1.4 in controls, with no significant differences.

Conclusion: Early fusion for congenital scoliosis patients had good long-term outcomes for pain and mental health after a minimum of 10 years. However, the patients had a significantly lower functioning and self-image compared with the age- and sex-matched healthy controls.

PODIUM PRESENTATION ABSTRACTS

45. Characterizing Endothoracic Deformity in EOS: The Spinal Penetration Index

Charles E. Johnston, MD; Anna M. McClung, BSN, RN; Ryan D. Muchow, MD USA

Summary: Spinal penetration index measurements from CT scans describe endothoracic deformity in 3 planes and provide quantitative assessment of thoracic constriction and outcome following surgical management.

Introduction: Scoliotic axial plane deformity producing spinal penetration into the convex hemithorax significantly contributes to type IIIb thoracic constriction in EOS. First described by Dubousset(2002) no standardized method to objectively characterize this endothoracic deformity exists, impairing assessment of surgical indications and outcomes. We developed spinal penetration index (SPI) measures to control endothoracic changes in 3 planes.

Methods: Axial chest CTs from an IRB approved EOS database were measured at the deformity apex (Figure 1). SPI components include: coronal plane convex-to-concave thoracic width ratio (CVXW /CAVW); sagittal plane anterior-to-posterior ratios in both concave (A/PCAV) and convex (A/PCVX) hemithoraces; and apical vertebral rotation (AVR). Normal SPI values were determined from control cases w/o deformity at T4,T6,T8,T10.

Results: 138 scans from 98 patients were measured and compared to 40 normals. CVX W/CAVW \approx .98 at control thoracic levels, confirming midline spine position. (Fig 1) A/PCVX and A/PCAV ratios varied 1.7-2.5 from T4-T10 depending on level and kyphosis. In EOS patients SPI ratios varied with curve severity. (Fig 2) CVXW/CAVW=.53 in cases $\leq 30^\circ$, and .44 for Cobb $>30^\circ$ ($p=.03$). A/PCAV was increased for $>30^\circ$ (3.5 vs 2.1 for $\leq 30^\circ$, $p<.0001$), while A/PCVX were less different (2.8 vs 2.2, $p=.09$). AVR was greater for $>30^\circ$ curves (30.4 vs 13.5, $p<.0001$). Postop scans (n=20) revealed no changes in SPI ratios with conventional growing constructs UNLESS the apex was specifically instrumented ("apical control") and corrected, in which case ratios improved toward normal.

Conclusion: SPI ratios quantitatively describe 3 planes of endothoracic deformity, providing basis and outcome measures for characterizing correction of convex spine hemithoracic penetration and rotation. Conventional distraction-based growing instrumentation is ineffective in correcting penetration and rotation due to lack of apical control.

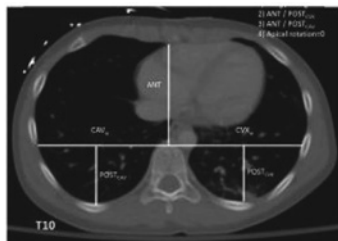


Figure 1

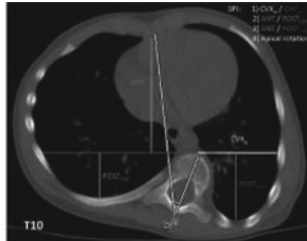


Figure 2

46. An Analysis of Thoracic Cage Deformities and Pulmonary Function Tests in Congenital Scoliosis

Xuhong Xue, MD; Jianxiang Shen, MD China

Summary: We investigated the association among the pulmonary function, thoracic and rib deformities in CS patients. PFTs correlate significantly with scoliotic angle, number of involved vertebra, thoracic sagittal diameter and diaphragm height. PFTs do not correlate with thoracic height, but significantly associated with the rib anomalies

Introduction: CS may progress rapidly in patients with concave thoracic cage deformities at early of age. Few reports have evaluated the association between the PFTs and thoracic cage deformities in CS patients. The purposes is to determine: (1) the relationship of thoracic cage parameters and preoperative PFTs in CS patients. (2) if patients with rib deformity have greater impairment of PFTs than those without rib deformity.

Methods: A total of 218 patients with CS and pulmonary dysfunction (FVC $<80\%$) was conducted in one spine center between Jan 2009 and Mar 2013. The demographic distribution, medical records, PFTs and radiographs of all patients were collected. Patients with %FVC or %FEV1 less than 65% was defined as clinically relevant impairment of pulmonary function, which were assigned to Group A. Those with %FVC of 65~80% were assigned to Group B. The association of PFTs and thoracic cage deformities was evaluated by correlation analysis.

Results: In total, 143 patients (65.6%) were assigned to Group A and 75 patients to Group B. PFTs were significant negative correlation with scoliotic angle, number of involved vertebra and thoracic sagittal diameter ($r=-0.16\sim-0.52$), while diaphragm height is significant positive ($r=0.27\sim0.31$). The thoracic height was significant positive correlation with age, stature, weight, height of diaphragm, thoracic transverse and sagittal longitudinal diameter ($r=0.22\sim0.74$), while negative correlation with scoliotic curve, number of involved vertebra, as well as kyphotic angle ($r=-0.22\sim-0.29$). PFTs do not correlate with thoracic height, but significantly associated with the rib anomalies. The patients in group A had smaller BMI and diaphragm height, larger thoracic transverse and anteroposterior diameter, more scoliotic angle and number of involved vertebra than Group B ($P<0.05$). The FVC and FEV1 were significantly lower in patients with rib anomalies than without rib anomalies. There was no association between the PFTs and the location of rib anomalies.

Conclusion: PFTs correlate significantly with scoliotic angle, number of involved vertebra, thoracic sagittal diameter and diaphragm height. PFTs were significantly lower in patients with rib anomalies, particular to the patients with fused rib.

PODIUM PRESENTATION ABSTRACTS

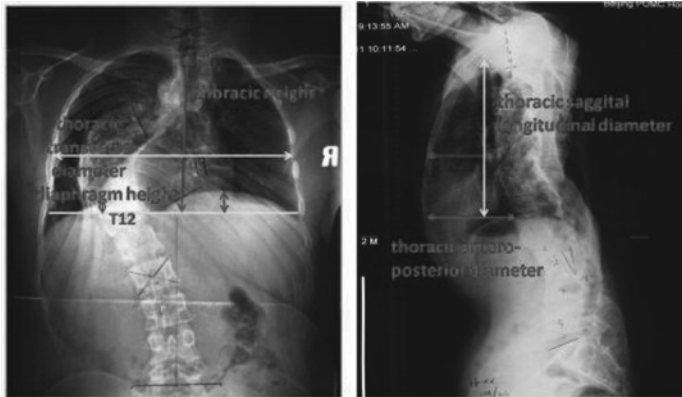


Fig 1. Demonstration of measurements performed on the posteroanterior(left) and lateral view (right) X-ray of a patient. Thoracic parameters include: thoracic height (the distance from T1 to T12), left and right diaphragm height (the distance from T12 center horizontal line to the diaphragm dome), thoracic transverse diameter (the distance of bilateral costal margin in apical vertebra level), thoracic anteroposterior diameter (the distance from chest wall to the anterior margin of vertebra in diaphragm dome level or apical vertebra of kyphosis level), and thoracic sagittal longitudinal diameter (the distance from apex pulmonis to the diaphragm dome).

47. Posterior Hemivertebra Resection in Children

Lucas Piantoni, MD; Ida Alejandra Francheri, MD; Carlos A. Tello, MD; Mariano A. Noel, MD; Eduardo Galaretto, MD; Rodrigo G. Remondino, MD; Ernesto Bersusky, MD

Argentina

Summary: The objective of this study is to assess hemivertebra resection by posterior approach in a period from 2002 to 2011.

A total of 68 patients with 82 hemivertebra along 71 surgical procedures. Intraoperatively 3 patients had neurophysiological compromise. Two superficial infections needed toilette and antibiotic therapy. One patient developed crankshaft.

Hemivertebra resection by posterior only approach with instrumentation demonstrated to be an excellent technique to solve this kind of congenital scoliosis, being simple, secure, reliable, less invasive and well tolerated.

Introduction: This is a retrospective study of children with congenital scoliosis regarding hemivertebra resection and instrumentation through posterior approach with a long follow-up.

Hemiepiphysiodesis, arthrodesis in situ and resection without instrumentation had been performed in the past with different results. Hemivertebra resection and spinal instrumentation through anterior and posterior resection has been advocated as the treatment of choice.

The objective of this study is to assess hemivertebra resection by posterior approach.

Methods: A total of 68 patients with 82 hemivertebra along 71 surgical procedures. From 2002 thru 2011. Thirty-six were females and 32 males. Mean age 5.5 years (0.8m-16). Mean follow-up was 6.59 years (2.1-10.8). Eighteen patients had additional pathologies: specific syndromes, cardiopathies, thoracic, abdominal and bone malformations.

Sixteen patients had partial hemivertebra while 52 had full mobile. Regarding levels 30 were thoracic, 17 thoracolumbar, 29 lumbar and 6 lumbosacral.

Results: Scoliosis mean pre operative angular value (AV) was 37.33", post-operative 18.98". Kyphosis AV was preop 28.70" while postop 14.07".

Thirty-eight patients were instrumented with 1 rod while 2 rods were used in 30. Monoaxial screws were used in 45 patients, poli in 18 while both in 1. Screws and hooks were used in 4 patients and only hooks in 3. Arthrodesis was performed in 65 patients, without complications so far in those who did not. Postop orthosis was used in 58 opportunities.

Several complications were found. Intraoperatively 3 patients had neurophysiological compromise solved by minimum intraoperative gestures without secuelae. Two superficial infections needed toilette and antibiotic therapy. Three patients needed additional surgery due to secondary curves, a mean 4.9 years later. One patient developed crankshaft.

Conclusion: Hemivertebra resection by posterior only approach with instrumentation demonstrated to be an excellent technique to solve this kind of congenital scoliosis, being simple, secure, reliable, less invasive and well tolerated.

48. Final Fusion after Growing Rod Treatment for Early Onset Scoliosis: Is it Really Final?

Connie Poe-Kochert, BSN; Claire Shannon, MD; Jeff Pawelek; George H. Thompson, MD; Christina Hardesty, MD; David S. Marks, FRCS; Behrooz A. Akbarnia, MD; Richard E. McCarthy, MD; John B. Emans, MD; Growing Spine Study Group

USA

Summary: Final Fusion was not the final surgery for 22 of 100 (22%) early onset scoliosis (EOS) patients who completed growing rod (GR) treatment and had a minimum of 2 years follow up

Introduction: Final Fusion is commonly considered to be the end point for EOS patients with GR treatment. But is it? The purpose of this study was to determine the incidence and cause of reoperation after final fusion for GR patients with EOS.

Methods: A multicenter EOS database was queried to identify GR patients with a minimum of 2 years follow up after final fusion. All reoperations were recorded as well their causes. Reoperation was defined as a return to the operating room for any reason related to the spinal deformity.

Results: There were 119 potential patients in which 100 patients (84%) met the inclusion criteria (38 neuromuscular, 31 syndromic, 22 idiopathic, and 9 congenital patients). Mean age at final fusion was 12.2 years (range, 8.5 to 18.7 years). Mean follow-up after final fusion was 4.3 years (range, 2.0 to 11.2 years). Twenty-two patients (22%) had reoperations (59 procedures): 9 patients (9 %) for infection (33 procedures); 6 patients (6 %) each for instrumentation failure (8 procedures) and painful or prominent instrumentation (6 procedures); 3 patients (3 %) each for coronal deformity (3 procedures), pseudoarthrosis (3 procedures), or sagittal decompensation (3 procedures); 2 patients (2 %) for neurological conditions (2 procedures), and 1 patient (1 %) for a thoracoplasty (1 procedure). There was a mean of 2.7 procedures per patient (range, 1 to 19 procedures): 10 neuromuscular, 8 syndromic, 4 idiopathic and no congenital patients required reoperation. Mean time to first reoperation after final fusion was 1.8 years (range, 11 days to 7.4 yrs). We did not attempt to determine the current results of these additional procedures.

Conclusion: A higher than anticipated percentage of EOS patient with GR treatment required reoperation after final fusion. Longer term follow-up after final

PODIUM PRESENTATION ABSTRACTS

fusion is necessary to determine final results. Parents need to be counseled to the possibility of further surgery after final fusion.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

49. Pre-Operative Halo-Gravity Traction for Severe Spinal Deformities at an SRS-GOP Site in West Africa: Protocols, Complications and Results

Venu M. Nemani, MD, PhD; Han Jo Kim, MD; Benjamin T. Bjerke-Kroll, MD, MS; Mitsuru Yagi, MD, PhD; Cristina Sacramento-Dominguez, MD, PhD; Harry Akoto, MD; Munish C. Gupta, MD; W. F. Hess, MD; Elias C. Papadopoulos, MD; Francisco J. S. Pérez-Gruoso, MD; Ferran Pellise, MD; Bettye Wright, RN, PA; Irene Wulff, MD; Jennifer Ayamga, Mphil; Rufai M. Mahmud, MD; Oheneba Boachie-Adjei, MD
USA

Summary: Halo-gravity traction can be used to apply a continuous distraction force across the spine over prolonged periods. We report the use of halo-gravity traction over a period of months prior to surgical correction of severe spinal deformities at an SRS-GOP site in West Africa. The results of this study show the traction protocol to be safe in achieving partial correction of extremely large deformities, and may obviate the need for 3-column osteotomies or combined anterior/posterior procedures.

Introduction: Previous reports of sustained traction prior to definitive fusion have been limited by low numbers and variability of traction protocols. We developed a novel halo-gravity traction (HGT) protocol for patients with severe spinal deformities, and assessed outcomes.

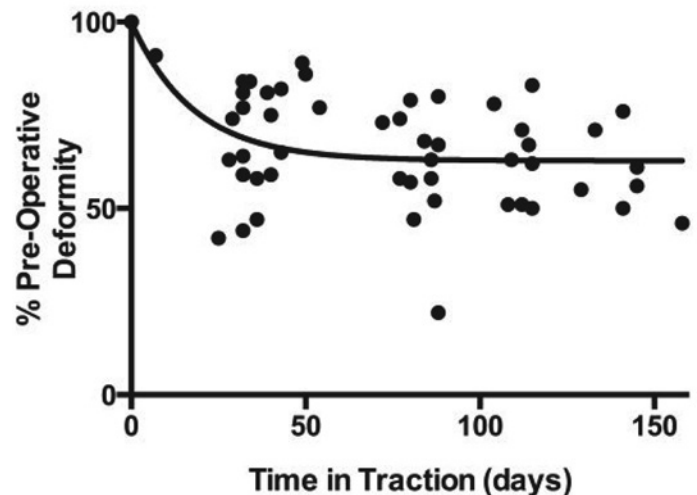
Methods: All patients (pts) that underwent HGT prior to deformity surgery in Ghana from 4/2012 to 8/2013 were reviewed. HGT was started at 20% and increased by 10% per week until 50% of body weight was reached by 4 wks. Traction was maintained at all times except during meals and personal hygiene. Xrays were obtained pre-traction, every 4 wks in traction, and at 6 wks post-op. Demographic variables, operative data, radiographic parameters, and HRQL scores were collected. A deformity reduction index (DRI) was calculated at each time point by summing the scoliosis and abnormal kyphosis for each patient and reported as a percentage of the pre-operative deformity.

Results: 29 pts underwent HGT for an average 107 days (range 58-179) prior to definitive posterior spinal fusion (24 pts) or placement of growing rods (5 pts). The major curve improved from 131° to 90° (31%) after HGT, and to 57° (56%) post-op. HGT was effective in correcting both scoliosis and kyphosis in pts with biplanar deformities, even after adjusting for curve flexibility. Pure kyphotic curves were rigid (flexibility 22% after traction), with a correction index (% post-op curve correction/% flexibility) of 3.88, which is similar to historical controls (Lenke et al, Spine, 2009). Curve correction with HGT plateaued at 63 days (Figure 1). SRS-22 scores improved significantly pre-traction (3.5) vs. post-op (4.5), but there was no change post-traction (3.9) vs. pre-traction (3.5). There were 11 pin tract infections, with no neurological complications.

Conclusion: HGT is a safe method to partially correct severe spinal deformities prior to a definitive procedure. It may obviate the need for higher risk 3-column

osteotomies to achieve optimum correction. A prospective study is underway to determine which specific curve types are most amenable to pre-operative traction.

Effect of Halo-Gravity Traction on Deformity Reduction Index



50. The Radiographic and Clinical Impact of Pre-Operative Halo-Gravity Traction in the Treatment of Early Onset Spinal Deformity

Patrick A. Sugrue, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Michael P. Kelly, MD; Scott J. Luhmann, MD; Brenda A. Sides, MA; David B. Bumpass, MD; Isaac Karikari, MD; Jeffrey L. Gum, MD
USA

Summary: Early onset spinal deformity produces radiographic and clinical challenges often requiring some form of growing instrumentation or early definitive fusion. Preoperative HGTx is a safe and effective means of correcting both coronal and sagittal plane deformity in patients ≤ 10 years and improves pulmonary function without any major complications encountered.

Introduction: Definitive correction of large and/or rigid spinal deformity is associated with an increased risk of neurological injury. Preoperative traction has been used in efforts to reduce that risk, but it has not been studied in the early onset deformity population. With this study, we aim to assess the overall radiographic effectiveness and safety of preoperative halo-gravity traction (HGTx) in patients ≤ 10 years of age with early onset spinal deformity.

Methods: Review of a prospectively collected database. All patients who underwent placement of growing rods, Shilla, VEPTR, or definitive instrumented posterior spinal fusion with preoperative HGTx ≤ 10 years of age were assessed using pre-traction and post-traction radiographs and clinical record review.

Results: 43 patients (24M, 19F) were included. The average age at the time of placement of HGT was 6 + 5 Yrs. with an average duration of HGTx of 60.43 days (SD 46.75) and an average maximum traction weight of 13.80 lbs. (SD 3.03). HGTx resulted in a statistically significant improvement in proximal thoracic Cobb angle (9.56°, 6.84%, $p < 0.001$), main thoracic Cobb angle (22.77°, 24.45%, $p < 0.001$), thoracolumbar/lumbar Cobb angle (11.39°, 12.12%, $p < 0.001$), coronal alignment (CSVL-C7) (5.28mm, 28.24%,

PODIUM PRESENTATION ABSTRACTS

$p < 0.05$), T1-T5 kyphosis (12.16° , 80.5%, $p < 0.05$), T5-T12 kyphosis (10.03° , 1.8%, $p < 0.05$), total thoracic kyphosis (19.89° , 23.75%, $p < 0.001$), apical vertebral translation (9.36mm, 12.99%, $p < 0.05$), and spine length (T1-S1) (2.49cm, 12.59%, $p < 0.001$). For those patients who were able to cooperate with PFT testing ($n=11$), they experienced a statistically significant improvement in predicted forced vital capacity (FVC) (56.1% vs 66.4%, $p < 0.05$) and predicted FEV1 (53.6% vs 63.6%, $p < 0.05$). There were no major clinical complications attributed to HGTx in this patient population.

Conclusion: The use of preoperative HGTx in early onset deformity is safe and effective in radiographic correction of both coronal and sagittal plane deformity and improves pulmonary function in the early onset spinal deformity population without any major complications.

51. Serial Casting for Infantile Idiopathic Scoliosis: When Can a Cure be Achieved?

*Daniel J. Sucato, MD, MS; Dong-Phuong Tran, MS; Anna M. McClung, BSN, RN; Charles E. Johnston, MD
USA*

Summary: Mehta serial casting for patients with infantile idiopathic scoliosis can grow the spine straight for a cure in nearly 40% of patients without subsequent need for treatment. This required on average 5 casts over a 10-11 month period. Predictors of success are younger age (<18 months) and smaller curve magnitude (<45 degrees).

Introduction: The goal of Mehta casting for infantile idiopathic scoliosis (IIS) is to grow the spine straight to avoid surgical treatment. There are no large consecutive studies demonstrating the likelihood of achieving a straight spine following Mehta casting and no predictors for success.

Methods: A single pediatric orthopedic institution's experience with casting in patients with IIS who were under 3 years of age prior to their first cast was performed. A minimum of 2 year evaluation following the removal of their last cast was required. Patients were categorized in 3 groups at final follow-up: radiographically cured if their major Cobb angle was <10 degrees, clinically-cured if the major Cobb angle was 10-15 degrees and no clinical deformity was present, or not cured. Comparisons were made between groups to determine predictors for success

Results: There were 31 consecutive patients at an average age of 20.0 months at first casting, treated with 5.1 casts over a 11.4 months period with an average starting curve of 48.2° . At a minimum of 2 years from the last cast, 19 had residual scoliosis, 8 were radiographically cured and 4 were clinically cured so that 12 of 31 (38.7%) patients were considered cured requiring no subsequent treatment. When compared to the non-cured group, the cured group were younger at casting (15.3 vs. 24.0 months, $p=0.0046$) and had smaller pre-cast major curves (41.3 vs. 56.0° , $p=0.0138$). There were no differences between the cure and no-cure groups for having a phase 1 rib (36.4 vs 26.3%), RVAD (20.8 vs 21.8°), the number of casts (4.7 vs. 5.2 casts,) or total duration in cast (10.0 vs. 11.9 months,). In the group with residual scoliosis 15/19 (78.9%) were treated with brace only, and 4/19 (21.1%) required surgical intervention.

Conclusion: Mehta casting can straighten a spine so that it does not have radiographic or clinical scoliosis requiring further treatment in nearly 40% of patients. Patients who are younger and have less major Cobb deformity are more likely to have a cure. Overall, casting has prevented surgery in 87.1% in this series with 3 years of after cast follow-up. Longer follow-up is needed to strengthen these conclusions.

52. Re-Operation after Magnetically Controlled Growing Rod Implantation: A Review of 23 Patients with Minimum Two-Year Follow Up

*Kenneth MC. Cheung, MBBS(UK), MD, FRCS(England), FHKCOS, FHKAM(ORTH); Kenny Kwan; John Ferguson; Colin Nnadi, FRCS(Orth); Ahmet Alanay; Muharrem Yazici, MD; Gokhan H. Demirkiran; Behrooz A. Akbarnia, MD
Hong Kong*

Summary: This is a retrospective review of prospectively collected data from a multicentre study of early onset scoliosis treated by the magnetically controlled growing rod with a minimum of 2-year follow-up. Re-operation rate was 43.5%. The causes of additional surgeries were failure of rod distraction, rod breakage, and failure of proximal fixation.

Introduction: Traditional growing rods (TGR) have been widely used for the treatment of early onset scoliosis (EOS). High complication rate is attributed to frequent surgical lengthening. Magnetically controlled growing rod (MCGR) allows non-invasive distractions in awake patients and is believed to reduce the number of additional surgeries after rod implantation. This study aims to report on the rate and reason for reoperation after MCGR surgery.

Methods: Consecutive patients undergoing MCGR treatment with a minimum of 2-year follow-up from 5 centres were included. All clinical and radiographic data were collected prospectively.

Results: Twenty-three patients were included in this study. The mean age at the time of surgery was 7.6 years (range, 4 to 14 years) and the mean follow-up period was 36 months (range, 24 to 50). Four had single-rod and 19 had dual-rod implanted. Ten patients (43.5%) required reoperation within the follow-up period, with a mean time to reoperation of 17 months after initial surgery (range, 5 to 29 months). Five were due to failure of rod distractions and the rods were changed except in one case, when one of the 2 rods was removed; 2 were due to failure of proximal foundation implants; 2 were due to rod breakage; and there was one case of wound infection with failure of proximal fixation. Comparing the group that needed reoperation to those that did not, there was no relationship between reoperation and preoperative Cobb angle, age at surgery, level of instrumentation, number of distraction episodes or cases that were converted from TGR.

Conclusion: This is the largest series with the longest follow-up to date that examines the need for additional surgery after the initial procedure. MCGR surgery is associated with a high frequency of reoperations for a variety of reasons. However, it compares well with TGR patients, as all will require reoperation within the first year for lengthening. Longer-term studies and comparisons with TGR patients are required to evaluate the efficacy and cost-effectiveness of this new implant for the management of patients with Early Onset Scoliosis.

PODIUM PRESENTATION ABSTRACTS

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

53. Pulmonary Function in Patients with Early Onset Idiopathic Scoliosis Mean 24 Years after Maturity

*Aina J. Danielsson, MD, PhD; Kerstin Löfdahl-Hällerman, MD, PhD
Sweden*

Summary: Patients with onset of idiopathic scoliosis (IS) before the age of 10 years (y) and treated before maturity were reexamined mean 24 y after end of bracing (B) and 29 y after surgery (S). Pulmonary function was reduced in 20% of B and 50% of S.

Introduction: The aim was to determine outcome in terms of pulmonary function in patients with early onset IS that were treated before maturity.

Methods: Consecutive patients with IS, diagnosis before the age of 10 y and treatment before maturity were invited to a clinical follow-up (FU). Treatment was performed between 1970 and 1995 with similar treatment protocol for bracing and surgery over the whole time period. The follow-up included radiography for determination of curve size and apex and spirometry for determination of vital capacity (VC) as liters and % predicted (pred.) and comparison with existing pre-treatment values. Mean values are presented.

Results: Of patients attending the FU, 68 were braced only (B) and 50 underwent surgery before maturity (S) while 6 were braced before maturity but operated later and 4 observed only. 106 were female. 3 patients were deceased. Initial values did not differ between those who attended (68% of the original group) and not.

The age at follow-up was 40.6 y for B and 42.6 y for S. Major curve sizes were similar at present FU, 35° (B) and 37° (S). One-fourth of the curves were >45°. Bracing time was 4.6 y with start between 3-17 y (mean 10.8 y) while surgery was performed at 13.5 y.

VC % pred. of braced patients was unchanged from before bracing until present follow-up (95 and 90 % pred. resp., ns). 60% of operated patients had less than 80% of pred. VC before and after surgery, mean 72 to 76 % pred., ns. This remained unchanged until now (78 % pred.). Values below 80% pred. were found in 14 (20%) of B and 25 (50%) of S at FU.

In patients with curve apex at T9/above, VC % pred. at present FU correlated with pretreatment curve size ($r_s = -0.30$ for B and $r_s = -0.31$ for S) and current curve size ($r_s = -0.37$ for B and $r_s = -0.46$ for S) and with length of bracing ($r_s = -0.38$).

Conclusion: Pulmonary function does not deteriorate with age in patients treated before maturity due to IS with onset before age 10y. Surgically treated patients have worse pulmonary function than the braced patients.

54. Incidence of False Positive Spinal Cord Monitoring Alerts in Surgery for Early Onset Scoliosis

*Oliver M. Stokes, MB BS, MSc, FRCS (Tr & Orth); Edward Bayley, MRCSEd; Rob Burton, BMBS, MSc, BMedSci; Sherief Elsayed, FRCS (Orth&Tr); Dominique A. Rothenfluh, MD, PhD; Hossein Mehdian, MD, MS(Orth), FRCS(Ed)
United Kingdom*

Summary: We present a prospective series of 97 patients with a mean age of 6.7-years that had EOS treated surgically. Spinal cord monitoring alerts occurred in 13% of idiopathic cases, 22% of congenital and 0% of neuromuscular. The false positive alert rate was 55% in congenital cases versus 17% in idiopathic cases. We postulate that the significantly increased incidence in congenital cases is due to the increased frequency of abnormalities of the neural axis and vascular supply in these patients.

Introduction: Spinal cord monitoring alerts are decreases in amplitude of SSEPs or MEPs. Alerts may be secondary to curve reduction, hypotension, or unknown causes. When surgical or anaesthetic manoeuvres fail to return the amplitudes to their pre-alert levels this is either associated with post-operative abnormal neurology (true positive), or normal neurology (false positive).

Methods: All deformity correction surgeries for early onset scoliosis between 2003 and 2012 had either dual- or mono-modality spinal cord monitoring in an attempt to increase safety. The data was prospectively collected identifying monitoring alerts, surgical or anaesthetic measures to address the alert and the post-operative neurological status of the patient.

Results: There were 117 procedures in 91 consecutive patients with a mean age of 6.7-years. 19 of the operations were for neuromuscular scoliosis, 51 for congenital and 47 for idiopathic. 57 procedures were monitored with SSEPs and MEPs, the others only SSEPs. There were 17 monitoring alerts. 2 of the alerts, in a single idiopathic case with dual modality monitoring, had no known cause. Monitoring alerts occurred in 6 idiopathic cases (13%) and 11 congenital cases (22%) there were no alerts in neuromuscular cases. In 5 of the idiopathic cases, there was a normalization of the monitoring with intra-operative manoeuvres. In the congenital cases 4/11 of the alerts responded to surgical or anaesthetic measures, while 7/11 cases had persistent abnormalities. One was a true positive with a neurological deficit post-operatively. The false positive rate, when a spinal cord monitoring alert occurs, was 55% in congenital cases versus a 17% in idiopathic cases. There was no false positive monitoring alert in the neuromuscular group, but there was 1 false negative.

Conclusion: Spinal cord monitoring has become a standard of care for spinal deformity correction. Technological advances have led to increased sensitivity of the equipment. False positive monitoring alerts are significantly more frequent in the correction of congenital scoliosis. We postulate that this is due to the frequency of abnormalities of the neural axis and vascular supply.

PODIUM PRESENTATION ABSTRACTS

55. Problems of Growing-Rod Treatments: Results of Patients who Completed Rod Lengthening

Kota Watanabe, MD; Morio Matsumoto, MD; Koki Uno, MD, PhD; Teppei Suzuki; Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Haruhisa Yanagida, MD; Manabu Ito, MD, PhD; Toru Hirano; Ken Yamazaki, MD; Shohei Minami; Hiroshi Taneichi, MD; Shiro Imagama, MD; Katsushi Takeshita, MD; Takuya Yamamoto; Ikuho Yonezawa, MD, PhD
Japan

Summary: Multicenter survey was conducted to evaluate the clinical results of patients who underwent final correction and fusion following growing rod for early-onset scoliosis. The complication rate was high affecting 61% of the patients. The correction obtained by final fusion was smaller than that obtained by the first growing rod placement.

Introduction: Growing rod surgery (GR) has been widely used for the treatment of early-onset scoliosis (EOS). However, there is little information about clinical results of final correction and fusion (growing rod graduates). The purpose of this study was to evaluate clinical results of patients who underwent final correction and fusion following GR for EOS.

Methods: 41 patients who underwent final correction and fusion surgery (FF) following GR for EOS in 12 spine institutes were included in this study. The mean age at the first growing rod surgery was 7.1 ± 2.1 years (range, 2.9-9.9 years) and the mean follow-up period was 6.9 ± 2.4 years (range, 5.0-12.0 years). The mean rod lengthening was 6.2 ± 3.3 times before FF. The etiology of these patients were combined skeletal and visceral anomalies in 12 patients, idiopathic 9, mesenchymal disorders 6, neurofibromatosis 6, neuromuscular 4, congenital 3, and iatrogenic 1. Perioperative complications and radiographical parameters were retrospectively reviewed.

Results: Complication during GR treatment occurred in 27 patients (61%). Among them, implant-related complication was 70%, infection 19%, neurological in 6% and others in 5%. The mean preoperative Cobb angle of proximal thoracic curve was $50 \pm 18^\circ$, main thoracic curve $85 \pm 17^\circ$, and lumbar curve $33 \pm 17^\circ$. After GR placement, the main thoracic curve was corrected to $49 \pm 17^\circ$ with the mean correction rate of $43 \pm 18\%$. Just before FF, the mean Cobb angle of the main curve significantly increased to $64 \pm 27^\circ$. After FF, the curve was corrected to $49 \pm 25^\circ$ with the mean correction rates of $23 \pm 23\%$. At the final follow-up, the main curve was corrected by $39 \pm 28\%$ of the curve before the first GR surgery.

Conclusion: The complication rate of GR was as high as 61%. Since the correction obtained by FF was small (correction rate of 23%) and the final Cobb angle was almost equal to that after GR placement, efforts to obtain maximum correction of the curve at the first surgery and to maintain the correction should be made.

56. Three-Dimensional Characterization of Torsion and Asymmetry of the Intervertebral Discs versus Vertebral Bodies in Adolescent Idiopathic Scoliosis

Tom P. Schlösser, MD; Marijn van Stralen, PhD; Rob C. Brink, Bsc; Winnie C. Chu, FRCR, FHKAM, MD; Tsz-ping Lam, MB,BS; Koen L. Vincken, PhD; Rene M. Castelein, MD, PhD; Jack C. Cheng, MD
Netherlands

Summary: The contribution of the vertebral bodies to the three-dimensional (3-D) deformity of adolescent idiopathic scoliosis (AIS) was compared to the intervertebral discs on a unique series of high-resolution computed tomographic scans. The discs contributed more to the spinal deformity than the bony structures in all three dimensions, suggesting that vertebral deformation is not an active growth process but rather it is secondary to the 3-D deformation of the spine.

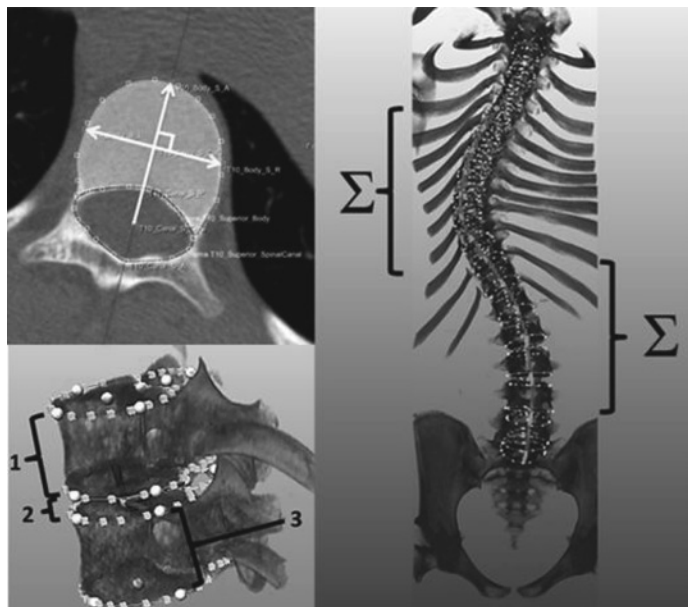
Introduction: There is an ongoing discussion about the causal role of vertebral growth processes in the etio-pathogenesis of AIS. In radiographic studies, contradictory findings have been reported on the contribution of the vertebral bodies as compared to the discs to the coronal deformity in AIS. As far as we know, the true 3-D deformity of the discs and vertebral bodies in scoliosis has not been compared to date.

Methods: A series of high-resolution computed tomographic scans, acquired in prone position for navigation purposes, of a total of seventy-seven patients with severe AIS was used for this study. Mechanical torsion and anterior-posterior and right-left asymmetry of each individual vertebral body and intervertebral disc was studied from T2 to L5, using semi-automatic analysis software. The anterior-posterior and right-left axis of the upper and lower endplates ('endplate-vectors') were automatically calculated, based on segmentations of the endplates and the spinal canal on reconstructed true transverse sections. Torsion was defined as the difference in axial rotation between two subsequent endplates, asymmetry as the relative anterior-posterior or right-left height difference of the discs and vertebrae.

Results: Deformation was found in the vertebral bodies and the discs, however, there was at least three times more torsion, anterior overgrowth and coronal wedging in the discs than in the vertebrae in the thoracic as well as in the (thoraco)lumbar curves ($P < 0.001$). These values correlated significantly with the Cobb angle ($r \geq 0.37$; $P < 0.001$). Anterior overgrowth and coronal asymmetry was greater in the apical regions whereas torsion was most pronounced in the transitional segments between the curves.

Conclusion: The discs contributed more to 3-D deformity than the bony structures, suggesting that the spinal deformation is not just an active skeletal growth process but rather a consequence of biomechanical forces that act on the complex structural components of the spine.

PODIUM PRESENTATION ABSTRACTS



With the image processing technique for semi-automatic analysis of the 3-D morphology of the vertebrae and intervertebral discs, anterior-posterior and left-right height differences were calculated taking tilt and rotation into account.

57. Two-Year Results of Anterior Vertebral Body Tethering for Immature Thoracic Idiopathic Scoliosis

Amer F. Samdani, MD; Robert J. Ames, BA; Joshua M. Pahys, MD; Jeff S. Kimball, BS; Harsh Grewal, MD, FACS, FAAP; Glenn J. Pelletier, MD; Randal R. Betz, MD
USA

Summary: Anterior vertebral body tethering offers a fusionless option for children with scoliosis as an alternative to fusion or bracing. To date, very few clinical data have been published on this technique. We report on our first 11 patients with minimum 2 year follow-up. This report demonstrates progressive thoracic scoliosis correction of 70% in this series with no major complications.

Introduction: Anterior vertebral body tethering (AVBT) is a promising new technique with abundant preclinical studies but very limited clinical results. It is a growth modulation technique which utilizes the patient's growth to attain progressive correction of their scoliosis. We report 2-year results of the initial cohort undergoing this procedure.

Methods: After obtaining IRB approval, we retrospectively reviewed clinical and radiographic data on a consecutive series of patients with idiopathic scoliosis (IS) who underwent AVBT with 2-year follow-up. We collected pertinent pre-op/intra-op/most recent clinical and radiographic parameters. Student's t-test and Fisher's exact test were used to compare different time points.

Results: 11 patients with thoracic IS (73% female) were identified with a mean age of 12.3 ± 1.6 years. Preoperatively, all were skeletally immature (Sanders mean = 3.4 ± 1.1 , Risser mean = 0.6 ± 1.1) and underwent tethering of an average of 7.8 ± 0.9 (range 7-9) levels with the most proximal being T5 and most distal L2. Median blood loss was 100 cc. Pre-op thoracic Cobb angle averaged 44.2 ± 9.0 and corrected to $20.3 \pm 11.0^\circ$ on first erect, with

progressive improvement at most recent (Cobb = $13.5 \pm 11.6^\circ$, % correction = 70%). Similarly, the pre-op lumbar curve of $21.2 \pm 6.8^\circ$ demonstrated progressive correction (first erect = 13.6 ± 3.9 , most recent = $5.4 \pm 4.8^\circ$). Axial rotation, as measured by a scoliometer, went from $12.4 \pm 3.3^\circ$ preoperatively to $6.9 \pm 3.4^\circ$ at the most recent measurement ($p < 0.01$). Sagittal measurements remained stable. No major complications were observed. As anticipated, two patients returned to the operating room at 2 years post-op for loosening of the tether to prevent overcorrection.

Conclusion: AVBT is a promising technique for skeletally immature patients with idiopathic scoliosis. This technique can be performed safely (no major complications) and effectively, resulting in progressive correction of the thoracic curve from average 44° pre-op to 13.5° at most recent follow-up. Overcorrection may occur but can be anticipated and easily controlled.

58. Factors Associated with Improved Long-Term Outcomes following Three-Column Osteotomies

Kevin R. O'Neill, MD, MS; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Han Jo Kim, MD; Brian J. Neuman, MD; Kristin R. Archer, PhD, DPT
USA

Summary: With a minimum 5 yr F/U, patient reported outcomes (PROs) in patients undergoing 3-column osteotomies (3-CO) were associated with improvements in radiographic alignment, but negatively effected by prior surgery and complications necessitating revision surgery.

Introduction: Studies have demonstrated sustained improvements in patient-reported outcomes (PROs) following 3-column osteotomies (3-CO), but no study has evaluated what factors impact long-term outcomes.

Methods: Analysis of 120 pts who underwent 3-CO (96-PSO/24-VCR) with a min. 5 yr follow-up (F/U) was performed at a single institution. The mean age was 48 yrs (range 8-79) and clinical F/U was 7 yrs (range 5-14). ODI and SRS scores and radiographic parameters were assessed at baseline and 5 yrs PO and complications through the latest clinical F/U. Separate multivariable linear regression analyses were performed to determine factors associated with 1) ODI, 2) SRS average, and 3) SRS satisfaction while controlling for time since surgery and baseline outcome scores.

Results: Follow-up rate for ODI scores was 89% and for SRS and satisfaction scores was 98%. The avg operative time was 561 min (range 300-1128) and mean blood loss was 2.1L (range 0.3-6.5). Fusion was performed over an avg of 10.5 levels and involved lumbosacral fusion in 91 pts (76%). Avg PROs were significantly improved from baseline at a min 5yrs F/U (ODI: 48 to 28, $p < 0.01$; SRS: 2.8 to 3.5, $p < 0.01$). The avg SRS satisfaction score was 4.0. Avg sagittal alignment (C7 plumb) improved 74mm, with 81% of pts < 95 mm. Major surgical complications occurred in 32 pts (27%) with major reoperations in 30 pts (25%). Permanent major complications occurred in 8 pts (7%). Multivariable regression analysis found that prior surgery and major reoperations were risk factors for worse ODI scores (Table 1). A diagnosis of adult idiopathic scoliosis and final sagittal alignment < 95 mm were associated with improved SRS scores. Improvement in major coronal Cobb and final pelvic tilt $< 30^\circ$ were associated with increased SRS satisfaction.

PODIUM PRESENTATION ABSTRACTS

Conclusion: Only 2 baseline patient factors were found to impact long-term PROs following 3-CO. Major reoperations were found to have a negative effect on outcomes, while radiographic improvements in sagittal alignment, major coronal Cobb, and pelvic tilt were associated with improved long-term PROs.

59. Utilization Trends of Pedicle Subtraction Osteotomies Compared to Posterior Spinal Fusion for Deformity: A National Database Analysis between 2008-2011

Jeffrey L. Gum, MD; Leah Y. Carreon, MD, MSc; Jacob M. Buchowski, MD, MS; Lawrence G. Lenke, MD; Steven D. Glassman, MD USA

Summary: A commercially available database (PearlDiver, Inc) was queried for both privately-insured (PI) and a 5% sampling of the Medicare (SAF5) claims from 2008-2011. The utilization of pedicle subtraction osteotomies was compared to three control groups. Over the study time interval, there is up to a 3.2-fold increase in the utilization of pedicle subtraction osteotomies while fusion procedures for spinal deformity, posterior spinal fusions, and adult spine deformity as a diagnosis had minimal to no increase.

Introduction: The utilization of pedicle subtraction osteotomies (PSO) for sagittal plane correction in spinal deformity surgery has not been well characterized. The purpose of the study is to analyze a national database to characterize the trends of PSO utilization in terms of frequency, demographics, and cost.

Methods: A commercially available database (PearlDiver, Inc) was queried for both privately-insured (PI) and a 5% sampling of the Medicare (SAF5) claims from 2008-2011. Revision and clarification of the coding guidelines for a PSO were released in 2008. Thoracic and lumbar PSO procedure (CPT) codes (22206-22208) were searched and compared to (1) six CPT codes for fusion in spine deformity (22800, 22802, 228804, 22808, 22810, 22812: FSD) (2) two CPT codes for posterior spinal fusion (22610, 22612: PSF) and (3) ten diagnosis (ICD-9) codes representative of adult spinal deformity (ASD). Differences in annual utilization, demographics, billing, and reimbursement data were then compared

Results: There was 1.9- and 3.2-fold increase in PSO utilization over the study time interval for both PI and SAF5 databases, respectively (Table). The 3 control groups had minimal to no increase over the study time interval (Table). 41% of PSOs were performed in patients between the age of 55-64 years old and 67% were female. The mean amount billed increased from \$4,670 to \$7,067 (151%) while the mean reimbursed amount increased from \$689 to \$1,088 (157%). The amount reimbursed versus billed was only 15%.

Conclusion: Over the study time interval, there is up to a 3.2-fold increase in the utilization of pedicle subtraction osteotomies while fusion procedures for spinal deformity, posterior spinal fusions, and adult spine deformity as a diagnosis had minimal to no increase.

Year	PSO		Fusion for Deformity		Post Spinal Fusion		Adult Spinal Deformity	
	PI	SAF5	PI	SAF5	PI	SAF5	PI	SAF5
2008	33	13	766	101	8,111	2,882	90,820	28,172
2009	38	15	750	87	8,172	3,293	91,686	29,841
2010	67	42	795	99	8,626	3,540	93,537	30,668
2011	61	32	734	112	8,424	3,624	99,099	33,376
TOTAL	199	102	3,045	399	33,333	13,339	375,142	122,057
% CHANGE	185%	246%	96%	111%	104%	126%	109%	118%

60. Is it the Vertebral Column Resection Procedure or the Nature of the Severe Pediatric Deformity that Creates a High Neurologic Complication Risk?

Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Daniel J. Sucato, MD, MS; Amer F. Samdani, MD; Harry L. Shufflebarger, MD; Patrick J. Cahill, MD; Sumeet Garg, MD; Mark A. Erickson, MD; Michael P. Kelly, MD; Brenda A. Sides, MA USA

Summary: In a consecutive multicenter series of 146 severe pediatric spinal deformity pts having a vertebral column resection procedure (VCR, n=67) or having at least 100° of maximum Cobb angle (N=79), there was no difference in the rate of spinal cord monitoring (SCM) alerts or actual neurologic deficits postoperative.

Introduction: It is well accepted that a VCR procedure performed for severe spinal deformity carries a high neurologic complication risk. However, it is unclear whether that risk is more inherent to the severe deformity or the actual VCR procedure. We sought to answer that question by investigating a prospectively accrued multicenter database of severe pediatric deformities treated with or without a VCR procedure.

Methods: 146 consecutive pts from 20 surgeons with severe pediatric spinal deformity were enrolled over a 2yr period (2012-2013) into a prospective study. All x-rays were measured electronically by an independent senior clinical nurse to confirm unbiased assessment of the actual Cobb measurements and procedures performed. 67 pts (34 female/33 male; ave age 15.3±2.84) were treated with a VCR procedure for either a minimum Cobb of 100° (n=42) or a stiff/fused deformity (n=25, ave Cobb angle of 85°, VCR group); while 79 pts (50 female/29 male; ave age 15.2±2.65) had at least 100° of deformity in the coronal or sagittal plane (ave Cobb angle of 103°) but did NOT have a VCR procedure to correct their deformity (NoVCR group). For all pts, it was noted whether there were any SCM alerts during the procedure as well as what the neurologic motor status of the patient was immediate postoperative.

Results: The VCR group had a 40.3% rate of SCM alerts during the procedure vs 48% for the NoVCR group demonstrating no significant difference between the 2 groups (p=0.34; odds ratio 1.37; 95% CI=0.71-2.65). Similarly, the VCR group had a 14.9% rate of immediate postoperative neurologic deficits vs 12.7% rate for the NoVCR group again showing no significant differences between groups (p=0.69; odds ratio 0.83; 95% CI=0.32-2.12).

Conclusion: In 146 consecutive pts with severe pediatric deformity, the rate of neurologic complications assessed by SCM alerts during surgery and/or new motor deficits postoperative were similar for those having or not having a VCR procedure. This confirms the notion that it is the nature of the severe deformity more than the actual procedure performed that creates the high neurologic risks when treating these challenging patients.

PODIUM PRESENTATION ABSTRACTS

61. Analysis of Perioperative Major Non-Neurologic Complications in 105 Posterior Vertebral Column Resection (PVCR) Procedures for Severe Rigid Deformities during 10 Years: Introspection on the Balance between Patients' Risk and Benefit

Jingming Xie; Yingsong Wang, MD; Ying Zhang; Tao Li; Zhi Zhao; Zhou Liu; Ni Bi; Leijie Chen; Zhiyue Shi
China

Summary: We reported the incidence of perioperative major non-neurologic complications (MNNC) in a series patients undergoing PVCR, and explored the possible factors.

Introduction: Though we constantly attempted to increase the corrective efficacy and neurological safety following PVCR, there are still significant risk of major and potentially lifethreatening complications. The aim of this study was to analyze the MNNC in PVCR procedures for severe rigid deformities, and to identify the factors that may increase the risk.

Methods: A total of 105 consecutive PVCR patients with severe rigid deformity in 2004-2013 at a single institution were reviewed. The demographic data, medical and surgical histories, perioperative and final follow-up radiographic measurements, and prevalence of perioperative MNNC were reviewed.

Results: The major curve of scoliosis was 108.9 ± 25.5 pre-operatively and 37.2 ± 16.8 at the final follow-up, and segmental kyphosis from 89.8 ± 31.1 to 30.4 ± 15.3 . There were 31 MNNCs in 24 patients: 16 respiratory complications in 13 patients, 9 cardiovascular adverse events in 7 cases, 1 malignant hyperthermia, and 1 optic deficit. There were 3 wound infection, and 1 of them had to partly remove the implant for infection control. One neurofibromatosis died at one day after operation. Factors showed no relationship with an increased prevalence of MNNC were age, BMI, operative duration time, presence of cardiac disease or neural axis malformation, and both sagittal and coronal correction rate. However, patients with T6 and upper resected level, larger scoliotic curve, lower preoperative pulmonary function, increased blood loss, and undergoing PVCR at the early period, showed a trend toward more MNNC encountered.

Conclusion: Patients with PVCR experienced expected highly rate of MNNCs, with an overall incidence of 22.9%. When considering PVCR, it is important to recognize the significantly higher inherent risks and provide appropriate trade off on the risk/benefit ratio of surgery.

62. Morphological Influence of Aorta and Superior Mesenteric Artery (SMA) following Posterior Vertebral Column Resection (PVCR) in Treatment of Severe Rigid Spinal Deformity ($>150^\circ$)

Ni Bi; Jingming Xie; Yong Sun; Yingsong Wang, MD; Ying Zhang; Zhou Liu; Tao Li; Zhiyue Shi; Leijie Chen; Zhi Zhao
China

Summary: To explore the morphological change of aorta and SMA following PVCR and to analyze the effect of PVCR on vascular safety.

Introduction: The neurological safety of PVCR for correcting severe rigid spinal deformity was widely concerned. However, there was few study focus on the vascular morphological changes after PVCR.

Methods: Thirteen patients with severe rigid spinal deformity treated by PVCR. The coronal or sagittal Cobb angles were larger than 150 degrees in all patients. CT angiography was performed pre- and post-operatively. The aorta length, the shortest distances among aorta and upper, lower end vertebrae and apical vertebrae, angle of tortuous aorta, arterial lumen proportion at the apex of the aorta angulation, SMA length, Aorta-SMA angle were measured respectively.

Results: There was no significant difference in the average vascular length after PVCR. The shortest distance between aorta and apical vertebral showed obviously decreased after PVCR. Compared with preoperatively measurement, arterial lumen proportion at angulation region increased 69.5%. The angle of tortuous aorta increased 244.1%. The angle of Aorta-SMA increased 74.4%. (Table)

Conclusion: PVCR for deformity correction does not result in significant change of the aorta length. It suggests that PVCR could maintain the vascular safety. For severe spinal deformities, the aorta is much close to the end vertebrae region but relatively far from apical vertebrae, which increases the risk of vessel injury when more than one vertebral column is resected. Increased angle of aorta-SMA after PVCR reduce the compression on the duodenal from SMA, and the risk of superior mesenteric artery syndrome. The angle of tortuous aorta is always related to the main curve of spinal deformity. The aortic blood flow is increased following the improvement of the aortic angulation after the correction of the main curve. But at the start of the flow change, it may increase the occurrence of adverse cardiovascular events, due to obviously hemodynamic changes.

63. High Dose of Tranexamic Acid Reduces Intraoperative Blood Loss in Patients Undergoing Posterior Vertebral Column Resection: A Clinical Comparative Study of 89 Consecutive Patients

Tao Li; Jingming Xie; Ying Zhang; Yingsong Wang, MD; Leijie Chen; Zhou Liu; Zhiyue Shi; Zhi Zhao; Ni Bi
China

Summary: This study retrospectively analyzed 89 consecutive patients undergoing posterior vertebral column resection (PVCR), 40 patients was treated by tranexamic acid (TXA). TXA can significant reduce blood loss and amount of blood transfusions with no major complication.

Introduction: High levels of intraoperative blood loss are widely documented in severe rigid scoliosis patients undergoing PVCR. High dose of TXA has been proved useful in major spinal surgery, but there was few studies focusing on the effectiveness and safety of high dose of TXA used in the patient undergoing PVCR.

Methods: 89 consecutive severe rigid scoliosis patients treated with PVCR were enrolled in this study (TXA group: n=40, Control group: n=49). In TXA group, a loading dose of TXA at 100mg/kg was given before skin incision followed by an infusion of 10 mg/kg/hr during surgery. Blood loss, real blood loss (RBL: =Blood loss/Blood volume), transfusion requirements were assessed. The complications, such as renal toxicity, deep venous thrombosis (DVT), myocardial infarction (MI) and seizure, were also assessed.

Results: There were no significant differences in demographic or surgical traits between two groups. The blood loss was 3550 ± 1442 ml in TXA group and 8705 ± 4795 ml in the control group ($P < 0.05$). 59.2% of blood loss was decreased in TXA group. The RBL with and without TXA was $89 \pm 61\%$ versus

PODIUM PRESENTATION ABSTRACTS

293±165% (P<0.05). Transfusion of packed red blood cells and autologous cell saver blood in the TXA group were both significantly less than those in the control group (P<0.05). There were no renal failure, DVT and seizure in all patients. In the TXA group, two patients developed an asymptomatic MI diagnosed by increased cardiac troponin after surgery.

Conclusion: High dose of TXA can significantly reduce intraoperative blood loss and the amount of blood transfusions in severe rigid scoliosis patients undergoing PVCR. No major complications were observed in all patients, but surgeon should pay high attention to the heart-related complication when using TXA.

64. The Changes of SEP/MEP following Ligating Spinal Cord Segmental Vessels in Applying Posterior Vertebral Column Resection (PVCR) to Correct Severe Rigid Spinal Deformity

Zhi Zhao; Jingming Xie; Ni Bi; Leijie Chen; Tao Li; Yingsong Wang, MD; Ying Zhang; Zhiyue Shi; Zhou Liu
China

Summary: We explored the SEP/MEP changes following ligating spinal cord segmental vessels in applying PVCR to correct severe spinal deformity.

Introduction: In applying PVCR to treat severe spinal deformity, it is unavoidable to ligating several spinal cord segmental vessels for exposure as well as vertebral resection and this process would threaten the safety of spinal cord.

Methods: 21 consecutive patients with severe rigid spinal deformities and being treated by PVCR were divided into 5 groups based on the number of spinal cord segmental vessels being ligated. IOM was used in the whole surgical process. The amplitude and latency changes of SEP/MEP were specially recorded for analysis during and following segmental vessel being ligated.

Results: The mean number of vessels being ligated was 1.9 pairs (1~3 pairs), no more than 3 branches were ligated in the same side. In the 5 groups, the amplitudes of SEP declined 53.2%, 59.1%, 66.9%, 71.7%, 78.2% respectively; the mean durations were 3.2, 3.6, 4.2, 4.9, 5.2 min respectively. In 10 cases, the amplitudes of SEP fell more than 50% following 1 pair of vessels being ligated, but gradually recovered to the baseline after 3.2 min. In another case, the amplitude of SEP declined more than 50% after 2 pairs of vessels being ligated and the duration was 5.2 min before recovering to the baseline. For all patients, the latency stages were no more than 10%, and MEP was normal. No neurological deficit occurrence.

Conclusion: SEP is so sensitive and the amplitude would decline more than 50% following 1 pair of vessels being ligated. The amplitude of SEP would fall more than 50% following no more than 3 pairs of vessels being ligated, but which can recover after a short duration. The more number of vessels are ligated, the amplitude of SEP will decline more obviously and the duration will last much longer. So following 3 pairs of vessels being ligated, the effect to the spinal cord is limit and the risk of spinal cord injury will be greatly increased following the number of segmental vessels being ligated.

65. Apex of Deformity for Three-Column Osteotomy: Does it Matter in the Occurrence of Complications

Cristina Sacramento-Dominguez, MD, PhD; Mitsuuru Yagi, MD, PhD; Jennifer Ayamga, BA, Mphil; Oheneba Boachie-Adjei, MD
Spain

Summary: We have analyzed the outcomes of hyperkyphotic deformity patients undergoing corrective spine surgery with PVCR and risk factors related with neurological complications. The results showed that the apex of kyphosis > T5 and a Cobb angle of kyphosis >120 deg. are risk factors for neurological complications.

Introduction: Posterior vertebral column resection (PVCR) is a challenging but effective technique for complex spine deformity correction. The purpose of this study is to review the clinical outcomes and the complications in hyperkyphotic patients undergoing corrective spine surgery with PVCR.

Methods: The clinical and radiographic data of 98 consecutive patients treated with PVCR from a single center database (FOCOS) were reviewed at pre-op, immediate post-op, and final follow-up. Inclusion criteria consisted of hyperkyphosis surgically treated with PVCR as a primary or revision procedure.

Results: There were 50 females and 48 males (average age 14+/-6.5yrs). 50 patients had post infectious hyperkyphosis, 31 congenital kyphosis, and 17 pts other etiologies. The averages (avg) for: BMI (20+/-10kg/m²), ASA (3+/-0.7), and FVC (76+/-23%). The pre-op localized kyphosis avg (104+/-30deg), fusion levels avg (10+/-3), estimated blood loss avg (1319 +/-720 mL) and surgical time avg (375+/-101 min.). 15 patients had an abnormal pre-op neurological status. Major complications occurred in 36pts and included neurologic in 23pts, implant related in 9pts, and deep infection in 4pts. The apex level of kyphosis was proximal thoracic >T5 (5pts), thoracic T6-T9 (17pts), thoracolumbar T10-L2 (55pts) and lumbar L3-S1 (9pts). The number of vertebrae involved in localized kyphosis (LK) avg. (5.2+/-1.5). Logistic regression analysis was performed to assess the relative risk analysis of the apex level of kyphosis, angle of kyphosis, and number of vertebrae involved in LK for postoperative complications and neurological complications. There was no significant difference for the total complications and apex of kyphosis or number of vertebrae involved in LK. However, significant differences were found for neurological complications and apex level of kyphosis >T5 (Odds ratio; 15, p=0.05), and the angle of kyphosis >120 deg. (Odds ratio; 3.56, p=0.03).

Conclusion: PVCR for hyperkyphosis is technically demanding and carries a substantial risk. Established surgical risk factors based on curve magnitude and apex level of kyphosis can guide surgeons in their pre-op planning and surgical management of severe hyperkyphosis in order to achieve optimal outcomes.

66. Classification and Surgical Decision Making of Ankylosing Spondylitis Kyphosis

Yan Wang, MD; Yonggang Zhang, PhD; GuoQuan Zheng
China

Summary: The lack of a widely accepted classification system contributes to the variation in surgical decision making. This new classification outlines 4 types of ankylosing spondylitis kyphosis according to the location of the apex and 2

PODIUM PRESENTATION ABSTRACTS

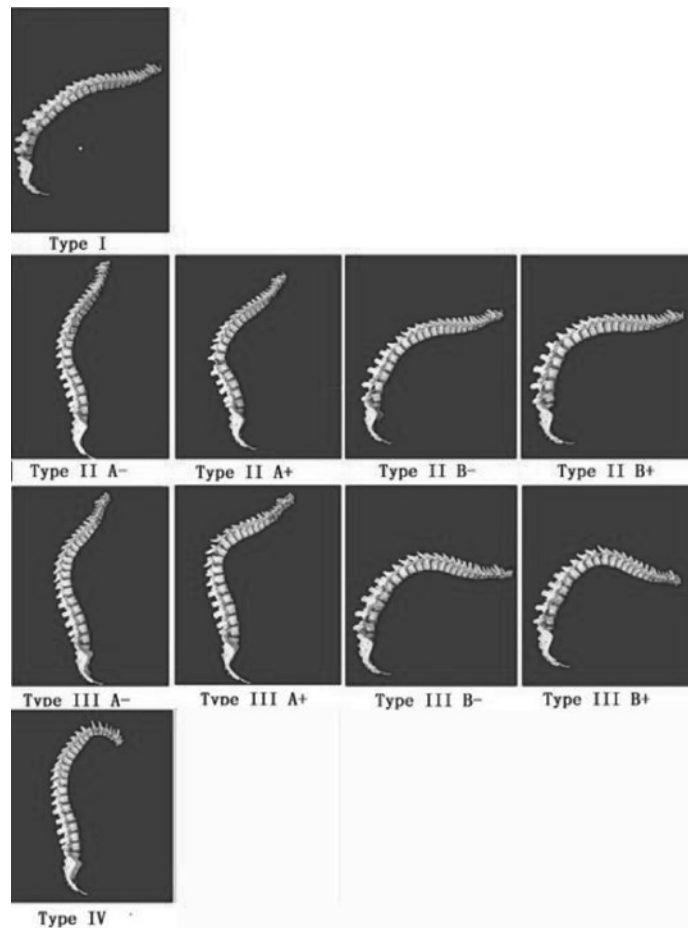
subtypes to describe the condition of the lumbar spine. Surgical decision making for AS kyphosis should be focused on the location of the osteotomy(ies) and the levels of osteotomy(ies).

Introduction: Ankylosing spondylitis is a chronic inflammatory disease that primarily affects the spine and sacroiliac joints yet the treatment choices of kyphosis remain controversial. The lack of a widely accepted classification system contributes to the variation in surgical decision making.

Methods: We have divided the kyphosis into 4 types according to the location of the apex: lumbar (type I), thoracolumbar (type II), thoracic (type III), and cervical or cervicothoracic junction kyphosis (type IV), and every type except type 1 has 2 subtypes: with normal lumbar lordosis (A) and with lumbar kyphosis (B). The surgical decision making is mainly focused on the location of the osteotomy(ies), the levels of the osteotomy(ies), and the anchor points of instrumentation. The total consecutive 258 patients suffering from AS with a kyphosis deformity who underwent a spinal osteotomy in our hospital were reviewed.

Results: 48 patients were divided into type I, 185 type II, and 25 type III. The thoracolumbar type (type II) was the most common. 183 cases were performed with a single PSO, and 64 patients underwent one stage continuous or an interrupted two-level osteotomy. The others underwent multilevel SPOs or hybrid techniques. The chin-brow vertical angle (CBVA) was improved from average 45.0° to 4.2° ($P=0.000$). The mean correction was 43.9° at the site of an osteotomy in a single PSO group. For patients who underwent a two-level spinal osteotomy, the mean correction was 24.9° at the superior site of the osteotomy and 38.1° at the inferior site of the osteotomy. There were 21 surgery-related complications that occurred (8.1%), including infections ($n=2$), CSF leaks ($n=11$), sagittal translation at the osteotomy site ($n=6$), cervical spine fracture ($n=1$) and intraoperative transient cardiac arrest ($n=1$). No major acute complications such as death or complete paralysis occurred.

Conclusion: This new classification system can be used reliably and effectively to classify AS kyphosis, which can be used to guide surgical decision making including determining the site and the levels of osteotomies.



†67. Implementing a Dashboard Reporting Tool Improves Surgeon Performance and Patient Outcomes

Ronald A. Lehman, MD; Harry L. Shufflebarger, MD; Michelle C. Marks, PT, MA; John M. Flynn, MD; Peter O. Newton, MD
USA

Summary: We found that Dashboard reporting tool to track performance resulted in “real-time” information that allowed surgeons to compare their outcomes with other surgeons performing the same operations. Tracking and reporting the variations resulted in over 60% of surgeons improving their operative times and decreasing EBL in just one year. These reports provide valuable information that will ultimately reduce variation, advance quality and improve patient outcomes.

Introduction: With increased visibility on optimizing independent, outcome measures and improving patient reporting outcomes, there is an increased effort to establish methods to promote individual surgeon performance improvement, A Dashboard Reporting Project was implemented over two years ago to facilitate comparison among a large group of surgeons from multiple sites so each could utilize this data for performance improvement.

Methods: Ten surgeons from seven centers prospectively enrolled patients with adolescent idiopathic scoliosis (AIS) into a multicenter database. Standard demographic and radiological data was recorded for each patient in addition to outcome specific outcomes indicators including: SRS scores, Cobb measurements,

PODIUM PRESENTATION ABSTRACTS

length of hospitalization (LOH), estimated blood loss (EBL), infections, neuromonitoring alerts/events, operative time and reoperation rates. In an observational cohort design, surgeon data was analyzed at one-year time points, and a step-wise comparison was utilized to determine variance in surgeon practices and if there were iterative improvements in patient and surgeon outcomes.

Results: There were 407 patients analyzed with 2-year follow-up. With the Dashboard data presented to each surgeon, they were able to ascertain how their outcomes compared to the other de-identified surgeons in the group for all outcome metrics. From year 1 to year 2 surgeons exercised varied self-improvement measures, and after the 2nd year surgeons received another Dashboard report. During this observational period, the largest improvements resulted in 60% of surgeons decreasing their operative time, and 70% decreasing their EBL (average 58.2cc) from Year 1 to Year 2.

Conclusion: The use of Dashboard reporting tool to track performance resulted in "real-time" information that allowed surgeons' to compare their outcomes with other surgeons performing the same operations. Tracking and reporting the variations resulted in over 60% of surgeons improving their operative times and decreasing EBL in just one year. These reports provide valuable information that will ultimately reduce variation, advance quality and improve patient outcomes.

†68. Increasing Hospital Charges for Adolescent Idiopathic Scoliosis in the United States

Christopher T. Martin, MD; Andrew J. Pugely, MD; Yubo Gao, PhD; Sergio A. Mendoza-Lattes, MD; John Callaghan; Ryan M. Ilgenfritz, MD; Stuart L. Weinstein, MD
USA

Summary: This study utilizes a national database to demonstrate that inflation adjusted charges for spinal fusions in pediatrics are rising markedly faster than in other areas of orthopaedic surgery or general pediatrics. In a separate analysis, detailed financial data from a single institution is analyzed in order to identify potential drivers of increased charges, showing that implant charges rose an average of 27.6% annually, whereas physician charges decreased 0.5% annually and other hospital charges rose more modestly at 5.3% annually. Implants may be the primary driver of increased hospital charges in pediatric spine.

Introduction: Trends in utilization rates, surgical procedure types, and hospital charges for adolescent idiopathic scoliosis (AIS) fusions have not been well investigated.

Methods: We used ICD-9 billing codes to identify 24,505 AIS fusion cases from the Kid's Inpatient Database (KID) between 1997 and 2009. Data was trended over time, and contrasted against other common procedures. In order to identify specific drivers of charges, we queried our own hospital's billing system, and averaged charges from 10 cases for each year in the study period, up to 2012. Dollar amounts were adjusted for inflation to 2009 dollars.

Results: Utilization rates for AIS fusions have remained constant, whereas utilization of adult spinal fusions increased three fold ($p<0.001$). Utilization of anterior thoracic fusions decreased 80% ($p<0.0001$). Mean hospital charges for AIS spinal fusions increased from \$49,901 in 1997 to \$144,800 in 2009 (190% increase), averaging 15.8% annually ($p<0.0001$), with charges for

adult spinal procedures increasing at a similar rate (13.4% annually, $p<0.0001$). Charges for the other non-spine conditions increased to a lesser degree (range of 7%-9.1% annually, $p<0.001$ for each). At our institution, spinal implant charges increased 27.6% annually, while surgeon charges decreased 0.5% annually, and all other charges increased only 5.2% annually. Over time, our surgeon used greater numbers of pedicle screws, and greater numbers of implants per surgery and per level fused ($p<0.05$ for each). Implant charges were 28% of the total hospital bill in 2003, rising to 53% in 2012.

Conclusion: While utilization rates for AIS fusions have remained constant over time, hospital charges have increased substantively, and there has been a shift towards performing posterior only surgeries. This corresponds to the widespread adoption of pedicle screw based constructs. Spinal implants may be the primary driver of increased charges. Strategies directed towards implant cost-savings may thus have the largest impact while further cuts to the already declining physician reimbursement may be less efficacious.

†69. Impact on Health-Related Quality of Life of Adult Spinal Deformity (ASD) Compared with Other Chronic Conditions

Ferran Pellise, MD; Alba Vila-Casademunt; Daniela Issa; Montse Domingo-Sabat; Juan Bago, MD; Francisco J. S. Pérez-Gruoso, MD; Ahmet Alanay; Emre Acaroglu, MD; European Spine Study Group
Spain

Summary: Medical and health policy providers should be aware of the impact of adult spinal deformity (ASD) on health-related quality of life (HRQOL). The purpose of this study was to compare the relative burden of four chronic conditions with that of ASD. The global burden of ASD was huge compared with other self-reported chronic conditions in the general population of 8 industrialized countries (3 continents). The impact of ASD on HRQOL warrants the same research and health policy attention as other important chronic diseases.

Introduction: Medical and health policy providers should be aware of the impact of adult spinal deformity (ASD) on health-related quality of life (HRQOL). The purpose of this study was to compare the relative burden of four chronic conditions with that of ASD.

Methods: The International Quality of Life Assessment project gathered data from 24,936 people and published the SF36 scores of patients with self-reported arthritis, chronic obstructive pulmonary disease, diabetes and hypertension from 8 industrialized countries (3 continents) (Quality of Life Research 13:283-298, 2004). We compared these with the SF36 baseline data of consecutive patients with ASD enrolled in a prospective multicentre European database. Four ASD groups were considered: all ASD patients, surgical candidates, and non-surgical candidates with and without previous surgery.

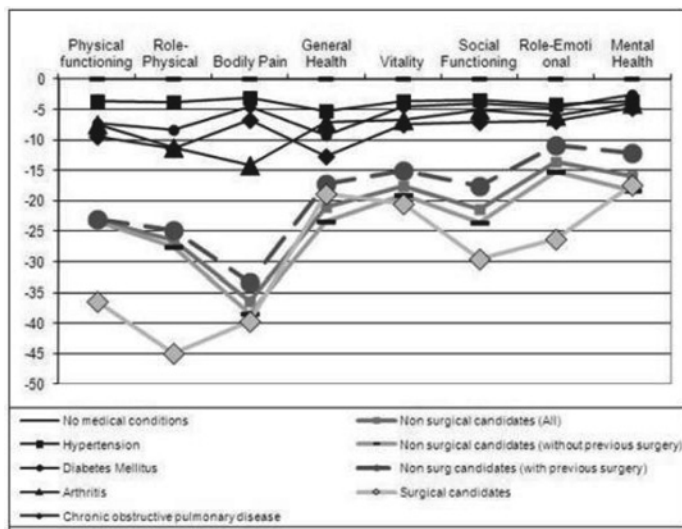
Adjusted estimates of the impact of chronic disease were calculated using separate multivariate linear regression models. Individuals without chronic conditions were used as the reference group. Coefficients for each chronic condition and ASD represent the difference compared with this healthy group.

Results: 504 patients (mean age 45.7y) met the inclusion criteria for ASD. The scores on all SF36 domains were lower in ASD patients than in any other chronic condition. Differences between ASD and the other chronic conditions were always greater than the reported minimal clinically important differences (3 to 5). When

PODIUM PRESENTATION ABSTRACTS

compared with individuals reporting no medical conditions, SF36 scores from the population with self-reported chronic conditions ranged from -3.1 to -14.1. Comparable scores for patients with ASD ranged from -10.9 to -45.0. Physical function, role physical and pain domains showed the worst scores. Surgical candidates with ASD displayed the worst HRQOL scores (-17.4 to -45.0) and patients previously operated the best (-10.9 to -33.3); however, even the latter remained worse than any scores for the other self-reported chronic conditions.

Conclusion: The global burden of ASD was huge compared with other self-reported chronic conditions in the general population of 8 industrialized countries. The impact of ASD on HRQOL warrants the same research and health policy attention as other important chronic diseases.



†70. A Genome-Wide Association Study Identified a Novel Susceptibility Locus for Severe Adolescent Idiopathic Scoliosis

Atsushi Miyake; Morio Matsumoto, MD; Yohei Takahashi; Yoji Ogura, MD; Katsuki Kono; Noriaki Kawakami, MD, DMSc; Koki Uno, MD, PhD; Manabu Ito, MD, PhD; Shohei Minami; Haruhisa Yanagida, MD; Hiroshi Taneichi, MD; Kota Watanabe; Taichi Tsuji, MD; Teppei Suzuki; Hideki Sudo; Toshiaki Kotani; Ikuho Yonezawa, MD, PhD; Kazuhiro Chiba, MD, PhD; Yoshiaki Toyama; Shiro Ikegawa, MD, PhD

Summary: Through a genome-wide association study and a replication study, we identified SNP on chromosome 17q24.3 significantly associated with susceptibility of severe adolescent idiopathic scoliosis (AIS) in Japanese. The result was replicated in Chinese. The association definitely satisfied the genome-wide significance.

Introduction: Adolescent idiopathic scoliosis (AIS) is the most common spinal deformity. Genetic factors play an important role in its etiology. Using a genome-wide association study (GWAS), we recently identified novel AIS susceptibility loci on chromosomes 10q24.31 and 6q24.1. To identify more AIS susceptibility loci relating to its severity and progression, we performed a GWAS by limiting the case subjects to those with severe AIS.

Methods: We defined Cobb's angle for severe AIS was above 40°. We recruited 554 females who had been diagnosed with severe AIS between age 10 and 18

years and 1,474 control subjects. Cases and controls were genotyped using the Illumina Human610 Genotyping BeadChip and the Illumina HumanHap550v3 Genotyping BeadChip, respectively. For the replication study, we recruited a Japanese independent set of 268 cases and 9,823 controls, and a Chinese set of 571 cases and 326 controls. Japanese controls were genotyped using the Illumina Genotyping BeadChip, and the other samples were genotyped by Invader assay. The association between the SNPs was examined by χ^2 test for three models (allele model, recessive model and dominant model) and minimum P values in the three models were evaluated.

Results: Through a GWAS and Japanese replication study six SNPs showed association of the genome-wide significance level (P value < 5.00×10^{-8}). Five of them were in the known loci of AIS susceptibility that we previously reported. One of them, rs12946942, was a novel SNP and showed significant association in the recessive model (P = 4.00×10^{-8}). The association of rs12946942 was also significant in the Chinese population, and combined P values from the Mantel-Haenszel method for the Japanese and Chinese studies in the recessive model showed genome-wide significance (P = 6.43×10^{-12}). rs12946942 is on chromosome 17q24.3 near the genes SOX9 and KCNJ2. They are promising candidate gene for severe AIS because they cause scoliosis phenotypes when mutated.

Conclusion: We identified a susceptibility locus for severe AIS on chromosome 17q24.3 that showed genome-wide significance. This locus contains two promising candidate genes that may be associated with the disease. Our findings will offer new insight into the etiology and progression of AIS.

†71. 2005 and 2013 Health Survey of SRS Member Surgeons Focusing on Thyroid Cancer and Cataract Prevalence: Occupational Radiation Risk?

Theodore A. Wagner, MD; Maria A. Vanushkina, BS; Sue Min Lai, PhD; Courtney M. O'Donnell, MD; Darin J. Davidson; Mark Weidenbaum, MD USA

Summary: We attempted to correlate cancer and cataract prevalence, radiation exposure and shielding habits in SRS members. A total of 733 unique responses were collected via surveys administered in 2005 and 2013. Overall, 13% of surgeons reported malignancies and 30% reported cataracts. Shielding equipment was grossly underutilized. We recommend implementation of mandatory surveillance of occupation-related health risks for SRS members in the future.

Introduction: Professional organizations, such as SRS, are minimally involved in surveillance or prevention of occupation-related health risks. In 2005, the diagnosis of three colleagues with thyroid cancer prompted a survey evaluation of these risks for spine deformity surgeons. Several studies have documented correlation between cumulative radiation doses and increased cancer and cataract rates. The survey was re-written with this in mind and repeated in 2013. We hypothesized that cancer and cataract prevalence relates to the cumulative radiation dose generated by C-arms and plain x-rays in operating rooms or treatment areas.

Methods: To expand the 2005 data set, a second survey of SRS members was conducted via Survey-Monkey with support from the SRS Instrumentation Committee. The 2013 questions requested additional information on cataracts, medically-related radiation exposure, and family history. The information from

PODIUM PRESENTATION ABSTRACTS

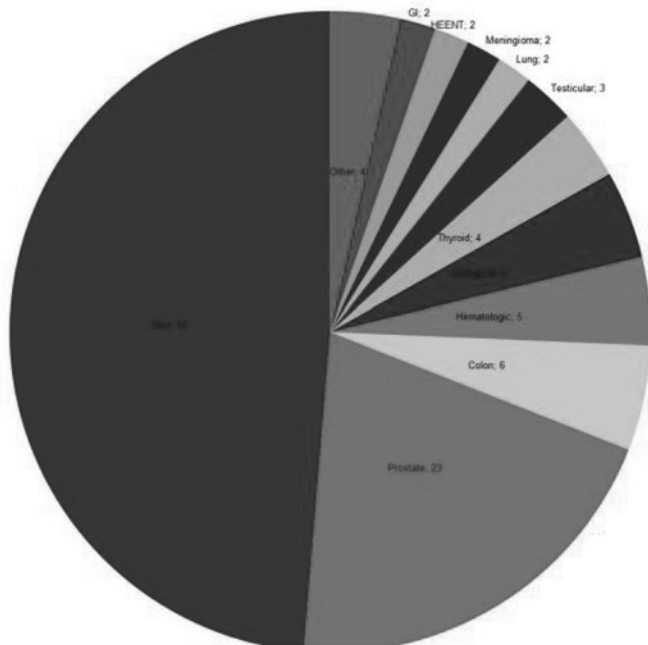
both surveys was combined and evaluated. Entries for surgeons who participated in both surveys were combined to avoid duplication. Surgeon cancer rates were compared with the age and gender adjusted general population statistics from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program data. The cataract rates were compared to the Center for Disease Control's Behavioral Risk Factor Surveillance System Vision Module data.

Results: Forty-two percent (429/1012) of the SRS member surgeons responded to the survey in 2013 compared to the 81% (528/650) response rate in 2005 for a total of 733 unique entries. Overall, 13.1% (n=96) of surgeons reported a malignancy. Of the 2013 group, 29.6% (n=61) reported suffering from cataracts. The use of protective equipment was low, with 47.3% (n=347) reporting regular use of lead neck shields and 5.6% (n=41) reporting regular use of lead eye protection.

Conclusion: This cohort of spine deformity surgeons appears to have a significant prevalence of cancers and cataracts, despite being under reported. Because the effect of radiation is cumulative, appropriate radiation protection must be emphasized during surgeon training and maintained throughout the lifetime. We recommend implementation of mandatory surveillance of occupation-related health risks in SRS members for the future.

Other 4

Distribution of Cancer Types in SRS Surgeons



†72. **A New Genetic Locus Increases Risk of Idiopathic Scoliosis in Females**
Carol Wise, PhD; Swakar Sharma, PhD; Douglas Londono, PhD; Walter Eckalbar; Xiaochong Gao; Ikuyo Kou; Atsushi Takahashi; Morio Matsumoto, MD; John A. Herring, MD; Shiro Ikegawa, MD, PhD; Nadav Ahituv; Derek Gordon, PhD USA

Summary: Genomic approaches are yielding new insights into the obscure etiology of idiopathic scoliosis (IS). By genome-wide association study (GWAS), we identified a new IS locus near PAX1, a gene previously associated with

scoliosis in mice, and found that the association was specific to females. DNA sequences in the IS-associated locus drove gene expression specifically in spinal cord and muscle in zebrafish assays. Our study suggests that we have identified the first sex-specific IS locus, implicating PAX1 and supporting a role in spinal cord and muscle development.

Introduction: Idiopathic scoliosis is common and highly heritable, yet underlying genetic contributions remain largely unknown. Progressive disease risk is substantially greater in female patients, for reasons that are also unknown. IS candidate genes have been recently discovered by GWAS. To discover and characterize new IS genetic risk factors, we expanded a prior GWAS, "GWAS I", by combining it with a new study, "GWAS II" in which we genotyped 1,201 non-Hispanic white (NHW) cases and controls. After combining the two studies we tested replication of top results in a Japanese GWAS and a separate (NHW) USA cohort.

Methods: GWAS II samples were genotyped on an Illumina beadchip that interrogates >730,000 single nucleotide polymorphisms (SNPs). SNPs were tested for IS association using the Cochran-Armitage Trend Test. GWAS statistical results were calculated using Sumstat and combined using Fisher's exact test. Top SNPs were genotyped in the USA cohort by Taqman assay. Candidate enhancer sequences were cloned into the E1b-GFP-Tol2 vector, injected into zebrafish embryos, and assayed for enhancer activity by monitoring green fluorescent protein expression.

Results: Strongest association results (Sumstat $P = 1.33 \times 10^{-8}$) were obtained on chromosome 20p11 near PAX1 and replicated in the Japanese GWAS (combined GWAS $P = 8.2 \times 10^{-10}$), and in the USA cohort (top SNP $P = 1.50 \times 10^{-3}$). Surprisingly, the 20p11 SNPs were previously associated with protection against early-onset androgenic alopecia, suggesting that the region confers sex-specific effects in various tissues. Accordingly, stratification by sex yielded IS association in females but not males. Zebrafish transgene assays revealed that DNA sequences in the chr20p11/PAX1 IS-associated locus drove clear gene expression in muscles and neurons of the developing spine, with little or no expression in twelve other tissues examined.

Conclusion: The 20p11/PAX1 region is a new IS susceptibility locus, conferring genetic risk that may be specific to females and likely affecting gene transcription in spinal cord and muscle.

*73. **Comparison of Surgical Outcomes between Anterior Fusion (ASF) and Posterior Fusion (PSF) in Patients with AIS Lenke Type 1 or 2 that Underwent Selective Thoracic Fusion: Long-Term Follow-up Study Longer Than 10 Postoperative Years**

Ayato Nohara; Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Toshiki Saito; Tetsuya Ohara; Yoshitaka Suzuki; Ryoji Tauchi, MD, PhD; Ryo Sugawara; Kosuke Takimura, MD; Kyotaro Ota; Kazuki Kawakami, BS Japan

Summary: The retrospective long-term follow-up study was conducted to compare posterior (P-Group) and anterior (A-Group) selective thoracic fusion in patients with AIS Lenke Type 1 or 2. The age, curve type, and magnitude of main curve at the time of surgery were matched in both groups. There were no significant differences in the correction rate and the incidence of disc

PODIUM PRESENTATION ABSTRACTS

degeneration (DD) on the unfused distal segments. The A-Group demonstrated much greater loss of correction than the P-group, which was mainly caused by adding-on.

Introduction: Although many studies have compared ASF with PSF in patients with IS, most are medium- or short-term follow-up (F/U) studies. The purpose of this study was to compare the clinical outcomes of selective thoracic fusion between those treated via an anterior approach and treated via a posterior approach with a minimum F/U 10 years.

Methods: This study was a retrospective comparative study. The inclusion criteria of this study were female, AIS Lenke type 1 or 2, a minimum F/U 10 years, MRI check-up following and at 5 years, and 10 years after surgery. The number of patients, age, curve types and magnitude of the main thoracic curve at the time of surgery were matched in both groups (P-group: 30 patients, mean age 15.7 years, number of fused segments 10.7, A-group: 30, 15.5 years, 7.2 segments). Complications, pulmonary function and SRS-30 were also evaluated. Adding-on (AO) was defined as a distalization of the LEV immediately following surgery.

Results: P-Group: AO occurred in 14 patients. Two patients demonstrated progression of scoliosis greater than 5° during F/U periods. DD occurred in 43% of patients at 10 years following surgery. There were significant differences in the %VC and FVC between before surgery and the final F/U ($P < 0.05$). A-Group: AO occurred in 16 patients; 11 of the 16 showed progression of scoliosis greater than 5°. DD was recognized in 53% of the patients. There was no significant difference in pulmonary function. There was a significant difference in self-image score in the SRS-30 between the two groups ($P < 0.05$).

Conclusion: Treatment via the anterior approach for selective thoracic fusion corrected scoliosis significantly better than treatment via a posterior approach immediately following surgery, followed by much greater loss of correction in the anterior group in the same level at the time of final F/U. Although the ASF fused shorter segments in comparison to PSF, there was no significant difference of the occurrence of DD. Comparison of the pulmonary function test demonstrated an increase in the P-group and restoration in the A-group during the perioperative period.

*74. **Minimum 20-Year Radiographic Outcomes for Treatment of Adolescent Idiopathic Scoliosis: Preliminary Results from a Novel Cohort of US Patients**
A. Noelle Larson, MD; David W. Polly, MD; William J. Shaughnessy, MD; Michael J. Yaszemski, MD, PhD
USA

Summary: AIS patients with 35-50° curves treated nonoperatively in childhood had progression in adulthood at a slow rate (mean 0.5 degree per year for thoracic curves). However, some individuals had rapid progression and others had no progression. Further work is required to determine why this occurs.

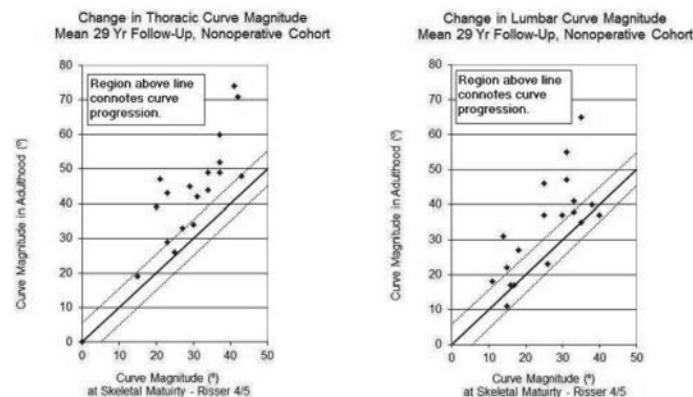
Introduction: There is limited recent data regarding the long-term outcomes of scoliosis treatment. This study evaluates the minimum 20-year outcomes following treatment of adolescent idiopathic scoliosis with bracing, surgery, or observation in a novel cohort of US patients.

Methods: All patients had radiographs from adolescence at skeletal maturity (Risser 4 or 5) and were contacted for current radiographs, pulmonary function

tests, and physical exam. Patients had at least a 35° idiopathic scoliosis curve magnitude during adolescence. Childhood treatment included bracing/observation (19) and surgery (12, either Harrington or CD instrumentation).

Results: Thirty-one patients had radiographs/physical exam at a minimum of 20-years following treatment. Mean time to follow-up was 28.1 years (range, 20-36). Mean age at childhood radiographs was 16.4 (range, 14 - 20). Mean age at follow-up was 44.1 years (range, 36-54). Of the 19 nonoperative patients, only 3 did not progress (Figure). For the remaining 16 patients, thoracic curves progressed a mean of 0.54° per year (range, 0.2 - 1.3), and lumbar curves progressed 0.37° (range, 0.2-0.9). Larger curves more frequently progressed (Rsquare 0.61, 0.49). Three patients in the nonoperative group underwent spine surgery in adulthood for lumbar discectomy (1), anterior cervical fusion (1), and lumbar fusion (1) below the level of the deformity. Of the 12 operative patients, 3 (25%) had additional procedures in adulthood, including implant removal (2) and distal extension of the fusion (1). Despite fusion, 8/12 surgical patients had mild curve progression, at a rate of 0.3° per year.

Conclusion: Idiopathic scoliosis curves between 35-50° continue to progress during adulthood, but this varies by individual. Thoracic curves progress more quickly than lumbar. Elucidation of the factors which govern progression in adulthood may help guide childhood treatment recommendations.



Curve progression for each patient. The solid line represents no change. The broken lines indicate +/- 5 degrees.

*75. **Prediction of Outcomes in AIS: Results from BraIST**
Lori A. Dolan, PhD; Stuart L. Weinstein, MD
USA

Summary: Recent research suggests current indications for bracing in AIS result in significant over-treatment. Many patients are at low risk for significant progression. Others present at higher risk but stand to benefit little from bracing. Sanders' digital maturity stage and Cobb angle accurately predict the natural history of AIS during the high-risk period. Bracing significantly altered the natural history.

Introduction: Recent research suggests current indications for bracing in AIS result in significant over-treatment. Many patients are actually at low risk for significant progression. Others present at higher risk but stand to benefit little from bracing. The purpose of this analysis was to develop a simple, yet accurate,

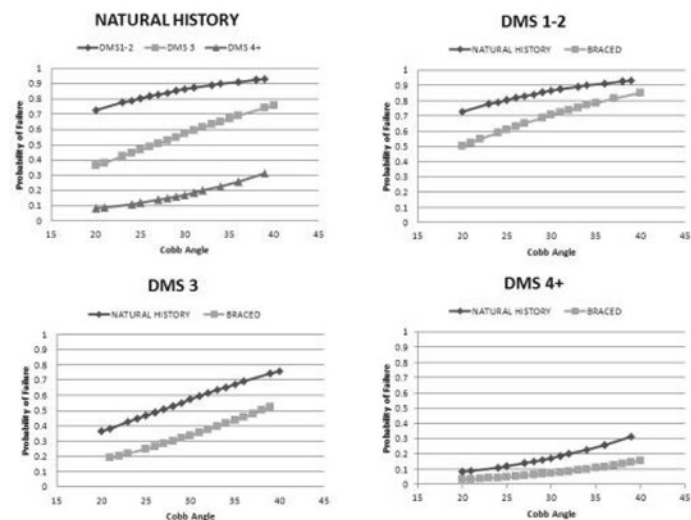
PODIUM PRESENTATION ABSTRACTS

model of the risk of significant curve progression in AIS and the risk reduction associated with bracing.

Methods: Data from 238 BraIST subjects were used (91 were observed, 147 were braced). All met current indications for bracing (Cobb 20-40°, Risser <3) and were followed until reaching a Cobb angle of >50° (failure) or until skeletal maturity. Logistic regression evaluated the relationship between initial variables, treatment and final outcome. The most predictive 3-variable model was chosen.

Results: The overall failure rate was 31% after bracing and 52% after observation. Age, gender, Risser, Sanders' digital maturity stage (DMS), curve type and Cobb angle were all associated with outcome. DMS stages were more predictive of failure than Risser grade, even with age included in the model. The best-fitting model included the variables DMS (1-2, 3, or 4+), Cobb angle, and treatment ($p < 0.0001$, c statistic=0.841). Increasing Cobb angle was associated with increased risk of failure across all DMS's; bracing significantly decreased the risk. In DMS 1-2, the risk of failure ranged from 73% (Cobb 20°) to 93% (Cobb 39°), Bracing reduced the risk to 50% and 84%, respectively. Risk was lower in DMS 3 patients, ranging from 36% (Cobb 20°) to 76% (Cobb 40°), reducing to 19% to 52% with bracing. The lowest risk of failure was noted at DMS 4+, ranging from 9% (Cobb 20°) to 31% (Cobb 39°), reducing to 3% to 15% with bracing.

Conclusion: DMS stages in combination with Cobb angle at presentation accurately predict the natural history of AIS during the high-risk period. Bracing significantly altered the natural history. This model provides a simple, yet predictive model of the risk of curve progression and the decrease in risk due to bracing. These results can be used by clinicians and families to make evidence-based decisions concerning bracing for AIS, with the family choosing observation or bracing based on their own risk-benefit considerations.



*76. Radiological Outcome in AIS Patients 25 Years after Treatment Ane Simony, MD; Mikkel Andersen, MD; Steen B. Christensen, MD Denmark

Summary: The purpose of this study was to evaluate the long term radiological outcome 25 years after scoliosis treatment.

Introduction: Few studies has been performed, to show the longterm effect of Boston brace treatment and posterior spinal fusion.

Methods: 219 patients treated with Boston brace or posterior spinal fusion a. m Harrington were invited to participate in a long term evaluation. The old medical charts and x-ray descriptions where available.

Standing X-ray was examined, the Cobb angel measured and compared to the patient's prior x-rays and the adjacent levels where evaluated for any signs of adjacent level disease or local kyphosis.

Results: 159 patients participated (78 %). 66 patients treated with Boston brace and 92 patients, treated with posterior spinal fusion a.m. Harrington. In the Brace group, the Cobb angel prior to treatment was 37.5° (35.1°-40.0°), after treatment 34.7° (31.9°-37.5°).Cobb angel after 25 years 40.2° (36.7°-43.6°).

In the surgical group the Cobb angel prior to treatment was 54.5° (50.4°-58.8°), 1 year postoperative 29.5 ° (25.7°-33.9°).Cobb angel after 25 years 32.35° (27.9°-39.5°).



26 patients had distal segment degeneration in x-rays (16.5%), 4 patients treated with Brace and 22 patients with posterior spinal fusion.

8 patients had proximal segment degeneration (5 %), 2 treated with brace and 6 patients with posterior spinal fusion. 4 patients were treated with posterior fusion of the distal adjacent segment (2.6%), 1 treated with Brace and 3 treated with posterior spinal fusion.

Conclusion: The average follow up was 24.5 years (range 23-35 years).

The Brace group had a small reduction of the spinal deformity during the treatment period, and X-rays shows a small progression of the deformity, Cobb angel increasing 5.5° within 25 years.

The surgically treated patients had a large correction during surgery and there is no statistical significant progression or loss of correction over a 25 year period.

Only 4 patients in the Brace group have distal segment degeneration and 1 was treated with a one level spinal fusion.

The surgically treated groups had a significant deformity correction during

PODIUM PRESENTATION ABSTRACTS

surgery and have maintained the correction after 25 years. 22 patients have distal degeneration and 3 patients were treated with distal adding on surgery. In this study we see a much lower rate of reoperations, than early reported.

36 year old female, standing lateral x-ray, 26 years after fusion surgery with Harring rod.

*77. Selective Thoracic Fusion (STF) Provides Similar HRQL but Can Cause More Lumbar Disc and Facet Joint Degeneration: A Comparison of AIS Patients with Normal Population 10 Years after Surgery

Sinan Kahraman; Meric Enercan; Tunay Sanli, MA; Bahadir H. Gokcen, MD; Erden Erturer; Neron Popovski, MD; Cagatay Ozturk, MD; Ahmet Alanay; Azmi Hamzaoglu, MD
Turkey

Summary: A retrospective study comparing long term (>10y) clinical and radiographical outcomes after (STF) in AIS patients versus age and gender matched healthy population. Clinical outcome studies revealed similar HRQL parameters but MRI demonstrated significantly more disc and facet joint degeneration in AIS patients. .

Introduction: STF for the treatment of AIS preserves lumbar motion segments, but leaves residual deformity. Our study aimed to evaluate long-term behavior of the lumbar curve in pts with AIS treated with STF and to assess clinical and radiological outcome in this fusion group compared with age and gender matched population group

Methods: Group A included 25 AIS pts with mean age 23,6 (19-30) (24f,1m) treated with STF using pedicle screws and having a min. 10 years (av. 11.4 (10-18 y)) f/up. Group B included 30 age and gender matched persons with no scoliosis. All patients had preoperative, postoperative and f/up .A-P and lateral scoliosis x-rays. All had MRIs taken at the final follow-up. Cobb angles of the thoracic and lumbar curves were measured. Follow-up lumbar MRIs' were evaluated for each patient in terms of disc degeneration (DD) and facet joint degeneration. Clinical evaluation was done by using SRS22r, ODI, NRS.

Results: Pts. in group A had an average of 40% correction in lumbar spine magnitude with no significant correction loss except one patient at final f/up. LIV disc angulation, sagittal and coronal balance were stable over time. Av. grading of lumbar DD was 2.16 (2-4) in group A and 1.86 (1-3) in group B. Lumbar FJDs were 2.05 (1-4) in group A and 1.60 (1-3) in the group B. There was significant difference between the two groups for DD except for L4-L5 level ($p=0,26$). FJD was significantly higher in the L1-L2 and L2-L3 levels (L1-L2 $p=0,002$, L2-L3 $p=0,002$) but not for the other levels. Outcome scores were similar without significant differences between two groups ($p>0.05$).

Conclusion: Spinal balance and correction of lumbar curve in AIS pts treated by STF were well maintained at a min. of 10 years f/up. Av. grading of DDs and FJDs were not similar with a matched population without AIS although outcome scores were similar. Degenerative changes were more significant at adjacent levels to fusion. STF provides satisfactory outcome at more than 10 years of follow-up. However, it may not prevent disc and facet joint degeneration which may be an issue at older ages.

*78. Higher Implant Density does not Result in Increased Curve Correction or Improved Clinical Outcomes in Adolescent Idiopathic Scoliosis

Tristan Nishnianidze, MD, PhD; Kenneth J. Rogers, PhD; Blazej A. Pruszczyński; Petya Yorgova, MS; Baron S. Lanner, MD; Suken A. Shah, MD
USA

Summary: Patients with high and low implant density constructs for AIS with 2-year follow-up were matched and compared. For a large array of measures, there was no radiographic or clinical outcome difference between HD and LD screw constructs in AIS patients with moderate curves. This would suggest that the use of low anchor density is equivalent in clinical practice and may require less time, have fewer complications and less cost.

Introduction: Increasing attention is being focused on quality, safety and value in spinal deformity surgery. The role of implant density, or the number of spinal anchors per level fused, is controversial; improved correction might be obtained at significant expense and/or risk. The purpose of this study was to assess outcome after PSF for AIS and compare low vs. high density constructs in a prospective cohort of AIS patients.

Methods: Seventy matched patients were identified from a multicenter prospective database of adolescents with AIS and minimum 2-year surgical follow up. All patients had Lenke 1 and 2 curves with predominantly screw constructs (>80% of implants). Screw density was calculated by dividing the number of screws by number of fused levels (s/l). In our data set, 35 patients had ≤ 1.54 s/l, defined as the low density construct group (LD) and these were matched with 35 patients by preop thoracic Cobb angle and age with ≥ 1.8 s/l to create a high density construct (HD) cohort. Analysis was conducted for variables including SRS outcomes scores, fusion length, regional Cobb angles, sagittal contour T2-T12, T5-T12, T2-T5, and global sagittal balance, preop, immediately postop and at 2 year follow-up.

Results: No significant differences were found between the high and low-density groups for each variable postoperatively. See the data table below for full results of the preop and postop coronal and sagittal radiographic parameters. Preoperative SRS total scores were similar (4.06 LD vs. 3.96 HD) and improved postoperatively in a similar fashion (4.50 LD vs. 4.49 HD), $p=0.51$.

Conclusion: These results suggest that for a large array of measures, there was no clinical or radiographic difference between HD and LD screw constructs in patients with moderate, flexible curves due to AIS. Should these results be further validated across many patients, curve patterns and long term outcomes, they would suggest that the use of low anchor density is equivalent in clinical practice. Additionally, lower density instrumentation techniques require less surgical time, may have fewer complications (risks of malposition and bleeding), and certainly lower cost.

PODIUM PRESENTATION ABSTRACTS

*79. Risk Factors for Neurological Complications in Patients Undergoing Corrective Surgery for Spinal Deformity: Results of the Scolio-Risk 1 Study International, Prospective, Multicenter Study

Michael G. Fehlings, MD, PhD; Lawrence G. Lenke, MD; Christopher I. Shaffrey, MD; Branko Kopjar, MD, PhD, MS; Kenneth M. Cheung, MBBS(UK), MD, FRCS(England), FHKCOS, FHKAM(ORTH); Leah Y. Carreon, MD, MSc; Mark B. Dekutoski, MD; Frank J. Schwab, MD; Oheneba Boachie-Adjei, MD; Khaled Kebaish, MD; Christopher P. Ames, MD; Yong Qiu, MD; Yukihiro Matsuyama, MD; Benny Dahl, MD, PhD, DMSci; Hossein Mehdian, MD, MS(Orth), FRCS(Ed); Ferran Pellise, MD; Stephen J. Lewis, MD; Sigurd H. Berven, MD Canada

Summary: We sought to define the neurological risks and predictive factors for neurological complications in a prospective, multicenter international study (ScolioRisk-1).

Introduction: We sought to define the neurological risks and predictive factors for neurological complications.

Methods: 45 surgeons from 15 investigational sites enrolled 274 patients. Data collection including an ASIA examination, ODI, VAS for pain, SF-36v2, and SRS-22R. Follow-up was performed at hospital discharge, 6 weeks, 6 months and 24 months. Corrective surgeries were performed per standard-of-care of the treating surgeon and institution. AE's were collected prospectively and adjudicated by an independent Clinical Events Committee. Subjects were classified into neurological success or failure based on the (i) decline in ASIA motor score at 12 weeks compared to the pre-operative status or (ii) occurrence of a neurological adverse event as adjudicated by the CEC. Univariate tests were performed to assess differences. Predictors included demographic information, comorbidities, history of prior surgery, surgical approach, pre-operative values of ODI, SF-36, Pain Score, ASIA score, staged surgical approach, blood loss and duration of surgery. Variables that had a p-value of $< .1$ in the univariate analysis were included in the multivariate logistic model.

Results: 88 (32%) subjects were classified as having sustained neurological complications. In the univariate analysis, only 2 variables emerged: the duration of surgery and extent of blood loss. In the multivariate logistic regression, the best fit was achieved with the model that included the surgery duration ($P = 0.0324$), blood loss ($P = 0.0282$) and the interaction of these terms ($P = 0.0169$).

Conclusion: Analysis suggests that the risk of neurological events in complex deformity surgery is associated with duration of surgery and blood loss. Further analysis will be conducted to investigate if these two parameters are intermediary or causative risk factors.

*80. Efficacy and Safety of Prophylactic Large Dose of Tranexamic Acid in Adolescent with Idiopathic Scoliosis Surgery: A Prospective, Randomized, Double-Blind, Placebo-Controlled Study

*En Xie, PhD, MD
China*

Summary: This is a double blind randomized placebo controlled study, after obtaining approval of ethics committee in the hospital and informed written

consent, 391 patients were randomized equally into 2 groups (tranexamic acid (TA) and placebo).

Introduction: Blood loss associated with spinal operations is a common potential cause of morbidity and often requires blood transfusion which subject patients to the known risks of blood transfusion including transmission of diseases.

Methods: 391 consecutive patients undergoing adolescent with idiopathic scoliosis Surgery with expected significant blood loss at our Hospital between June 2010 and December 2013 were randomly assigned to 2 groups, TA and placebo. Shortly after the induction of anesthesia, patients received either TA or placebo as a loading dose of 2 g (for teenagers) or 30 mg/kg (for children), followed immediately by continuous infusion of 100 mg/h (for adults) or 1 mg/kg/h (for children) during surgery and for 5 hours after the operation. Outcome measures included total (i.e., intraoperative and postoperative) blood loss, amount of blood transfusion, as well as postoperative hemoglobin, and hematocrite levels. The data were analyzed by means of Statistical Package for the Social Science Version 12.0. The results were presented as mean \pm SD. Independent Student t test was used to compare the 2 groups and differences were considered significant if the P-value was < 0.05 .

Results: There were 201 males and 190 females, ranging in age from 4 to 14 years with a mean of 10 and median of 9 years. Statistical analysis showed no significant differences between the 2 study groups with regard to age, sex, weight, preoperative hemoglobin, and hematocrite levels, type of surgery, as well as operative time. In contrast, patients who received TA had 49% reduction of blood loss ($P < 0.007$) and required 80% less blood transfusion ($P < 0.008$) than patients who received placebo. The hospital stay was shorter in the TA group, but it did not achieve statistical significance. There were no complications related to the use of large doses of TA in this study.

Conclusion: Prophylactic use of large doses of TA provides an effective, safe, and cheap method for reducing blood loss during and after spinal operations. Hence, TA may help in reducing not only transfusion related complications but also operative expenses.

*81. Intraocular Pressure in Lumbar Spine Fusion Patients: A Prospective, Randomized Study

*Sanford E. Emery, MD, MBA; John C. France, MD; Scott D. Daffner, MD; Matthew Ellison, MD; Brian W. Grose, MD; Nina Clovis
USA*

Summary: Perioperative blindness is a rare complication of spine surgery in the prone position. We performed a randomized, prospective study measuring intraocular pressure in adult lumbar fusion patients, comparing groups with a head-neutral position vs. inclination upward 10 degrees. Extending the neck with 10 degrees of inclination resulted in statistically significantly lower intraocular pressure compared to patients in the head-neutral position. This intervention could potentially mitigate the risk of perioperative blindness in posterior spine surgery.

Introduction: Ischemic optic neuropathy (ION) resulting in visual loss is a rare but devastating complication in spine surgery. Procedure time, blood loss, prone position and systemic factors may contribute to the risk of perioperative blindness. Elevated intraocular pressure (IOP) results in decreased perfusion and

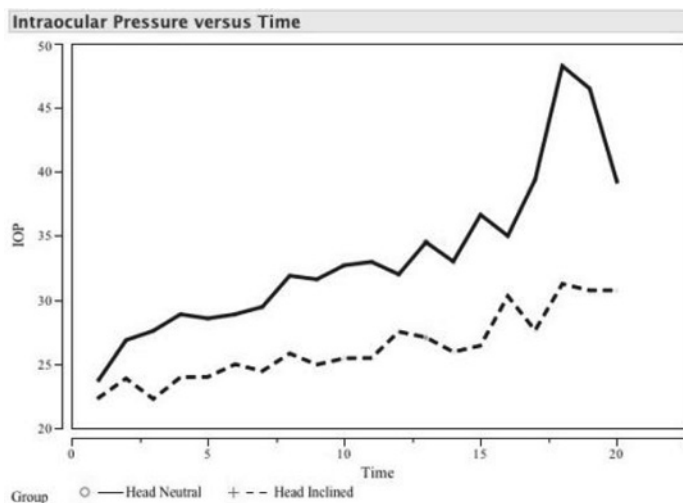
PODIUM PRESENTATION ABSTRACTS

possibly ION. We evaluated the effect of head positioning on IOP in lumbar spine fusion patients.

Methods: Surgeries were performed on 51 patients at one institution. Inclusion criteria were lumbar spine fusion in patients 18-80 years old. Exclusion criteria included eye disease or injury, history of cervical stenosis, neck pain or current neoplasm. The control group had the head in neutral position with the face parallel to the floor; the experimental group had neck extension so the face had an angle of inclination of 10° with the floor. All patients were managed with tongs and ten pounds of traction on a table. Using an applanation tonometer, one author made all IOP measurements in pre-op holding, supine after anesthetic induction, prone after positioning on the table and at regular intervals throughout the case. IOP measurements were recorded with respective time points and corresponding blood pressure and CO2 values. Independent variables included age, duration of procedure, blood loss, type/amount of fluid replacement, blood pressure, PCO2, gender and head position.

Results: Data were analyzed using ANOVA. Mean values for IOP measurements in the prone position were statistically significantly lower in the 10° elevated group versus the head-neutral group ($P < 0.0014$). No patient sustained visual loss or any cervical spine related complications.

Conclusion: Ten degree elevation of the head in the prone position for adult lumbar spine fusion patients resulted in statistically significantly lower IOP measurements compared to controls. As lower IOP correlates with improved intraocular perfusion, this positioning intervention could mitigate the risk of perioperative blindness in spine surgery patients in the prone position.



82. Outcomes of Operative and Non-Operative Treatment for Adult Spinal Deformity (ASD): A Prospective, Multicenter Matched and Unmatched Cohort Assessment with Minimum Two-Year Follow Up

Justin S. Smith, MD, PhD; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Richard Hostin, MD; Oheneba Boachie-Adjei, MD; Behrooz A. Akbarinia, MD; Eric Klineberg, MD; Munish C. Gupta, MD; Vedat Deviren, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group
USA

Summary: Adults with spinal deformity typically present with pain and disability. The present study is a large prospective, multicenter analysis of operative (op) and nonoperative (nonop) treatment for adult spinal deformity (ASD). At minimum 2-yr follow-up, both unmatched and matched analyses demonstrated significant improvement in health-related quality of life (HRQL) measures for op patients. In contrast, nonop treatment appears to at best maintain presenting levels of pain and disability.

Introduction: Adults with spinal deformity typically present with pain and disability.

Our objective was to compare outcomes for op and nonop treatment for ASD based on a prospective, multi-center patient population.

Methods: This is a multicenter, prospective analysis of consecutive ASD patients electing for op or nonop care at enrollment. Inclusion criteria: age > 18 yr and ASD. Propensity scores were used to match op and nonop patients based on baseline (BL) ODI, SRS22, maximum thoracolumbar/lumbar Cobb angle, pelvic incidence to lumbar lordosis mismatch (PI-LL), and leg pain numeric rating scale (NRS) score.

Results: 689 patients met criteria, including 286 op and 403 nonop, with mean ages of 53 and 55 yrs, minimum 2-yr follow-up rates of 86% and 55%, and mean follow-up of 24.7 and 24.8 months, respectively. At BL, compared with nonop, op patients had significantly worse HRQL based on ODI, SRS22, SF36, and leg and back pain NRS ($p < 0.001$) and had worse deformity based on pelvic tilt, PI-LL, and C7SVA ($p < 0.002$). Before reaching min 2-yr follow-up 38 nonop patients converted to op treatment and were analyzed in the op group. At min 2-yr follow-up all HRQL measures assessed significantly improved for op patients ($p < 0.001$), but none of these measures improved significantly for nonop patients ($p > 0.11$). 97 matched op-nonop pairs were identified based on propensity scores. At last follow-up the 97 matched op patients had significant improvement in all HRQL measures assessed ($p < 0.001$), but the 97 matched nonop patients lacked significant improvement in any of the HRQL measures ($p > 0.20$). Paired op-nonop analysis demonstrated the op patients to have significantly better HRQL scores at follow-up for all measures assessed ($p < 0.001$), except SF36 MCS ($p = 0.058$). Overall minor and major complication rates for op patients were 53% and 40%, respectively.

Conclusion: Op treatment for ASD can provide significant improvement of HRQL measures at min 2-yr follow-up. In contrast, nonop treatment appears to at best maintain presenting levels of pain and disability.

PODIUM PRESENTATION ABSTRACTS

83. Long-Term Outcome and Health Care Utilization following Surgical Treatment of Adult Spine Deformity

Cody E. Bunger; Shailu Sharma, MPT

Denmark

Summary: Adult spine deformity surgery's impact on patients' health outcomes and health-care utilization was investigated. Although over 40% patients reported improved activity-endurance, and emotional-cosmesis levels, overall health-score was poorer in comparison to matched controls. Patients' surgical age and co-morbidity displayed non-significant differences in health-care consumption.

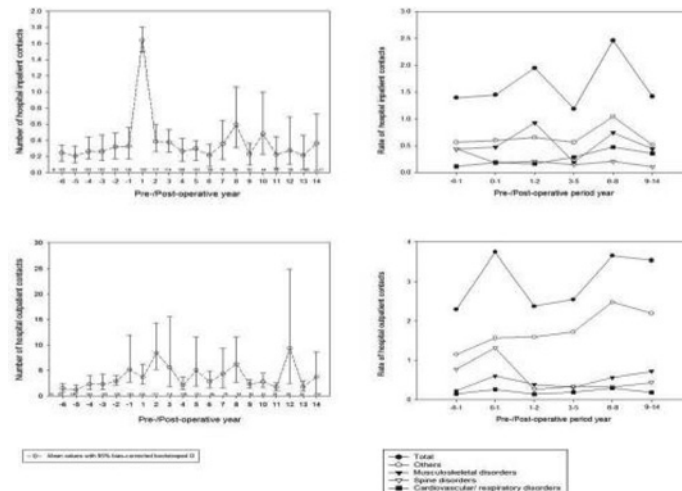
During follow-up, spine-related-utilization decreased and services related to other musculoskeletal disorders constituted major proportion of hospital health-care use. In contrast, primary-sector utilization throughout follow-up rose steadily due to increased visitations to general practitioner and physical therapist

Introduction: The impact of adult spine deformity surgery on patients' health outcomes and postoperative health care utilization is currently indeterminate. Hence assessment of long-term impact of deformity surgery on pain, employment status, self-reported benefits, overall health and consumption of health services was our primary aim.

Methods: 123 patients (mean age 42.4 years, Cobb 64.8o) having undergone spine deformity correction surgery between 1992- 2009 at Aarhus University Hospital were included. At follow-up, patients completed: Life Quality scoliosis Scale, Dallas Pain questionnaire, and EQ-5D. Data on primary and hospital-based health-care use were obtained from National Danish registers. Utilization data were available for six years preoperatively until the end of follow-up in 2011; overall follow-up spanned over 20 years with a postoperative average follow-up of 7.8 years.

Results: Changes in frequency and type of pain medication indicated reduced pain medication consumption at follow-up ($P=0.00$). Long-term employment status was maintained at pre-surgery levels. Improved endurance was reported by 38% of the patients and perceived emotional-cosmetic improvements by 40%-77%. EQ-5D health score was significantly poorer (0.68 vs. 0.83) compared to age-gender matched controls. Spine deformity surgery had its greatest impact on hospital-based health-care utilization for the first two years after surgery. During follow-up, spine-related hospital utilization decreased and services related to musculoskeletal system disorders constituted the major proportion of hospital health-care use. In contrast, primary-sector utilization throughout follow-up rose steadily due to increased visitations to general practitioner and physical therapist. Patients' surgical age and co-morbidity status displayed no significant differences in health care consumption. Poor education levels and being unemployed strongly influenced the extent of health-care consumption.

Conclusion: Adult deformity correction surgery does not lead to an alarming rise in the long-term hospital based health-care use but primary care use increases. Alongside patients experience maintenance of working stature, improvement in activity and pain levels, under low complication rate in all age groups.



Hospital based health care resource utilization prior to and after the spine deformity surgery.

Values are means with 95 % bias-corrected bootstrapped confidence intervals. N along the x-axis indicates number of patients completing the follow-up for that respective year; where (-6-1), indicates preoperative follow-up years, (1) surgical year, and (2-14) the postoperative follow-up years

84. Prevalence of Cancer in Spinal Deformity Patients Receiving High Dose (≥ 40 mg) Bone Morphogenetic Protein (rhBMP-2)

Christine R. Baldus, RN, MHS; Jeffrey L. Gum, MD; Keith H. Bridwell, MD; Azeem Ahmad, BA, BS; Addisu Mesfin, MD; Leah Y. Carreon, MD, MSC
USA

Summary: In a study based from a single institution of 641 adult deformity patients who received greater than 40mg of rhBMP-2 for spinal fusion, regression analysis showed exposure to BMP did not increase the risk of development of new or recurrent SEER cancer even after controlling for known risk factors. Age-adjusted prevalence rates of new post-BMP SEER cancers were not higher than rates reported by NCI.

Introduction: Recent studies have raised concern over the safety of BMP, specifically, its relationship to cancer (CA) risk. The purpose of this study was to determine if there is an increased risk of developing a primary Surveillance, Epidemiology & End Result (SEER) CA or a recurrence/metastasis after exposure to high dose rhBMP-2.

Methods: Adult deformity patients from a single institution receiving a cumulative BMP dose ≥ 40 mg from 7/2002 to 7/2009 were identified. To determine the occurrence of a primary CA or recurrent/metastasis, questionnaires were mailed and telephone follow-up attempted for all non-responders. Of 690 patients identified, 49 patients were excluded (16 refused, 28 non-responders, 5 deceased with unknown CA histories), leaving 641 (93%) available for analysis.

Results: There were 146 males and 495 females with mean age at 1st exposure of 53.4 ± 14.3 . Sixty percent (386) had past smoking history. Mean cumulative BMP dose was $114\text{mg} \pm 76$ with most patients (539, 84%) having 1 exposure (mean 1.2 ± 0.54 , range 1-8). Forty-nine patients (7.6%) had a SEER CA prior to BMP exposure, 34 (5%) had a SEER CA after exposure and 6 (1%)

PODIUM PRESENTATION ABSTRACTS

had a recurrence/metastasis. Patients were classified by cumulative BMP dose: Medium (40-89mg, n=327) or High (≥ 90 mg, n=314). Cancer rate was higher in the medium vs high dose, but this was not statistically significant (Medium dose: 23/327, 7% vs High dose: 11/314, 4%; $p=0.053$). Recurrence/metastasis was the same in both groups (3 each group, $p=1.000$).

Binary logistic analysis showed cumulative BMP dose ($p=0.13$, OR=1.00, CI: 0.30-1.37) and number of exposures ($p=0.17$, OR=1.49, CI: 0.86-2.68) did not increase the risk of developing a new SEER CA even after controlling for risk factors known to affect development of SEER CA (age, gender, race, smoking status, CA history, region of residence). Prevalence rate in our patient population (5.3%) was less than expected based on SEER crude age-adjusted prevalence rates (7.1%). The gender-adjusted NCI/SEER rate for patients 50-59 years is 4.24%.

Conclusion: Exposure to high dose rhBMP-2 did not increase the risk of development of a new or recurrent SEER CA. Prevalence of new post-BMP SEER CA was not higher than reported by NCI.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

85. Revision Surgery in Adult Spinal Deformity Patients Achieves Similar Improvement in HRQOL Compared to Primary Surgery: Prospective, Multicenter Analysis

Lukas P. Zebala, MD; Floreana A. Naef; Haruki Funao, MD; Virginie Lafage, PhD; Eric Klineberg, MD; Michael P. Kelly, MD; Munish C. Gupta, MD; Han Jo Kim, MD; Gregory M. Mundis, MD; Shay Bess, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Christopher P. Ames, MD; Khaled Kebaish, MD; International Spine Study Group
USA

Summary: A large, prospective multicenter database review demonstrated that adult spinal deformity patients undergoing primary surgery have larger coronal deformity while revision surgery patients have more sagittal deformity. Baseline HRQoLs indicate both groups have significant pain and disability and surgery resulted in significant improvement at 2-year follow-up. Radiographic improvement was significant in both primary and revision patients. Revision patients should be counseled that they are at higher risk of major complications compared to patients without prior surgery.

Introduction: Patient reported outcome, radiographic correction and complications are hypothesized to be influenced by primary (PS) or revision (RS) surgery for adult spinal deformity (ASD).

This study assessed 2-year multicenter HRQoL, radiographic outcomes and complications of PS versus RS.

Methods: A prospective, multicenter database was retrospectively reviewed to identify patients with ASD (scoliosis $>20^\circ$, SVA >5 cm, PT $>25^\circ$, thoracic kyphosis $>60^\circ$) at minimum 2-year follow-up. Patients were stratified as PS (no surgery) or RS (prior PSF/1). Demographic, surgical, radiographic and HRQoL data were analyzed. Complications were classified as major/minor. Continuous variables were assessed by t-test and categorical variables by chi-square.

Results: 238 consecutive patients (137 PS, 101 RS) were included. RS were older (59 vs 52 yrs, $p<0.001$), more overweight (BMI, 29 vs. 26, $p=0.003$) and with more comorbidity (Charlson Index, 1.7 vs 1.1, $p<0.01$). PS had more preop scoliosis (T 49 vs 33°, TL 39 vs 32°, L 13 vs 9°, $p<0.01$) and both groups improved at 2-year f/u (T 19 vs 23°, TL 18 vs 18°, L 5 vs 6°, $P<0.01$). RS had more preop sagittal deformity (LL 33 vs 48°, SVA, 89 vs 29 mm, PI-LL, 24 vs 6, PT 28 vs 19°, $p<0.001$) with significant 2 year change (LL 50 vs 53°, SVA 40 vs 22 mm, PI-LL 7 vs 1, PT 23 vs 19°, $p<0.001$). RS averaged 1.0 prior surgery. PS had more # PSF levels (10 vs 9, $p=0.03$) and Ponte osteotomy (58% vs 45% pts, $p=0.04$), but less 3 column osteotomy (6% vs 38% pts, $p<0.001$). 90 RS (89%) and 77 PS (56%) were fused to sacrum ($p<0.001$). Interbody fusion was similar (59% PS vs 63% RS pts, $p=0.5$). RS had more preop disability and similar 2-year improvement.

Major complication rate was 49.5% in RS (78 complications) and 31.4% in PS (57 complications, $p=0.01$). Minor complication rate was similar (49.5% PS vs 43.6% RS, $p=0.4$). 30 PS (22%) and 30 RS (30%) had additional surgery within 2-years ($p=0.17$).

Conclusion: The largest prospective, multicenter study to date demonstrated that PS had larger coronal and RS larger sagittal preop deformity with significant 2-year improvements. PS and RS had significant preop pain and disability and both achieved similar 2-year HRQoL improvement. Surgeons can expect more major complications in RS.

86. Patients with Instrumented Fusions to the Ilium Report Greater Impairment of Perineal Care with Construct Extension to the Upper Thoracic versus Extension to the Thoracolumbar Junction with Two-Year Follow Up

Daniel M. Sciubba, MD; Justin K. Scheer, BS; Justin S. Smith, MD, PhD; Virginie Lafage, PhD; Eric Klineberg, MD; Munish C. Gupta, MD; Gregory M. Mundis, MD; Themistocles S. Protopsaltis, MD; Han Jo Kim, MD; Tyler Koski, MD; D. K. Hamilton, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Robert A. Hart, MD; Christopher P. Ames, MD; International Spine Study Group
USA

Summary: Instrumented arthrodesis for adult spinal deformity (ASD) results in increased spinal stiffness that may negatively impact postoperative perineal care. A retrospective review of a multicenter prospective ASD database was conducted with patients grouped based on upper most instrumented vertebra (UT:T1-6) and TL:T9-L1). There was no statistically significant difference in overall lumbar spinal disability index for UT and TL, but UT reported a statistically higher rate of impairment in performing personal hygiene functions after toileting than TL.

Introduction: Instrumented arthrodesis for adult spinal deformity (ASD) results in increased spinal stiffness. This may negatively impact activities of daily living such as postoperative perineal care. The objective was to evaluate perineal impairment in patients with proximal fusion to the upper thoracic spine versus proximal fusion to the thoracolumbar spine.

Methods: A retrospective review of a multicenter prospective ASD database was conducted. Inclusion criteria: age ≥ 18 yr, ASD, fixation to ilium. Cohorts were defined based on upper-most instrumented vertebra (UIV) as UT (T1-6) and TL (T9-L1). Outcome measures included Lumbar Stiffness Disability Index (LSDI), Oswestry Disability Index (ODI), Short Form-36 (SF-36), and Scoliosis Research

PODIUM PRESENTATION ABSTRACTS

Society-22 (SRS22) preoperatively, 1 year, and 2 years postoperatively. **Results:** 134 patients met criteria (UT:64, TL:70), with mean age of 61.2 ± 9.9 yrs. There were no significant differences between UT and TL for age, BMI, or Charlson Comorbidity Index. Both UT and TL had statistically similar HRQOL scores for all outcomes (ODI, PCS, MCS, SRS) at all time points. Both UT and TL had statistically similar radiographic measurements for all measures at all time points ($p > 0.05$ for all) with the exception of 1 and 2yr SVA in which UT had a significantly lower mean SVA than TL (0.6 ± 6.0 cm vs. 2.8 ± 5.2 , $p = 0.0073$, and 1.6 ± 4.9 vs. 3.9 ± 5.6 , $p = 0.0083$, respectively). Both UT and TL had statistically similar LSDI total scores as well as individual scores at all time points with the exception of 2yr LSDI question #4 (hygiene after toileting) in which UT had a significantly higher score of 2.1 ± 0.9 vs. 1.8 ± 1.0 in the TL group ($p = 0.0227$).

Conclusion: Patients undergoing long instrumented fusions to the ilium show durable improvements in HRQOL and radiographic assessments over 2yrs postop regardless of UIV in the UT or TL region. There was no statistically significant difference in overall LSDI for UT and TL, but UT reported a statistically higher rate of impairment in performing personal hygiene functions after toileting than TL.

87. Frequency and Complication Differences in Comorbid Psychiatric Disorders in Adult Spinal Deformity versus Spinal Fusion

Courtney Toombs, BS; Justin C. Paul, MD, PhD; Baron S. Lonner, MD
USA

Summary: Adult spinal deformity patients with psychiatric diagnoses have increased complications, especially those with the most severe psychiatric diagnoses, when compared to adult fusion patients and controlling for case complexity within each group. All patients with psychiatric diagnoses fare worse than non-psychiatric patients. Spinal deformity patients fare worse than other spinal fusion patients overall.

Introduction: Adult spinal fusion (ASF) patients suffer from severe back pain and often depression. Psychiatric comorbidities in the adult spinal deformity (ASD) population are not well understood, despite the apparent psychological effects of poor cosmesis. We hypothesized a high incidence of comorbid psychiatric disorders in ASD negatively impacting perioperative outcomes.

Methods: The Nationwide Inpatient Sample (NIS) databases from 2001-2010 were queried for patients age ≥ 18 with in-hospital stays including a spine arthrodesis. Patients were divided into two groups: adult spinal deformity (diagnosis of scoliosis, excluding neuromuscular & congenital) and all other adult spinal fusion. Subjects were further stratified by presence of a comorbid psychiatric diagnosis. Differences between each surgical group on psychiatric frequency and complications/mortality were calculated using ANOVA and all analysis was adjusted for operative complexity.

Results: 3,366,352 ASD and 219,975 ASF patients were identified. The rate of comorbid psychiatric diagnoses in ASD was significantly higher (23.5%) than in ASF patients (19.4%, $p < 0.001$). Complication rates were higher for ASD compared to ASF; patients without a psychiatric diagnosis in both surgical groups had lower or identical complication rates and less mortality than psychiatric patients, across all disorder categories (Table). Patients with psychotic and suicidal disorders and dementia showed more complications than non-psych

patients; patients with mood, anxiety and alcohol disorders showed fewer. **Conclusion:** Psychiatric comorbidities are more common in the adult spinal deformity population than in adult fusion patients. ASD and ASF patients with the most common psychiatric disorders (mood, anxiety and alcohol abuse) are not at increased risk for complications. Those patients with psychotic and suicidal disorders and dementia are at a significant risk for increased complications and surgeons should be aware of these specific risks.

88. The Influence of Patient, Hospital and Procedural Factors on the Cost and Length of Stay following Adult Spinal Deformity Surgery

Andrew J. Pugely, MD; Christopher T. Martin, MD; Yubo Gao, PhD; Stuart L. Weinstein, MD; Sergio A. Mendoza-Lattes, MD
USA

Summary: In a retrospective review of the National Inpatient Sample, hospital costs and LOS after adult deformity surgery rise with increasing patient comorbidities. Surgeons should be aware of the particularly costly patient, hospital, and procedure characteristics.

Introduction: Adult spinal deformity surgery is associated with high resource utilization. The incremental effect of patient, hospital, and procedural characteristics has not been well defined. Thus the purpose of this study was to examine the influence these individual characteristics have on hospital costs and length of stay (LOS).

Methods: We queried the 2011 National Inpatient Sample (NIS) dataset for patients between 30 and 95 undergoing elective spinal fusion. International Classification of Disease 9th Revision (ICD-9) codes were used to identify cases of adult scoliosis that underwent thoracic and/or lumbar spinal fusions. Pediatric, cervical spine, and non-elective cases were excluded. Using generalized linear models, we estimated the impact of each patient, hospital, and procedures characteristic on hospitalization costs and the length of stay (LOS). Procedural characteristics were identified by ICD-9 codes and treated independently in the models.

Results: In 2011, 36,798 patients underwent spinal arthrodesis for adult spinal deformity in the US. Of these, 15.6% had no comorbidities while 35.2% had three or more. The most common conditions included hypertension (57.9%), renal disease (18.6%), and depression (17.7%). Mean hospital costs were \$52,571 and mean hospital LOS was 4.9 days. With incremental comorbidities, both hospital costs and LOS increased. Both marginal costs and LOS rose with inpatient death (+\$56,586, +4.3 days), patients with AIDS (+\$37,480, +1.2 days), pulmonary-circulatory disorders (+\$12,406, +2.4 days), and electrolyte disturbances (+\$6,542 +1.5 days). Costs and LOS were highest with the following procedures: revision anterior column surgery (+\$30,933, +0.8 days), fusion of 9 or more levels (+\$27,292, +0.7 days), anterior interbody fusion (+\$15,903, +0.8 days), rBMP use (+\$5,392, +0.2 days). Patients treated in the West had the highest costs (+\$23,451, -0.4 days). All p values were < 0.001 .

Conclusion: Hospital costs and LOS after adult deformity surgery rise with increasing patient comorbidities. Surgeons should be aware of the particularly costly patient, hospital, and procedure characteristics, as reimbursements may not adequately cover these costs.

PODIUM PRESENTATION ABSTRACTS

89. Incidence of Radiographic and Implant-Related Complications in Adult Spinal Deformity Surgery, Patient Risk Factors and Impact on HRQOL

Alex Soroceanu, MD, CM, MPH, FRCSC; Douglas C. Burton, MD; Justin S. Smith, MD, PhD; Vedat Deviren, MD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Behrooz A. Akbarnia, MD; Christopher P. Ames, MD; Thomas J. Errico; Shay Bess, MD; Richard Hostin, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group
USA

Summary: This study looks at the incidence of radiographic and implant related complications following adult spinal deformity surgery. Predictors of radiographic and implant related complications included ASA, Schwab SRS curves type D, and Schwab SRS PT modifier ++. These complications occurred in one third of patients and significantly affected HRQOL measures.

Introduction: This study examines the incidence of radiographic and implant-related complications (RIC) in adult spinal deformity (ASD) surgery and their effect on the rate of reoperation. It also identifies risk factors for the development of RIC, and examines their impact on HRQOL.

Methods: A multicenter prospective database of surgical ASD patients was reviewed. Patients with 2-yr follow up were included. HRQOL were measured using the ODI, SF-36, and SRS. Univariate testing was performed as appropriate. Multivariate logistic regression modeling was used to determine independent predictors of RIC. Multivariate repeated measures mixed models were used to examine HRQOL, accounting for confounders.

Results: 245 patients were included. The incidence of RIC was 31.7%. 52.6% of those patients required reoperation. Univariate analysis identified the following potential risk factors for RIC : weight ($p=0.012$), ASA ($p=0.004$), revision setting ($p=0.026$), stopping the fusion in the lower vs the upper thoracic spine ($p=0.005$), Schwab PT modifier ++ ($p=0.034$), PI-LL modifier ++ ($p=0.001$), SVA modifier ++ ($p=0.0001$), higher T1SPI ($p=0.0001$), and higher T1 slope ($p=0.02$). Double curves were associated with lower risk RIC ($p=0.004$). Independent predictors of RIC as identified on multivariate logistic regression included: ASA ($p=0.022$), SVA modifier ++ ($p=0.001$) and double curves ($p=0.014$). RIC and non RIC patients improved over time, as measured on the ODI ($p=0.0001$), SF36 ($p=0.0001$), and SRS ($p=0.0001$). However, the overall improvement was less for RIC patients RIC (SRS $p=0.0025$, ODI $p=0.015$, SF36 $p=0.049$). They also had a lower rate of improvement over time on the SF-36p ($p=0.0001$).

Conclusion: This study identified that a third of patients undergoing ASD surgery experienced a radiographic or implant related complication, and that half of them required a re-operation. These complications significantly affected HRQOL measures. Baseline patient characteristics and parameters of the Schwab classification can be used to identify those patients at greater risk.

90. Radiological Outcomes and Complications of S2 Alar-Iliac Fixation in Adult Patients with Osteoporotic Spine

Meric Enercan; Sinan Kahraman; Bahadır H. Gokcen, MD; Ayhan Mutlu; Erden Erturer; Gagatay Ozturk, MD; Ahmet Alanay; Azmi Hamzaoglu, MD
Turkey

Summary: S2AI pelvic fixation had higher rate of loosening in osteoporotic patients (BMD; T score $< -2,5$). Improved fixation techniques should be considered in osteopenic and osteoporotic patients.

Introduction: S2-alar-iliac (S2AI) screw has been popularized recently as an alternative technique to traditional iliac screw for lumbopelvic fixation. S2AI fixation provides a low profile pelvic fixation, has easier connection with S1 screw and does not require exposure of posterior superior iliac spine and detachment of erector spinal muscles. Recent studies reported rates of 13% for loosening and 6.5% for breakage of S2AI screw in adult deformity surgery. The aim of this study is to evaluate radiologic outcomes and complications of S2AI fixation in patients with osteoporotic spine undergoing long fusion to the sacrum.

Methods: 46 pts (38F,8M) with preop BMD T score under $-2,5$ and who underwent a long fusion (more than 5 levels) to the sacrum with S2AI technique were reviewed retrospectively. Cement augmented fenestrated pedicle fixation technique (except S1 and S2AI screws) was performed to augment posterior fixation in all patients. Preop, postop, f/up standing AP/L, pelvis AP and 3D CT scan were reviewed for radiological data.

Results: Mean age was 63.6 years (58-84), mean f/up was 28.8 months (24-49). Av instrumented level was 9.6 (5-16 levels). In addition to lumbopelvic fixation, interbody fusion for L5-S1 level was performed in 84.7% of the patients. Lumbosacral fusion was achieved in 93.4% of patients. Revision surgery was performed in 4 patients (8%); for pseudoarthrosis at L5-S1 level in 3 and rod breakage at the level of osteotomy in 1. Among 92 S2AI screws, 31 screws (33,6%) had more than 2mm loosening. 3D CT analysis of S2AI screws showed circumferential loosening at sacral-alar portion of screw in 22, both alar and ilium portion in 7, and only around iliac portion in 2 screws. There was no S2AI screw breakage at the final f/up.

Conclusion: S2AI pelvic fixation had higher rate of loosening (33.6%) in severely osteoporotic patients than previously reported studies. Although S2AI screw loosening rate was high, lumbosacral fusion was achieved in majority (93.7%) of the patients. This is believed to be related with the addition of L5-S1 interbody fusions to lumbopelvic fixation. S2AI screws may not provide enough primary stability in osteopenic and osteoporotic patients. Improved fixation techniques should be considered in this group of patients.

91. Unanticipated Revision Surgery in Adult Spinal Deformity: An Experience with 815 Cases

Feng Zhu; Bao Hong-da, PhD; Xu Sun, MD, PhD; Zhen Liu; Zhu Ze-Zhang; Qiao Jun; Yong Qiu
China

Summary: The current study aimed to review the overall prevalence and indications of revision surgeries after index spine fusion performed to treat adult scoliosis in one single institution.

PODIUM PRESENTATION ABSTRACTS

Introduction: Spine fusion is considered as the final therapeutic intervention in the management of adult scoliosis. In a recent publication in 2010, reoperations after index spine fusion for adult scoliosis were performed in 9% of the patients in a single institution (n = 643).

Methods: The scoliosis database of our center was searched and all of the cases with index spinal fusion surgeries performed for adult scoliosis from 1998 to 2011 were identified. The clinical data and radiographs of patients were reviewed to provide information on the indication of initial operation and any subsequent reoperation. A total of 815 patients were identified, with a mean age of 30.49 years (20 years to 76 years). The mean follow-up periods were 6.4 years (2 years to 15 years) for the entire cohort and 7.6 years (2.5 years to 12 years) for the subset of the cohort requiring revision.

Results: Among the 815 patients, 62 (7.61%) underwent at least one revision surgery. The most common reasons for revision were implant breakage (23/62 = 37.1%), deformity progression (10/62 = 16.1%), and infection (9/62 = 14.5%). The other indications were pseudarthrosis (8), implant dislodgement (6), junctional kyphosis (5), and neurological deficit (1). Revision rate was significantly higher in patients aged more than 40 years (15.23% vs. 5.87%), in patients with degenerative or congenital scoliosis (15.12% and 12.82%) or in patients with hybrid constructs (12.12% vs. 5.82%).

Conclusion: In this largest single-institution series, revision surgery after the index spinal fusion in patients with adult scoliosis was required for a relatively low proportion of surgical cases (7.61%). The main indications for revision were implant breakage, deformity progression and infection.

92. Dynamic Sagittal Balance Evaluated by Three-Dimensional Gait Analysis in Patients with Degenerative Lumbar Kyphosis

Yo Shiba, MD; Hiroshi Taneichi, MD; Satoshi Inami; Makoto Ohe, MD; Hiroshi Moridaira; Daisaku Takeuchi; Yutaka Nohara, MD
Japan

Summary: Twenty-six patients with degenerative lumbar kyphoscoliosis (DLKS) underwent gait analysis using 3-dimensional motion analysis system (3D-MAS). Dynamic sagittal vertical axis (D-SVA) was significantly greater than static SVA not only at the end of walking but the beginning of walking ($p=0.06, p<0.001$). Dynamic trunk angle (D-TA) was significantly larger than static TA as well ($p<0.001, p<0.001$).

Gait analysis using 3D-MAS gave us to useful information about real dynamic balance that cannot be detected by SVA

Introduction: To analyze dynamic sagittal global balance (SGB) in patients with degenerative lumbar kyphoscoliosis (DLKS) and to reveal difference between static and dynamic SGB.

Methods: Twenty-six patients with DLKS underwent gait analysis using 3-dimensional motion analysis system (3D-MAS). Two reflection markers were attached to the skin surface on C7 and S1 spinous processes in all patients. Then they walked on treadmill at self-selected walking speed, and 3-dimensional location of these surface markers (C7-S1) were recorded by synchronized 4 cameras that were placed separately. The angles between vertical axis and the line C7-S1 (dynamic-trunk angle: D-TA) and horizontally projected distance of the line C7-S1 (dynamic sagittal vertical axis: D-SVA) were continuously recorded

during walking. D-TA and D-SVA were compared to static trunk angle (S-TA) and static SVA (S-SVA) that were obtained regular standing full-length lateral X-ray.

Results: The patients ceased their walking on the treadmill at 4.0 minutes on the average due to back pain or severe spinal fatigue. A mean D-TA was 27.4 degrees at the beginning of walking and 30.1 degrees at the end of walking. Whereas, D-SVA was 16.3 cm at the beginning of walking and 22.1 cm at the end of walking on the average. A mean change of D-TA and D-SVA between the beginning and the end of walking were 5.8 degrees and 4.7 cm, respectively. On the other hand, an average S-TA and S-SVA were 17.6 degrees and 12.8 cm, respectively. D-SVA was significantly greater than S-SVA not only at the end of walking but the beginning of walking ($p=0.06, p<0.001$). D-TA was significantly larger than S-TA as well ($p<0.001, p<0.001$).

Conclusion: In this study, we revealed that dynamic SGB during walking was significantly worse than static SGB in the patients with DLKS. Compensated static SGB at standing was no longer maintained after start of walking because compensatory mechanisms such as retroversion of the pelvis did not work. Gait analysis using 3D-MAS gave us to useful about real dynamic balance that cannot be detected SVA.

93. Do Adult Deformity Revisions Vary by UIV Location? Two- to Ten-Year Follow Up

Prokopis Annis, MD; Brandon Lawrence, MD; William R. Spiker, MD; Michael D. Daubs, MD; Darrel S. Brodke, MD
USA

Summary: Revision rates for adult deformity surgery were assessed by location of the upper-instrumented vertebrae (UIV). Patients with the UIV in the upper thoracic spine (UT) had similar rates of revision as those within the thoracolumbar (TL) spine. UT revisions were due to pseudarthrosis while TL revisions were due to proximal junctional failure.

Introduction: Complication rates are relatively high in adult deformity surgery. While pseudarthrosis is widely thought to be the most common complication leading to revision surgery, proximal junctional failure (PJF) may rival or exceed pseudarthrosis as a reason for revision. The rate of PJF appears to vary based on the level of the upper-instrumented vertebrae (UIV), whereas pseudarthrosis rate seems to depend on the number of levels fused. The purpose of this study was to review and compare revision rates of fusions with the UIV in the UT or TL spine.

Methods: Retrospective review of 216 consecutive patients with minimum 2-year follow-up after adult deformity surgery at a single institution. Patients were divided into 2 cohorts, those with fusion to the UT spine (T1-T5) and TL spine (T8-L2). Revision rates were calculated at 24 months and at final follow-up.

Results: 216 patients with mean age 61 years (18-86) and mean follow-up 43 months (24-126) were reviewed. 72 patients had the UIV in the UT spine, and 144 patients in the TL spine. The early (<2 year) and overall revision rates for the entire cohort were 26% and 34%. Early revision for pseudarthrosis was more common in the UT than TL group (21% vs 5%) ($p=0.0005$), while early revision for PJF was more common in the TL spine (15% vs 3% rate) ($p=0.0087$). There were no differences in overall revision rate for the UT and TL patients at 2-year and final follow up.

PODIUM PRESENTATION ABSTRACTS

Conclusion: The complication profile varied based on the location of the UIV with similar early and overall revision rates. While revision for PJF was significantly lower in those fused to the UT spine versus the TL spine, the nonunion rate requiring revision was significantly higher in patients fused to the UT spine, negating the perceived benefit of the longer fusion.

94. Recurrence Proximal Junctional Kyphosis following Adult Spinal Deformity Surgery: Incidence and Risk Factors

Haruki Funao, MD; Floreana A. Naef; Jaysson T. Brooks, MD; Richard L. Skolasky, ScD; Khaled Kebaish, MD

USA

Summary: Clinical results and functional outcome of revision surgery for proximal junctional kyphosis (PJK) was reviewed. The incidence of recurrent PJK (rePJK) was 12/39=30.1%. Statistically significant risk factors for rePJK were: large initial segmental kyphotic angle and pre thoracic kyphosis (TK), high pre SVA, and a greater correction of TK and SVA. Although clinical outcome was significantly improved in both rePJK and non-rePJK groups, there was no significant improvement in SRS self-image in rePJK and sagittally imbalanced patients.

Introduction: The outcome of revision surgery for proximal junctional kyphosis is still unclear. The purpose of the present study is to assess the radiographic and clinical outcome of revision surgery for symptomatic PJK, and to elucidate the incidence and risk factors for additional recurrence of PJK (rePJK).

Methods: A retrospective review from a prospectively collected database was performed. We included all patients who had revision surgeries for symptomatic PJK with a minimum 2-year follow-up. Radiographic/clinical assessment was conducted. Statistical analyses were performed using Student t test and χ^2 test. Significance was set at $p < 0.05$.

Results: A total of 39 patients met inclusion criteria. Mean age was 63 years (22-80). 24 were females, mean BMI was 29.9. 32 three column osteotomies were performed in 30 patients (PSO 24, VCR 8), and multiple Ponte osteotomies in 9. The incidence of rePJK was 12/39 patients (30.1%), eight of those (66.7%) were identified within 8 weeks from the index surgery. There were no significant differences in age, operative time, EBL, hospital stay, number of fused levels, and follow-up periods between the two groups. There were significant differences in (non-rePJK/rePJK) : initial segmental kyphotic angle ($26.6/35.6^\circ$), pre thoracic kyphosis (TK) ($38.6/52.8^\circ$), pre TK+ lumbar lordosis (LL) + pelvic incidence (PI), ($59.8/78.9^\circ$), and pre SVA ($9.3/15.9$ cm). Statistically significant risk factors for rePJK were: initial segmental kyphotic angle ($>40^\circ$), pre TK ($>60^\circ$), pre TK+LL+PI ($>60^\circ$), pre SVA (>10.0 cm), and the correction of TK ($>15^\circ$) and SVA (>5.0 cm). Most of SRS22 domains and ODI were significantly improved in both groups (Table). However, there was no significant improvement in SRS self-image in rePJK and sagittally imbalanced (SVA >5.0 cm) patients at final follow-up. Seven patients required revision surgery; rePJK (3), screw pull out (1), pseudoarthrosis(2), residual coronal imbalance (1).

Conclusion: The incidence of recurrent PJK was 30.1%. Large initial segmental kyphotic angle, preoperative thoracic kyphosis and sagittal imbalance & greater correction of thoracic kyphosis & SVA were considered risk factors for recurrence.

95. Chain of Compensation Related to PI-LL Mismatch: A Complete Standing Axis Investigation Including Lower Extremities

Virginie Lafage, PhD; Emmanuelle Ferrero; Renaud Lafage, MS; Vincent Challier, MD; Barthelemy Liabaud, MD; Bassel G. Diebo, MD; Shian Liu, BS; Jean-Marc Vital; Keyvan Mazda; Themistocles S. Protopsaltis, MD; Thomas J. Errico; Frank J. Schwab, MD

USA

Summary: Spino-pelvic mechanisms of compensation involve modified sagittal spinal curvatures, retroversion of the pelvis in addition to knee flexion and pelvic shift. However, lower limb mechanisms of compensation remain poorly described. 161 patients with sagittal spinal deformity (SSD) received full body stereoradiographs and were analyzed for compensatory mechanisms. Preliminary data suggests there is a transfer of compensation towards the lower limbs; as PI-LL increases and pelvic retroversion is maximized.

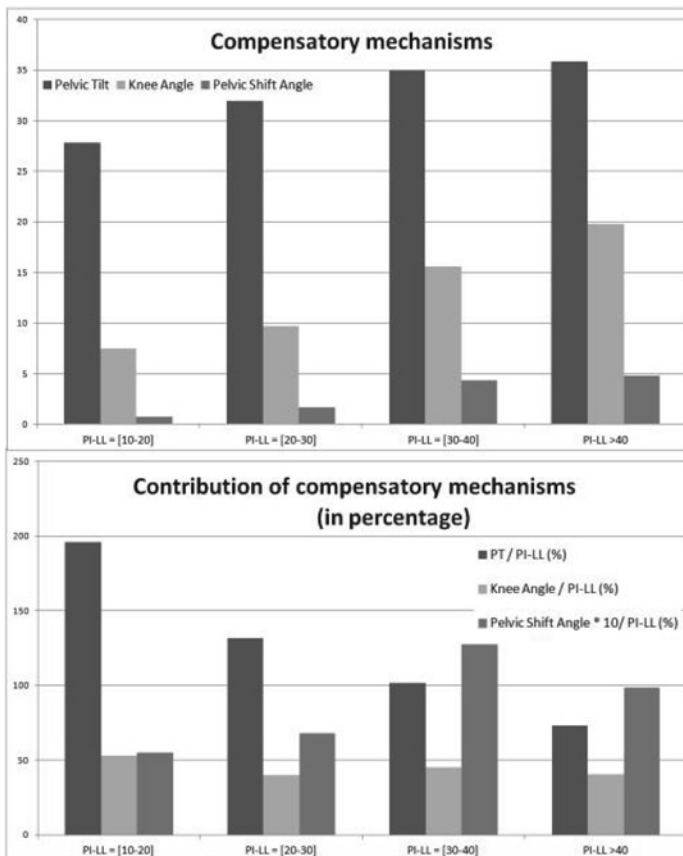
Introduction: SSD patients recruit compensatory mechanisms to maintain erect posture and align the head over the pelvis. Spino-pelvic mechanisms of compensation involving retroversion of the pelvis have been described. Additionally, knee flexion and pelvic shift have been proposed as limbs mechanisms, but how and when these mechanisms contribute is poorly understood. We propose in this study to determine the percentage of each compensatory response based on global spinal deformity.

Methods: This is a retrospective review of adult Spinal Sagittal Deformity patients (SSD) who underwent stereoradiography between 2012-2013. Radiographic measurements were performed with validated software. Patients with a PI greater than LL were categorized based on their mismatch and compared in terms of compensatory mechanisms normalized to each patient's PI-LL: PT, Knee flexion and pelvic shift angle (the angle between the lines formed from the posterior-superior corner of S1 to the anterior distal cortex of the tibia and the vertical).

Results: 161 Patients were included with a mean age of 62.93 ± 12.8 yrs, BMI 27, and 80.6% females. At baseline, SVA 62.3 ± 61.5 mm, PT $29.2 \pm 8.4^\circ$, PI-LL $21.0 \pm 14.9^\circ$. Patients were categorized based on their PI-LL in 4 groups of PI-LL mismatch of 10° (Fig). There were significant differences between the groups in PT, knee flexion, and pelvic shift angle by ANOVA ($p < 0.000$). Specifically, the cohort with a PI-LL 10-20 had a significantly higher PT with respect to malalignment, and lower knee angle compared to the cohort with a PI-LL $>40^\circ$ ($p < 0.000$) (Fig).

Conclusion: In less severe mismatch with a PI-LL <10 , PT is the main contributor of compensation. Gradually with increasing mismatch between PI and LL, pelvic version becomes exhausted, at which point there appears to be a steady transfer of compensation towards the lower limbs; this is evident with the increase in knee angle and decrease in pelvic shift contribution, which is perhaps, linked. Consequently, as the PI-LL mismatch increases and pelvic retroversion is maximized, there is a significant trend toward lower limb participation in compensation.

PODIUM PRESENTATION ABSTRACTS



96. Decreasing Long Construct Pedicle Screw Reduction and Residual Forces using a Computer-Assisted Rod Bending System

Antoine G. Tohmeh, MD; Robert E. Isaacs, MD; Zachary A. Dooley, MS; Alexander W. Turner, PhD; Gregory M. Mundis, MD
USA

Summary: A computer-assisted rod bending system demonstrated significant reductions in peak and residual screw forces in a multi-level simulated pedicle screw construct compared with a manually bent rod. The manual rod screws had more peak loads above reported pullout values. By matching the rod shape to the screw locations, the screw loads are minimized, decreasing potential for screw pullout or loosening.

Introduction: Previous biomechanical studies have shown reduction loads on pedicle screws during assembly of the construct with a rod that inadequately fits the screw locations can reduce the strength of the screw-bone interface. In this study, axial pedicle screw forces on a unilateral 7-level construct were evaluated for 2 rod bending techniques: manual and computer-assisted (Bendini).

Methods: A custom test fixture was created with 8 unilateral pedicle screws based on clinical screw positions. The most caudal screw was fixed while the remaining 7 screws were translated in the A-P direction; each attached to a cantilever spring. Axial force was measured on all 8 screws via load cells. Six surgeons first manually bent a rod using a French bender, inserted the rod, reduced as needed, and locked the rod in place while force data was acquired from each screw. The rod was removed and repeated with the Bendini system.

Each screw location was digitized using an IR camera and a stylus. The rod was then bent using a proprietary rod-bender per computer-generated bend instructions (distance, rotation, bend angle). The rod was inserted, reduced, and locked in place while force data was recorded. The max tensile and compressive forces during screw reduction/lock down, and residual force (absolute value of compressive/tensile force at end of test) for each screw were compared between rod bending methods with a paired t-test.

Results: The residual force was 56% lower ($p = 0.004$) for the computer-assisted rod (95 N) versus the manually bent rod (217 N). The average maximum tensile force was 44% less for the Bendini rod (Bendini: 278 N, manual: 495 N; $p = 0.009$) and the max compressive force was 50% less (Bendini: 210 N, manual: 423 N; $p = 0.004$). The total proportion of screws with load peaks exceeding 500 N was 15% for the manual rod and 0% for Bendini, while loads greater than 300 N were over 6 times more likely (38% vs 6%) with manual rod bending.

Conclusion: The computer-assisted rod bending system decreased axial pedicle screw loads during rod reduction and lock down by creating a better conforming rod than one bent manually. Since forces as low as 300 N can result in screw pullout, the imprecision of manual rod bending can have significant clinical implications.

97. Surgical Approach and its Effect on PFT in AIS Patients: Approach May Not Matter

Daniel J. Sucato, MD, MS; Anna M. McClung, BSN, RN
USA

Summary: Pulmonary function tests on 112 AIS patients were worse with greater preoperative spinal deformity. PFT's improved following surgical treatment for all approaches and the primary determinant of improvement was the improvement in the main thoracic curve correction for all groups.

Introduction: Surgical approach for AIS with a main thoracic curve (MTC) can include posterior only, posterior with an anterior release (open or thoracoscopic) and may include thoracoplasty or may be an anterior approach alone. The objective of this study is to determine the effect of surgical approach on pulmonary function tests (PFTs) for AIS.

Methods: This is a retrospective review of a prospective database specific to pulmonary outcomes in operative AIS patients treated from 2000 to 2009 at a single pediatric orthopedic institution. Perioperative, clinical and radiographic data were examined in all patients with a structural MTC and 2 years of postoperative follow-up. Patients were grouped based on surgical approach: Open Anterior release with PSF: OAR/PSF, Thoracoscopic Anterior release with PSF: TAR/PSF, TAR/PSF with a thoracoplasty: TAR/PSF+TP, Thoracoscopic Anterior fusion: TAF, Posterior fusion: PSF, and PSF with a thoracoplasty: PSF+TP.

Results: Preoperative PFTs were obtained in 112 patients. Patients undergoing an anterior release were significantly younger than those treated with a PSF alone (Table 1). Preoperative % predicted for both FVC and FEV1 were lower in the patients treated with an anterior release or TAF in comparison to the PSF or PSF+TP cohort and may be attributed to the significantly greater preoperative MTC. The overall correction of the MTC was >50% was the same in all groups (Table 1). At 2 years postoperatively % predicted for FVC and FEV1 in

PODIUM PRESENTATION ABSTRACTS

all patient groups had improved with no differences found between approaches (Table 1). A logistic regression analysis demonstrated an association between PFT % change and preoperative MTC size and % MTC correction for FVC ($p=0.0114$, $p=.0018$) and FEV1 ($p=0.001$, $p=0.0244$). No other factors, including surgical approach, affected % predicted change.

Conclusion: A large thoracic curve negatively impacts preoperative pulmonary function. Improvement in pulmonary function correlates with greater curve correction which was achieved with a combined anterior and posterior approach. An anterior release and/or thoracoplasty does not have an added detrimental effect on a posterior instrumented fusion for AIS.

98. The Effect of Late Isolated Rib Hump Resection on the Evolution of Pulmonary Function

Heiko Koller, MD; Tobias L. Schulte, MD, PhD; Juliane Zenner, MD; Jens A. Schmücker, MD; Luis Ferraris, MD; Axel Hempfing, MD; Marc Dreimann, MD; Oliver Meier, MD; Michael Mayer, PhD

Germany

Summary: Isolated rib hump resection (iRHR), done at a second stage after scoliosis correction is accomplished, is a rare procedure. Analysis of iRHR in 26 patients with 5yrs follow-up demonstrated a significant decline of predicted Forced Vital Capacity (FVC%) by 9%. Pulmonary function (PF) at follow-up correlated with lower clinical outcomes. Results using validated outcome measures for PF (COPD Assessment Test, CAT) stressed that iRHR should be retained for patients with strong need for correction of residual deformity and with mild-to-moderate preoperative pulmonary impairment.

Introduction: An isolated rib hump resection (iRHR) is done after scoliosis correction and fusion has been achieved. iRHR is thought to add a further decline in PF. However, the burden iRHR has on PF is yet to be defined.

Methods: In an 11 yrs period 75 patients with major thoracic curve (TC) had iRHR. Patients with PF tests preop and at last F/U were included. PF value reported was predicted FVC (FVC%). According to the Am. Thoracic Society, classification of pulmonary impairment was into 'no' impairment (FVC: $>80-100\%$), mild (FVC: $>65\leq 80\%$), moderate (FVC: $>50\leq 65$) and severe (FVC: $\leq 50\%$). Outcome was studied using validated measures (SRS-24 Score, COMI, CAT). The CAT (worst:40pt) classifies into mild impairment (<10 pt), moderate (10-20pt), high ($>20-30$ pt) and disabled (>30 pt).

Results: 26 patients full-filled selection criteria, 22 were females. Avg. age was 28yrs (15-54yrs) and BMI was 23 ± 4 . 20 pts had prior chest-cage surgery. 20 pts had AIS, 6 congenital/syndromic scoliosis. Number of ribs resected was 7.2 ± 1 , blood loss was 834 ± 725 ml. Preop FVC% was $66\pm 15\%$ and at F/U $57\pm 14\%$. The avg. FVC%-change preop to F/U was a loss of $9\pm 12\%$ ($p<.02$). 14 patients had a FVC%-change preop to F/U $\geq 5\%$ and this was more likely in pts with lower preop FVC% ($p=.03$). Length of F/U was 61 ± 39 months and had no sig. impact on FVC% or FVC%-change. FVC% at F/U correlated with preop age ($p=.02$), TC ($p=.04$) and vertebral rotation ($p=.02$). Before PSF, the avg. TC was 94° and thoracic kyphosis was 50° . At time of iRHR, TC was 67° and kyphosis was 46° . Rib hump height before iRHR was 34 ± 9 mm and at F/U $15\pm 6^\circ$ ($p<.03$). At F/U, avg. SRS-24 score was 81, COMI was 4pt, and CAT was 8pt. 8 patients had a CAT ≥ 10 pt. Comparison of patients with

pulmonary impairment preop vs F/U showed the following: 4 pts vs 1 pt had no PF impairment, 8 pts vs 4 pts had mild, 10 pts vs 13 pts had moderate, and 4 pts vs 8 pts had severe impairment. Patients with CAT ≥ 10 pt had lower clinical outcomes (COMI: $p=.011$ / SRS-score: $p=.03$).

Conclusion: 5 years after iRHR the FVC% declined on avg. 9%. Although PF shows a modest improvement with F/U length, several patients had long lasting effects following iRHR. It should be reserved for patients with sig. suffering from residual deformity. PFT are mandatory for decision making.

99. Thoracic Volume and Pulmonary Function at a Minimum of 20 Years following Treatment of Adolescent Idiopathic Scoliosis: Preliminary Results

Kristin England, MD; A. Noelle Larson, MD; David W. Polly, MD; Charles Gerald T. Ledonio, MD; Michael J. Yaszemski, MD, PhD

USA

Summary: Advanced 3D modeling techniques allowed for calculation of change in thoracic volume in AIS patients from completion of growth in adolescence to mid-adulthood at a mean 24-year follow-up. On average, patients treated with bracing had smaller adult thoracic volumes (height-normalized) compared to surgically managed patients.

Introduction: Long-term follow-up studies of adolescent scoliosis patients are limited. This preliminary study evaluates a novel cohort of US patients treated with bracing or surgery at a minimum of 20-year follow-up. The change in thoracic volume from the completion of growth to latest follow-up was calculated and compared to current pulmonary function results and curve magnitude.

Methods: Ten patients had biplanar radiographs at skeletal maturity in adolescence (Risser 4 or 5) and returned at a mean of 24 years follow-up. Mean age was 38 years. All patients were noted to have at least a 35 degree idiopathic scoliosis curve pattern diagnosed during adolescence. Childhood treatment included bracing (5) and surgery (4 - CD instrumentation/ 1- Harrington rod). Utilizing Blender software, a model of the spine and thorax was constructed based on PA and lateral plain radiographs at the completion of growth in adolescence and at latest follow-up. The thoracic volume was then computed by meshing the space within the thoracic cavity. Pulmonary function testing and radiographs were performed at latest follow-up.

Results: Excluding one Harrington rod patient with a 50 degree residual curve pattern, thoracic volume at latest follow-up was significantly greater in the surgical cohort compared to the bracing cohort (mean 2674 cc vs. 1713 cc, $p=0.016$). This relationship held even when corrected for standing height. FVC and FEV1 were typically within normal range, but the majority of patients had lower than expected maximal expiratory and inspiratory pressures (Table). Mean thoracic volume did not change significantly from late adolescence to latest follow-up (91 cc in bracing cohort, 55 cc in surgical group).

Conclusion: Thoracic volume modeling provides additional information regarding the pulmonary sequelae of thoracic spine deformity. Larger sample size is needed to correlate thoracic volume with pulmonary function.

PODIUM PRESENTATION ABSTRACTS

100. The Effects of the Three-Dimensional Deformity of Adolescent Idiopathic Scoliosis on Pulmonary Function

Burt Yaszay, MD; Tracey Bastrom, MA; Carrie E. Bartley, MA; Stefan Parent, MD, PhD; Peter O. Newton, MD
USA

Summary: Three-dimensional preoperative deformity measurements (coronal, sagittal, and axial rotation) of 163 AIS patients were obtained and compared to these same patients' preop FEV, FVC, and TLC measurements to determine which deformity measurements predict pulmonary dysfunction. We found that larger thoracic coronal, sagittal, and axial deformities increase the risk of pulmonary impairment in patients with AIS, with decreasing thoracic kyphosis as the most consistent predictor.

Introduction: Utilizing 2D measurements, previous studies have found that in AIS, increased thoracic Cobb and decreased thoracic kyphosis contribute to pulmonary dysfunction. Recent technology has improved our ability to measure and understand the true 3D deformity in AIS. The purpose of this study was to evaluate which 3D radiographic measures predict pulmonary dysfunction.

Methods: One hundred and sixty-three surgically treated AIS patients with preoperative PFTs and imaging were identified at a single center. Each spine was reconstructed in 3D to obtain the true coronal, sagittal, and apical rotational deformities. These were then correlated to the patient's corresponding preop FEV, FVC, and TLC measurements. Regression analysis was performed to determine the relative effect of each radiographic measure.

Results: There were 124 thoracic and 39 lumbar major curves. The range of preop thoracic and lumbar coronal angle was 11-115° and 11-98°, respectively. The range of preop thoracic kyphosis (T5-T12) and thoracic apical vertebral rotation was -56-44° and 0-29°, respectively. Increasing thoracic Cobb and thoracic vertebral rotation and decreasing thoracic kyphosis most significantly correlated with decreasing pulmonary function, especially FEV (Table). In patients with the largest degree of thoracic deformity (Coronal Cobb >80°, thoracic lordosis >20°, and absolute apical rotation > 25°), the majority of patients had moderate to severe pulmonary impairment (≤65% predicted). Regression analysis found thoracic kyphosis to be the most consistent predictor of FEV (r²=0.087), FVC (r²=0.069), and TLC (r²=0.098) impairment.

Conclusion: Larger thoracic coronal, sagittal, and axial deformities increase the risk of pulmonary impairment in patients with AIS. Of these, decreasing thoracic kyphosis is the most consistent predictor. This information can guide surgeons in the decision making process for determining which surgical techniques to utilize and which component of the deformity to focus on. Further analysis is needed to determine the value of improvement in these radiographic measures following surgery on the potential for improved pulmonary function.

Table. Correlation of Radiographic and Pulmonary Measurements.

	% Predicted FEV	% Predicted FVC	% Predicted TLC
T1-T5 Kyphosis	0.026	0.065	-0.002
T5-T12 Kyphosis	0.444	0.298	0.327
T10-L2 Kyphosis	0.173	<i>0.132</i>	<i>0.148</i>
T12-L5 Lordosis	-0.088	-0.086	-0.136
Upper Thoracic curve	-0.224	-0.166	-0.142
Thoracic curve	-0.401	-0.298	-0.212
Lumbar curve	0.015	-0.026	0.032
Thoracic apex rotation (Absolute value)	-0.408	-0.256	-0.175
Lumbar Apex Rotation (Absolute value)	0.233	0.067	0.197

*bold values represent statistical significance, p<0.05.

101. 3D Analysis: The Truth About the "Hypokyphosing Effect of Pedicle Screws" in AIS

Peter O. Newton, MD; Takahito Fujimori, MD, Msc; Josh Doan, MEng; Fredrick G. Reighard, MPH; Diana A. Glaser, PhD; Amirhossein Misaghi, MD
USA

Summary: Thoracic pedicle screws do not lordose the spine per se. The thoracic spine in AIS is segmentally hypokyphotic (if not lordotic) especially at the apex, which can only be measured by a segmental 3D analysis. Posterior instrumentation with thoracic pedicle screws in this series of patients was associated with an average increase in thoracic kyphosis of 16°.

Introduction: The purpose of this study was to evaluate the true 3D changes of thoracic kyphosis in patients with adolescent idiopathic scoliosis (AIS) from preop to postop when thoracic pedicle screw instrumentation was utilized.

Methods: 60 consecutive (Lenke 1 and 2) pre- and postop images of AIS patients treated with segmental thoracic pedicle screw instrumentation were analyzed in the "3D sagittal plane". The technique measured 3D kyphosis or lordosis in the anatomic plane of sagittal motion for each specific spinal motion segment (different for each motion segment due to varied axial rotation). The kyphosis (+) and lordosis (-) values for each of the segments between T5 and T12 were summed to give the "3D T5-T12 kyphosis". These values were compared to the standard 2D T5-T12 kyphosis measured on the lateral radiographs.

Results: The average age of the patients was 14 ± 2 years and the preop Cobb was 46 ± 8°. The preop 3D T5-T12 kyphosis was 7.4 ± 13.8° and the 3D kyphosis significantly increased to 23.3 ± 5.6° postop. The standard 2D T5-T12 kyphosis measured 17.8 ± 15.3° preop and 23.9 ± 5.7° postop. The difference between the 2D and 3D T5-T12 kyphosis measurements strongly correlated with apical vertebral rotation (r = -0.88, p = 0.01); as apical rotation

PODIUM PRESENTATION ABSTRACTS

increases, the “error” of 2D kyphosis increases. Postop, when the apical rotation is small, there is little difference in 2D and 3D kyphosis measures.

Conclusion: Routine 2D measures of thoracic kyphosis erroneously underestimate the preoperative loss of kyphosis in AIS due to errors associated with axial plane rotation inherent in thoracic scoliosis. Derotation of the apically hypokyphotic segments (with pedicle screw inst) back into the anatomic sagittal plane unmasks the “true” sagittal deformity, rather than creates it. Additionally, substantial normalization of kyphosis is possible when this is recognized and addressed. In this series of patients, pedicle screw instrumentation was associated with an average increase in kyphosis of 16°.

102. When Does Proximal Junctional Failure Require Revision? Validation and Utility of the PJF Severity Score

Robert A. Hart, MD; Christopher P. Ames, MD; Jayme R. Hiratzka, MD; D. K. Hamilton, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Michael P. Kelly, MD; Marilyn L. Gates, MD; Mark D. Rahm, MD; Munish C. Gupta, MD; Justin S. Smith, MD, PhD; Richard Hostin, MD; Eric Klineberg, MD; International Spine Study Group

USA

Summary: Proximal Junctional Failure (PJF) is a well known complication following adult spinal deformity surgery. Previous descriptions have been hindered by differing definitions and lack of a validated classification. We demonstrate the validity and clinical utility of a PJF Severity Score through retrospective review of a cohort of patients experiencing PJF. We were able to define a threshold score above which patients were uniformly indicated for revision surgical fusion.

Introduction: Proximal Junctional Failure (PJF) is a potentially catastrophic complication following adult spinal deformity (ASD) surgery. Preliminary validity and reliability of the PJF Severity Score (PJFSS) has been established using clinical scenarios. We sought to further establish its validity and utility in predicting revision surgery for patients experiencing PJF.

Methods: A prospectively collected multi-center database of surgically treated ASD patients was reviewed at 2 year minimum follow-up. Radiographs and clinical course of all patients experiencing PJF were reviewed. PJFSS scores were applied via consensus of 3 independent reviewers by assigning points in 4 categories (Focal VAS, Instrumentation Problem, Change in Kyphosis, UIV/UIV+1 Injury). Neurologic injury was excluded from analysis as it would typically lead to urgent revision surgery. Correlation of PJFSS with performance of revision surgery was assessed and a threshold score above which revision fusion was uniformly performed was sought.

Results: 37 patients with PJF were identified, 6 (16.2%) of whom underwent revision fusion. One patient did not have a focal VAS score recorded before undergoing revision surgery and was excluded. PJFSS scores ranged from 2- 10 (maximum possible 11). Total PJFSS scores correlated strongly with indication for revision surgery ($p=.0057$). All 4 component scores moderately correlated with indication for surgery though only UIV/UIV+1 Injury Severity reached statistical significance ($p = .014$). 3 of 5 (60%) patients undergoing revision surgery due to PJF had PJFSS scores of > 9 or higher; all other patients had scores of 8 or less.

Conclusion: The PJFSS has demonstrated validity and utility in predicting need

for revision surgery among patients experiencing PJF following ASD surgery. All of the component scores demonstrated similar independent correlations. In patients without neurological deficit, all patients reaching a threshold score of 9 or greater underwent revision surgery. Further evaluation of the PJFSS will center on its correlation with clinical outcomes and its perceived value to the community of spinal deformity surgeons.

103. Pelvic Alignment Influences Disc Hydration Properties after AIS Surgery: A Prospective MRI-Based Study

Kariman Abelin-Genevois, MD, MSc; Erik Estivaleres, PhD; Jerome Briot; Pascal Swider, PhD; Jerome Sales de Gauzy, PhD
France

Summary: This prospective study analyzes the volumetric and hydration properties of the intervertebral discs after AIS surgery (45 patients) at a minimum two years follow up. Disc volumes (annulus and nucleus) were extrapolated from 3D MRI reconstruction. Results showed a significant and sustainable improvement in disc hydration properties after AIS surgery up to +33% two years after surgery. These changes were strongly influenced by the spino pelvic organization. Results are discussed according to the extent of fusion.

Introduction: The goal of surgical treatment of idiopathic scoliosis is to restore a straight and balanced spine, to improve the appearance of the trunk and to prevent early lumbar degenerative changes. To determine which factors influence the future of the lumbar segment below spinal fusion, a prospective MRI study was designed. Influence of the spino-pelvic morphology on lumbar disc behavior was investigated in a cohort of 45 surgically treated AIS.

Methods: Total disc and nucleus volumes were extrapolated from MRI (T2-weighted sequence) by 3D reconstruction using custom-made image processing software (Violas et al. Spine 2007). Sagittal parameters were measured pre and postoperatively on full spine standing views (pelvic incidence, sacral slope, lumbar lordosis).

Results: Mean PI was 55° (34° - 80°). After surgery, loss of lordosis was moderate (3°) but significant ($p=0.02$), modifying the lumbo pelvic congruity. In order to evaluate the influence of the pelvic incidence on the behavior of the lumbar spine, patients were categorized either low or high PI.

Total disc volumes remained stable. Two years results showed significant hydration uptake. Results varied according to the pelvic incidence and the fusion extent.

After selective fusion (4 or 5 unfused discs), in low PI subgroup, disc hydration improved except in the two first discs. In 8 patients, 5 years data showed increasing hydration levels up to 33% in all levels.

In high PI subgroup, disc modifications were modest, only concerning the lowest levels.

In long fusions (2 or 3 unfused discs), disc hydration uptake was observed in all levels when PI was low and only in the intermediate disc (L3L4) when PI was high.

Conclusion: This prospective MRI study showed a significant and sustainable improvement in disc hydration properties after AIS surgery. These changes are clearly under the influence of the sagittal spino pelvic organization. Low PI positively influenced the volumetric changes. When PI is high, shear stresses

PODIUM PRESENTATION ABSTRACTS

disturb disc homeostasis in the free-motion segment. Patients with high pelvic incidence may present a higher risk for accelerated disc degenerative changes after extended fusion. Restoration of an adequate spino pelvic balance should be a major concern in AIS surgical planning.

104. Lumbopelvic Posture: Is Pelvic Incidence the Best Indicator For Lordosis?

Roger P. Jackson, MD; Anne McManus, RN
USA

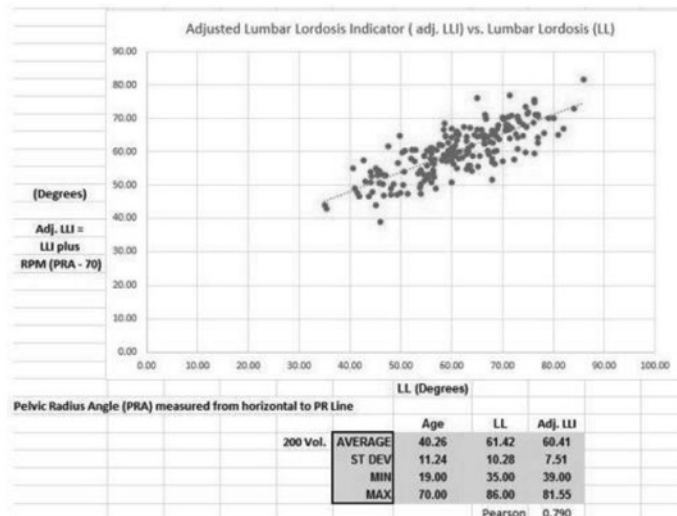
Summary: Retrospective radiographic study of the “match” and “mis-match” between lumbar lordosis (LL) and pelvic incidence (PI), where $PI=S1$ endplate slope (SS) + pelvic tilt (PT); and towards understanding the role that pelvic morphology plays in regulating upright lumbopelvic posture.

Introduction: Interest is growing among researchers, clinicians and surgeons alike in the “match” and “mis-match” between lumbar lordosis (LL) and pelvic incidence (PI), where $PI=S1$ endplate slope (SS) + pelvic tilt (PT); and towards understanding the role that pelvic morphology plays in regulating upright lumbopelvic posture.

Methods: Retrospective study of standing spine films showing both hips in 200 adult volunteers (F: 112 /M: 88, avg. age 40). Measurements were made to compare correlations of LL vs. PI with LL vs. that of: pelvic lordosis (PL) - angle between S1 endplate tangent line and the pelvic radius (PR) line, using the PR technique; lumbar lordosis indicator (LLI) - complementary angle to PL (i.e. $LLI = 90^\circ - PL$); and LLI + a retroverted pelvis modifier (RPM) measured \pm from a “pelvic posture” baseline (i.e. adjusted LLI, see graph).

Results: PI, PL and LLI were correlated with each other ($r = .99$). PI and LL “matched” ($\pm 10^\circ$) in 62% (125/200) of volunteers while LLI “matched” in 70% (141/200). Correlations for LL vs. PI, PL and LLI were all the same ($r = .59$). Combining LLI with RPM (adjusted LLI) improved the LL correlation from good ($r = .59$) to excellent ($r = .79$) and the adjusted LLI “matched” LL ($\pm 10^\circ$) in 90% (181/200) of volunteers. RPM represented the influence of “pelvic posture” on LL ($r = .69$).

Conclusion: LLI was a better “matching indicator” for LL ($\pm 10^\circ$) compared to PI (70% vs. 62%, respectively). LLI + RPM improved the “match” to include 90% of volunteers. Both PI and LLI tended to underestimate LL. This was partially explained by the “pelvic posture”, measured from the RPM baseline. PI was dependent upon registration of the entire S1 endplate. Because PL is constant, the PR technique could measure LL without subsequent reliance on the anterior S1 endplate, which was difficult to see in some cases. The PR technique replaced the sacral endplate and PT lines with the PR line, and allowed lordosis to be measured from the PR line (i.e. lumbopelvic lordosis), as previously published. Factoring in “pelvic posture” over the hips provided a better “match” between pelvic morphology and LL compared to prior reports.



105. Clinical Tolerance to Sagittal Imbalance Varies with Age

Ferran Pellise, MD; Alba Vila-Casademunt; Montse Domingo-Sabat; Juan Bago, MD; Ahmet Alanay; Ibrahim Obeid; Francisco J. S. Pérez-Gruoso, MD; Emre Acaroglu, MD; European Spine Study Group
Spain

Summary: Sagittal spinal alignment and HRQOL both deteriorate with age. This cross-sectional study, including 685 patients with adult spinal deformity (ASD) consecutively enrolled in a European multicentre ASD database, evaluated the influence of age on the clinical repercussions of sagittal imbalance. The adjusted HRQOL scores showed that clinical tolerance to sagittal imbalance and loss of lumbar lordosis appear to vary with age. Severe sagittal imbalance seems to have greater HRQL impact in younger patients.

Introduction: Sagittal spinal alignment and HRQL both vary with age. With normal aging, there is a tendency for worsening HRQL and an anterior shift of the plumb line. Compensatory mechanisms for positive sagittal balance (pelvic retroversion and erector spinae contraction) might also deteriorate with age. Potential age variations in clinical tolerance to sagittal imbalance have never been evaluated.

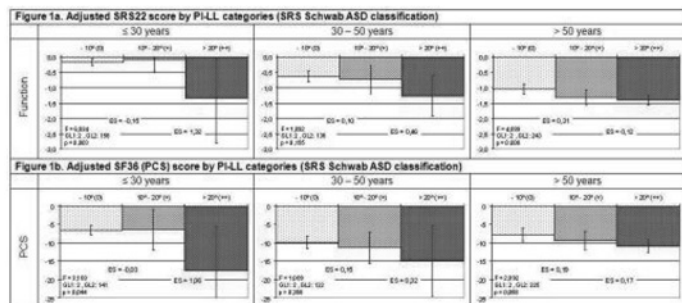
Methods: This was a cross-sectional study of HRQL and radiological data from consecutively enrolled patients in a European multicentre adult spinal deformity (ASD) database. SF36v2 and SRS22 scores were adjusted for age and gender by subtracting norm values. Patients were stratified by age-group (<30, 30-50, >50 y) and sagittal alignment, according to previously defined cut-off points for Lordosis Gap (<5°, >25°), Global Tilt (<20°, >35°) and PI-LL mismatch (<10°, >20°). Mean and 95%CI of HRQL scores were calculated and differences among groups compared using F-ANOVA and Cohen Effect Sizes (ES) (small 0.2 / medium 0.5 / large 0.8).

Results: Data from 685 patients with ASD (561 females), mean age 45.4y (SD19.1), were analyzed. In patients with greater sagittal imbalance (Lordosis Gap>25°; Global Tilt>35° or PI-LL>20°), SF36 Physical Component Summary (PCS) scores were closer to their corresponding age and gender general population norm values with increasing age. In the older age-group, increasing

PODIUM PRESENTATION ABSTRACTS

severity of sagittal imbalance had little influence on HRQL scores; in contrast, in younger patients, severe sagittal imbalance was associated with a marked reduction in HRQL. The ESs for the difference in SRS22 (subtotal and domains) scores between the + and ++ PI-LL categories were greater in the <30y group (range 0.78 to 1.32) than in the >50y group (0.12 to 0.15); similar findings were obtained for the SF36-PCS (ES 1.06 and 0.17, respectively) (Figure).

Conclusion: The age and gender adjusted HRQL scores show that clinical tolerance to sagittal imbalance and loss of lumbar lordosis appear to vary with age. In younger patients, severe sagittal imbalance seems to have greater impact on HRQL; in older patients, HRQL does not differ markedly in relation to the severity of the deformity. This information may be valuable for treatment decision-making in ASD.



106. 18-Year Follow Up of Surgically Treated Scheuermann Patients Deterioration of Results over Time

Harm C. Graat, MD, PhD; Janneke J. Schimmel, MSc; Lotte Van Hessem, MD; Roel J. Hoogendoorn, MD, PhD; Allard J. Hosman, MD, PhD; Marinus De Kleuver, MD, PhD

Netherlands

Summary: This is the largest known series to date of 29 surgically treated Scheuermann patients with 14-21 year follow-up. ODI scores were significantly improved at short term post-operative, but scores returned to preoperative values at the end of follow up. 72% of patients were satisfied, but 69% had implant failure and 53% had proximal junctional kyphosis. Patients operated via an anterior and posterior approach tend to perform better than posterior only operated patients.

Introduction: Long term outcome on quality of life and radiological results of surgically treated Scheuermann patients is unknown. This is a unique cohort with follow-up of 14-21 years with 29 of the original 33 patients included, and previously assessed in 2000 (2-8 yrs post-op).

Methods: After institutional review board approval and informed consent 29 (89%) of an original cohort of 33 Scheuermann patients were included. All were operated between 1991 and 1998 with posterior instrumentation with a second generation hybrid stainless steel implant, of whom 13 via a posterior approach and 16 via a combined 2 stage anterior and posterior approach. Clinical (ODI), radiological (proximal, distal junctional kyphosis (PJK and DJK) and implant failure) and quality of life (EQ-5d) data were retrieved.

Results: Average follow-up was 18 years (14-21), average age at follow-up: 44 years (34-63). Median ODI at end of follow-up was 18 (range 0-62),

which returned to preoperative values; pre-op: 21 (range 0-72) and worse than short term year post-op: 12 (range 0-52) ($p < 0.05$). A significantly larger proportion of patients in the combined anterior/posterior approach group versus the posterior approach only group reached a normal $ODI \leq 22$ score at final follow-up (13 versus 4, $P < 0.006$). At final follow-up median EQ-5d scores were below normal population values, respectively VAS 80 (range 30-100) and utility score 0.78 (range 0.009-1). 72% of the patients were satisfied. DJK did not occur, while PJK was present in 53% of the patients, and instrumentation failure occurred in 69%. No differences in clinical outcome were found in patients with/without PJK or implant failure ($p > 0.05$).

Conclusion: The long term clinical and radiological results of this cohort with 89% follow-up were somewhat disappointing, and clearly worse than the short term results. Despite 72% of patients being "satisfied", the ODI, VAS and EQ5D reflected significant back pain related problems in daily life. High numbers of implant failure and PJK were found, but no correlation was found with the clinical outcome. Patients operated via an anterior and posterior approach tend to perform better than posterior only operated patients. This series clearly highlights the importance of long term follow-up studies.

107. Distal Fusion Level Selection in Scheuermanns Kyphosis: A Comparison of Lordotic Disc Segment versus the Stable Sagittal Vertebrae

Han Jo Kim, MD; Venu M. Nemani, MD, PhD; Kevin R. O'Neill, MD, MS; Brian J. Neuman, MD; Oheneba Boachie-Adjei, MD; Matthew E. Cunningham, MD, PhD; Lawrence G. Lenke, MD

USA

Summary: When selecting fusion levels for fusion in Scheuermann's Kyphosis (SK), the optimal distal level (LIV) historically utilized the lordotic discs after the transitional segment. However, due to the often large kyphosis, patients have compensatory hyperlordosis in the lumbar spine making it difficult to truly determine the lordotic disc levels. We instead utilized the stable sagittal vertebrae (SSV) and saw a significant decrease in distal junctional problems (4% vs. 29%) and sustained alignment at average 3 year follow up.

Introduction: When selecting fusion levels for fusion in Scheuermann's Kyphosis (SK), the optimal distal level (LIV) is not always clear. Historically, lordotic discs after the transitional segment have been used, but due to the large kyphosis and compensatory hyperlordosis in the lumbar spine there is difficulty in truly determining lordotic disc levels. We instead utilized the stable sagittal vertebrae (SSV) to see if there was a difference.

Methods: This is a retrospective review of operative SK cases between 2002-2010. Demographics, fusion levels, disc angles, radiographic parameters and need for revision surgery were collected. Pts were separated into 2 groups based on their LIV. Group 1 patients had a LIV distal to or at the SSV; Group 2 patients had an LIV proximal to the SSV. An analysis was then performed on the entire cohort by applying the lordotic disc vs. SSV method in choosing a LIV and complications were compared.

Results: A total of 50 patients in the study period underwent spinal fusion for SK. Of them, 6 were excluded for incomplete data or follow up, leaving a total of 44 for analysis (Group 1: n=26, Group 2: n=18). Both groups had similar demographics with the mean follow up time of 3.3 yrs. Both groups underwent

PODIUM PRESENTATION ABSTRACTS

similar corrections in thoracic kyphosis (TK) with operative intervention which was sustained at the latest post-operative time point. The disc angle below the LIV maintained lordosis in both groups, but Group 2 had less lordosis (7.8 vs. 2.3, $p=0.02$). (Table 1)

When comparing cases where the first lordotic disc was incorporated in the fusion versus not, LIV issues necessitating revision surgery (24% vs. 38%, $p=0.08$), were similar. When comparing cases using the SSV as the marker for the LIV, including the SSV resulted in less distal LIV problems necessitating revision surgery compared to fusing short of the SSV (4% vs. 29% $p=0.01$).

Conclusion: We recommend the use of the SSV in decision making for the LIV in SK. There was a significant decrease in distal Junctional problems when the SSV was incorporated in the fusion compared to using the first lordotic disc.

108. Sagittal Spinopelvic Alignment in Skeletally Mature Patients with Scheuermann's Disease

Marcin Tyrakowski, MD, PhD; Steven M. Mardjetko, MD, FAAP; Kris Siemionow, MD

Poland

Summary: Sagittal spinopelvic alignment in skeletally mature patients with Scheuermann's disease (SD) is presented in the study. Patients with SD had significantly lower pelvic incidence (PI) than healthy adults and adolescents. There was negligible correlation between PI and TK, TLK and LL in patients with SD.

Introduction: Sagittal spinopelvic alignment has been characterized in normal subjects and in various spinal pathologies. No study has investigated spinopelvic parameters in Scheuermann's disease (SD).

The aim of the study was to analyze anatomical and positional parameters of spinopelvic sagittal alignment in mature patients with SD.

Methods: Standing postero-anterior and lateral radiographs of the skeletally mature patients (Risser sign of 4 or 5) with SD were analyzed. Pelvic positional and anatomic parameters and spinal parameters were measured. Pelvic incidence (PI) was compared to the values reported for healthy individuals (*t*-test). Correlations between the parameters were quantified by Pearson's linear correlation coefficient (*r*).

Results: Forty-five patients met the inclusion criteria (16 females and 29 males; mean age of 23 years). There were 29 patients with the typical (thoracic) form of SD and 16 with the atypical (thoracolumbar) form. The mean PI in all of the patients was 41° and was significantly lower than reported for healthy adults and adolescents ($p<0.0001$) and not significantly different from reported for healthy children ($p=0.24$). Patients with atypical SD had significantly lower PI than these with typical form (43° vs. 37° ; $p=0.041$). The difference in PI between females and males with SD was not significant (40° vs. 41° ; $p=0.55$). There was negligible correlation between PI and lumbar lordosis ($r=0.16$; $p=0.31$), thoracic kyphosis ($r=-0.14$; $p=0.35$) or thoracolumbar kyphosis ($r=-0.42$; $p=0.041^*$).

Conclusion: This study demonstrated that skeletally mature patients with SD have significantly lower PI than healthy adults. There was no correlation between PI and lumbar lordosis in individuals with SD. This challenges the role of PI in predicting the proper values of lumbar lordosis in this group of patients.

109. Growth Modulation Changes in Childhood Post-Tubercular Kyphosis: Long-Term Prospective Multicenter Study over 10 Years

S. Rajasekaran, PhD

India

Summary: Growth Modulation changes are responsible for the spontaneous correction of kyphosis in 44% and progressive deterioration in 39% of post-tuberculous kyphosis in children. Growth changes in the affected vertebrae, uninfected vertebrae within the kyphotic segment and the disc spaces in the primary and secondary curve were studied over a period of 10 years. Many favourable and deleterious changes with growth were observed and apart from age, these were more related to the presence of instability and 'Spine-at-risk' radiological signs.

Introduction: Unlike other kyphosis, post tubercular kyphosis shows variable progression during growth with spontaneous correction in 44%; deterioration in 39% and no change in 17%. We studied the changes secondary to growth modulation responsible for this change.

Methods: 63 spinal lesions in 61 children (mean age 6.9 years, 26 males, 35 females) were followed up for 10 years from four centres under the Madras TB Spine study. 28 children were <5 years, 20 were 6-10 years and 13 were 11-15 years. Overall, 154 vertebrae were affected: 38 thoracic, 75 TL and 41 lumbar. Growth modulation changes over 10 years were calculated in three ROI: infected vertebrae, adjacent uninvolved vertebrae and the disc spaces within the curves.

Results: Spontaneous correction of deformity with anterior overgrowth of the fusion mass was seen in 30 children (0-5y-16; 6-10y-11; >11 -3) and was more common in thoracic and lumbar than TL region ($p<0.01$). Worsening of kyphosis due to anterior growth suppression was seen in 16 and was more common in TL (11) than in thoracic(3) or lumbar(2) ($p<0.01$). 'Spine-at-risk' radiological signs were significantly more common in patients showing progression ($p<0.01$). Numerous changes in the adjacent uninvolved vertebra were seen: anterior wedging (53); ring apophysis changes (26); attrition of anterior vertebral body (26); longitudinal overgrowth (40) and posterior wedging in vertebra of compensatory curves (45). 136 disc spaces showed wedging with anterior wedging in 10 and posterior wedging in 126 disc spaces. Bony changes were more common in the primary kyphotic curve and disc space changes in the compensatory curves.

Conclusion: Growth changes responsible for spontaneous improvement or progression in post TB kyphosis in children is documented. These changes were found to depend on the age and region of involvement but more importantly on the integrity of facet joints and the presence of 'Spine-at-risk' radiological signs. Spontaneous correction was more common in lumbar region and deterioration more in thoracolumbar region.

PODIUM PRESENTATION ABSTRACTS

110. Current Evidence Regarding the Surgical and Non-Surgical Treatment of Pediatric Lumbar Spondylolysis: A Report from the Scoliosis Research Society Evidence-Based Medicine Committee

Charles H. Crawford, MD; Charles Gerald T. Ledonio, MD; Shay Bess, MD; Jacob M. Buchowski, MD, MS; Douglas C. Burton, MD; Serena Hu; Baron S. Lonner, MD; David W. Polly, MD; Justin S. Smith, MD, PhD; James O. Sanders, MD USA

Summary: This SRS sponsored literature review determined that although natural history studies suggest a benign course for spondylolysis, numerous treatment series suggest that patients who present to clinicians with pain and activity limitations can benefit from both surgical and non-surgical treatment (Level IV, Low Quality Evidence). Although it is implied that the majority of surgically treated patients have failed non-surgical treatment, there is insufficient evidence to know which patients will benefit from specific treatment modalities (both non-operative and operative).

Introduction: Spondylolysis is common among children and adolescents and no formal synthesis of the published literature regarding treatment has been previously performed. The SRS requested an assessment of the current state of peer reviewed evidence regarding pediatric spondylolysis with the goal of identifying both what is really known and what research remains essential to further understanding.

Methods: A comprehensive literature search was performed with the assistance of a medical librarian. Citations and abstracts were retrieved. Abstracts were reviewed for exclusions and data from included studies were analyzed by committee. Consistent Level I studies were considered to provide Good (High Quality) Evidence for the clinical question. Consistent Level II or III studies were considered to provide Fair (Moderate Quality) Evidence. Level IV studies were considered to provide Poor (Low Quality) Evidence.

Results: From 947 initial citations with abstract, 383 articles underwent full text review. The best available evidence for the clinical questions regarding surgical and non-surgical treatment was provided by 58 included studies. None of the studies were graded as Level I or Level II evidence. Two of the studies were graded as Level III evidence. Fifty-six of the studies were graded as Level IV evidence. No Level V (expert opinion) studies were included in the final list.

Conclusion: Although natural history studies suggest a benign, relatively asymptomatic course for spondylolysis in the majority of patients, both non-operative and operative treatment series suggest that a substantial number of patients present with pain and activity limitations attributed to spondylolysis. Pain resolution and return to activity is common with both non-operative and operative treatment (80-85% respectively). Although it is implied that the majority of operatively treated patients have failed non-operative treatment, the specific treatment modalities and duration required before failure is declared is not well defined. There is insufficient evidence to know which patients will benefit from specific treatment modalities (both non-operative and operative).

111. High-Grade Spondylolisthesis Surgical Management: Reduction or Arthrodesis In Situ: A Multicenter Review of 207 Cases

Féthi Laouissat; Clément Silvestre; Gerard Bollini; Thierry Odent, MD, PhD; Jerome Sales de Gauzy, PhD; Pierre Guigui; Keyvan Mazda; Pierre Roussouly, MD France

Summary: Study design: Multicenter Restrospective review of radiological results database of 207 high grade spondylolisthesis (HGSPL) patients treated surgically

Introduction: Background Data: Relative to In situ arthrodesis, reduction of HGSPL can provide better spinal alignment and spino-pelvic balance but radiological outcomes for a large cohort of patients is still lacking.

Objectives: To compare arthrodesis "in situ", and arthrodesis after reduction techniques with respect to sagittal spinal alignment in HGSPL surgical management

Methods: The sagittal spinal alignment of 156 patients affected with HGSPL and treated by reduction and arthrodesis, was compared with a population of 51 HGSPL treated by "in situ" arthrodesis. The differences between preoperative and postoperative spinal and pelvic parameters: Pelvic tilt (PT), percentage of slip, Lumbar Lordosis (LL), L5 incidence (IL5), Dubousset lumbo-sacral angle (Dub-LSA) and C7 Tilt were analyzed using a paired t test.

Results: Reduction technique compared with arthrodesis in situ was associated with significantly greater decrease (preop to postop) of PT (29° to 26° vs 29° to 31° , $p < 0,001$), IL5 (66° to 49° vs 63° to 68° , $p < 0,0001$) and LL (66° to 53° vs 62° to 62° , $p < 0,0005$) by correcting the lumbo-sacral kyphosis (80° to 94° vs 76° to 82° , $p < 0,0001$) and reducing the slippage (68% to 35% vs 59% to 58% , $p < 0,0001$) Moreover, C7 tilt was associated with a significant change (8° to $5,6^{\circ}$ vs $6,8^{\circ}$ to $11,4^{\circ}$, $p < 0,0001$).

Conclusion: The reduction of HGSPL potentially improves overall spino-pelvic parameters by providing better sagittal spinal alignment than in situ technique.

112. The Role of Athletic Activity on Lumbar Structural Abnormalities in Adolescent Patients with Symptomatic Low Back Pain

Gregory D. Schroeder, MD; Marco Mendoza, MD; Erika Daley, BS; Cynthia LaBella, MD; Jason W. Savage, MD; Alpesh A. Patel, MD; Wellington Hsu, MD USA

Summary: Adolescent patients with low back pain were stratified by athletic participation, and imaging studies were blinded and reviewed by two authors. Each level was assigned a Pfirrmann grade and evaluated for a herniated disc and/or pars fracture. Athletes were more likely to have lumbar pathology (67% versus 40%, $p = 0.01$). Specifically, the risk of a pars injury was increased in athletes (32% vs. 2%, $p = 0.0003$) even though the PI was similar (51.5° vs. 48.7° , $p = 0.41$).

Introduction: It is unknown whether elite athletes are predisposed to a higher prevalence of lumbar spine pathology, and classic studies that linked athletic activity to spondylolysis were completed without analyzing lumbopelvic alignment.

Methods: Records of patients ages 10-18 between 2004-2012 were evaluated. Included patients had low back pain, a lumbar spine MRI, and reported athletic.

PODIUM PRESENTATION ABSTRACTS

Patients who participated in sports at least 5 days or 20 hours per week, or were on a varsity team were stratified to the "athlete" group. A control "non-athlete" group included patients who participated in sports < 3 days or < 5 hours per week. Athletes were also stratified into contact, hyperextension, and rotational activities. Imaging studies were blinded and reviewed by two authors. Each level was assigned a Pfirrmann grade and evaluated for a herniated disc and/or pars fracture. The senior author graded pathology in cases of disagreement.

Results: 66 athletes and 48 non-athletes were identified. BMI, smoking history and PI (51.5° vs. 48.7°, respectively, $p = 0.41$) were similar between groups. The overall prevalence of lumbar pathology was 55%, and athletes were more likely to have lumbar pathology (67% vs. 40%, $p = 0.01$). Specifically, the risk of a pars injury was increased in athletes (32% vs. 2%, $p = 0.0003$); however, there was no difference in the average Pfirrmann grade (1.19 vs. 1.14, $p = 0.41$), percentage of patients with at least one degenerative disc (39% of athletes vs. 31% of non-athletes), or rate of disc herniation (27% of athletes vs. 33% of non-athletes). Contact, hyperextension, and rotation athletes demonstrated an increased risk of a pars fracture, but no difference in incidence of degenerative changes (Table 1).

Conclusion: Adolescents with low back pain have a higher-than-expected prevalence of structural pathology regardless of athletic activity. Competitive athletics also increases the rate of pars fracture in athletes with similar lumbopelvic alignment.

Table 1:

	All Non-Athletes (48)	Contact Athletes (29)*	P Value	Hyper-Extension Athletes (21)**	P Value	Rotation Athletes (18)***	P Value
Pfirrmann average	1.14	1.28	0.17	1.09	0.26	1.16	0.87
% with at least one degenerative disc	31%	45%	0.33	33%	< 1.00	28%	< 1.00
% with a HNP	33%	34%	<1.00	33%	< 1.00	11%	0.12
% with a pars fracture	2%	17%	0.03	38%	0.0002	56%	0.00002
% with a at least one degenerative disc, a HNP and/or a pars fracture	40%	66%	0.04	67%	0.07	72%	0.03

P value compares the group of athletes and the non athlete control group

* Contact sports were defined by the American Academy of Pediatrics. Athletes in the group played Basketball (14), Soccer (11), Football (4), Lacrosse (2) and Wrestling (1)

**Hyperextension sports included: Gymnastics (12); Cheerleading (2); Ballet(2); Dance (2); Pole Vault (1); and Ice Skating (1)

***Rotation Athletes include: Baseball/Softball (10); Tennis (7); Lacrosse (2); and Badminton (1)

113. Inefficiency of Preoperative Donated Autologous Blood to Decrease Transfusion Requirements after Surgery in AIS Patients

Jesús F. Burgos, PhD; Carlos Barrios, MD, PhD; Cesar Perez-Caballero; Vicente García, MD; Ignacio Sanpera, MD, PhD; Gabriel Piza Vallespir, MD, PhD; Luis Miguel Antón-Rodríguez, PhD; Pedro Domenech, MD
Spain

Summary: The use of preoperative autologous blood donation (PABD) for surgical treatment of adolescent idiopathic scoliosis (AIS) is still highly controversial. In a retrospective case-control study the determinants of transfusion were analyzed. The risk for transfusion was 2-fold higher in PABD patients than in non-donors.

Introduction: The use of preoperative autologous blood donation (PABD) for surgical treatment of adolescent idiopathic scoliosis (AIS) is still highly controversial. The objective of this study was to analyze autologous and allogeneic blood use among patients undergoing surgery for AIS that participated in PABD and patients who reject blood donation.

Methods: Retrospective, case-control study. Medical records of 37 non-consecutive girls treated for Lenke type I AIS between January 2010 and December 2012 were reviewed. The curves have an average Cobb angle of 58 (50-79). There were 25 PABD patients and 13 non-donors. All cases followed the same hematologic and clinical protocol for intra and postoperative blood transfusion.

Results: No differences existed between the two groups of girls regarding age, major curve size and fused levels.

Average preoperative hemoglobine was lower in PABD than in non-donors (12.2 vs 13.5 mg/dl; $P < 0.05$). One PABD patient (4%) and 12 non-donors (92.3%) did not required postop transfusion. An average of 1.5 blood units were intraoperatively transfused in the PABD group. Three patients (12%) in this group did not require intraoperative transfusion. One single patient needed intraoperative transfusion in the non-donor group. In the Intensive Unit care (IUC), 14 PABD patients were transfused an average of 1.3 units during IUC stay. Only one non-donor case received a blood unit in the Only one patients in the whole sample was transfused for hematocrit <30. In 12 PABD patients (48%), one or more stored blood units were not used. Average hemoglobin at discharge from intensive care unit was 9.6 mg/ml in PABD patients and 9.5 mg/dl in non-donors. None of the patients was transfused in the ward.

Conclusion: The risk for transfusion was 2-fold higher in PABD patients than in non-donors. The majority of these patients was transfused at a high hemoglobin (>8) and in one third the collected blood was not used. Apart from the high cost of storage, in our experience PABD induces too many unnecessary transfusions.

114. Efficacy of Epoetin Beta Injection during Autologous Blood Collection before Scoliosis Surgery

Shota Ikegami, PhD; Jun Takahashi, MD; Keihiro Mukaiyama; Shugo Kuraishi; Masayuki Shimizu; Toshimasa Futatsugi; Hiroyuki Kato, MD, PhD
Japan

Summary: The use of epoetin beta injection during autologous blood collection before scoliosis surgery results in a 0.3 g/dL hemoglobin gain after one blood collection regardless of hemoglobin concentration. Accordingly, sufficient blood collection could be achieved even in anemic patients with scoliosis.

Introduction: The use of autologous blood collection (ABC) is preferred for scoliosis surgery, which tends to be associated with high bleeding rates. However, few studies have examined whether pre-operative ABC is useful in anemic patients. The objective of this study was to clarify the efficacy of recombinant human erythropoietin- β (EPO- β) injection in ABC before scoliosis surgery.

Methods: Forty-seven (35 women, 12 men) consecutive scoliosis surgery patients underwent pre-operative ABC. Median patient age was 15 (5-60) years. ABC was performed weekly according to body weight with EPO- β 24,000 U subcutaneous injection. The collected blood volumes were compared among the low-Hb (<13 g/dL), med-Hb (13-13.9 g/dL), and high-Hb (≥ 14 g/dL) groups

PODIUM PRESENTATION ABSTRACTS

using the Kruskal-Wallis test. Calculated Hb decreases among collections and the suppressive effect of an EPO- β injection against Hb decreases were estimated using a linear mixed model.

Results: Patients underwent a median of 4 (2-7) ABC collections. Median collected volume per ABC was 200 (40-400) g. Median blood collection was 700 (160-2,400) g. The total collections were 725 g, 650 g, and 700 g in the low-Hb, med-Hb, and high-Hb groups, respectively, and there was no significant difference among the groups ($p=0.902$). Median blood loss during surgery was 500 (10-2600) g, and 45/47 patients (96%) avoided an unplanned allogeneic transfusion, including 7/8 (88%) cases of blood loss > 1,000 g. The suppressive effect of an EPO- β injection against Hb decreases was estimated at 0.3 ± 0.1 g/dL ($p=0.027$) after Hb adjustment, a confounding factor.

Conclusion: ABC with EPO- β injection is useful for avoiding allogeneic transfusion during scoliosis surgery. With EPO- β , patients in the low-Hb group achieved ABC volumes equivalent to those of patients in the high-Hb group.

115. Variation in Readmission for Surgical Site Infections (SSIs) and Reoperation following Spinal Fusions for Neuromuscular Scoliosis

Lisa McLeod, MD; John M. Flynn, MD; Mark A. Erickson, MD; Nancy H. Miller, MS, MD; John P. Dormans, MD
USA

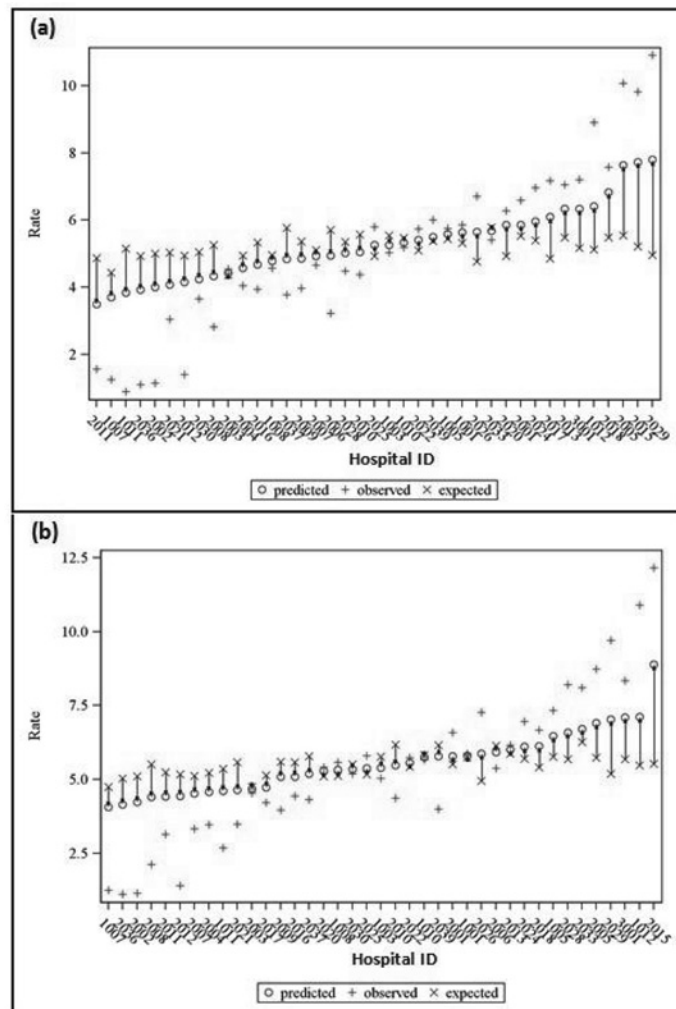
Summary: For children with NMS undergoing spinal fusion operations, risk of readmission for SSI and reoperation was impacted by the hospital at which the procedure was performed.

Introduction: Readmission following spinal fusion for NMS negatively impacts safety and value. This study examined risk-adjusted variation in 60d readmission rates for SSI and reoperation across 39 Children's Hospitals Association (CHA) spine centers.

Methods: Retrospective cohort study using the Pediatric Health Information Systems (PHIS) database involving children aged 0-18 years with ICD9 codes indicating NMS and a spinal fusion procedure discharged from 39 CHA hospitals from 1/1/2007-9/1/2012. Readmissions at 60d for SSI were identified using ICD9 codes for (1) infectious complication of procedure, or (2) sepsis/bacterial infection plus reoperation. Mixed effects logistic regression was used to estimate expected (population-level risk) and predicted (weighted average of hospital-specific and population-level risk) readmission rates. Predicted vs. expected (pe) ratios were calculated for each hospital.

Results: Among the 7,560 surgeries in the study cohort, 60d readmission rates were 7% for reoperation and 6% for SSI. Reoperations were associated with an SSI in 70% of cases. Across hospitals, SSI and reoperation rates ranged from 1-12%. After adjusting for age, gender, payor, presence of a gastric tube, VP shunt, or tracheostomy, prior admissions, other chronic conditions, and procedure type, 14/39 hospitals had pe ratios <1 (better than expected outcomes) for both SSIs and reoperations (Figure).

Conclusion: This study indicates that risk of readmission for SSI and reoperation is likely affected by a combination of patient factors and the hospital at which the surgery is performed. Closer examination of the processes and organization of care at centers with better than expected outcomes may offer valuable strategies for improving outcomes across all hospitals.



60d readmission rates for (a) SSIs and (b) reoperation following spinal fusion for NMS. Arrows show the deviation of each hospital's rates from what would be expected from their given case mix.

116. A Prospective Study of a Decision-Making Algorithm for Significant Neurophysiologic Intraoperative Monitoring Events in Severe Spinal Deformity Surgery

Benjamin T. Bjerke-Kroll, MD, MS; Daniel Zuchelli, BS; Venu M. Nemani, MD, PhD; Ronald G. Emerson, MD; Jennifer Ayamga, Mphil; Oheneba Boachie-Adjei, MD; FOCOS Research Associates
USA

Summary: Neurophysiologic Intraoperative Monitoring (NIOM) has decreased intraoperative spinal cord injury by providing real-time feedback for potentially harmful intraoperative events. With a stepwise algorithm to identify and reverse inciting events, full intraoperative recovery of neurologic signals was noted in a majority of cases where triggering events were not related to osteotomy. This approach obviated the need to perform intraoperative wake up test or abort the surgical procedure.

PODIUM PRESENTATION ABSTRACTS

Introduction: The risk of spinal cord injury in severe spinal deformity surgery is relatively high. We examine the relationship between triggers of NIOM events and final neurologic status after an appropriately applied algorithm to reverse the inciting cause.

Methods: A prospectively-collected database was reviewed for all spinal deformity surgery performed at a single site at a West African hospital during a 12-month period, using NIOM coupled along with a decision-making algorithm to identify and reverse inciting events where possible. We examined the surgical and systemic triggers of NIOM events, the subsequent corrective measures, and neurological status upon surgical completion. A significant NIOM event was defined as a 50% or greater decrease from baseline in the amplitude of tibial nerve SSEP or 75% decrease in the MEP amplitude recorded from the lower extremity muscle with the largest baseline response.

Results: 88 patients met inclusion criteria. The average age was 14 years (3-28), and male:female ratio was 43:45. Diagnoses included idiopathic scoliosis (20), congenital scoliosis (9), congenital kyphosis (7), congenital kyphoscoliosis (11), idiopathic kyphoscoliosis (5), early-onset scoliosis (6), post-infectious kyphosis (15), and other (15). The average kyphosis was 108° (54-176°); the average scoliosis was 100° (48-177°). There were 44 separate NIOM events in 34 patients (39%). 4 patients had only osteotomy-triggered NIOM events, 6 patients had both osteotomy and non-osteotomy related events, 23 of patients had events triggered only by other identifiable causes; in one case no trigger was identified. NIOM changes persisted until case completion in 100% (11/11) of cases with an osteotomy-related or unidentified triggering event. In contrast, only 17% (4/23) of patients with NIOM events unrelated to osteotomy had persistent changes.

Conclusion: NIOM allows timely identification of the cause of potential spinal cord injury and reversal of inciting events. Events attributable to a cause other than an osteotomy are unlikely to result in neurologic deficits, and we believe a Stagnara wake-up test or halting of the procedure is not warranted. In contrast, NIOM events from an osteotomy-related cause commonly result in irreversible neurologic change.

117. Reliability of X-Ray Based Evaluation of Pedicle Screw Misplacement in Adolescent Spinal Deformity

Saankritya Ayan, MD; Beverly Thornhill, MD; Adam L. Wollowick, MD; Terry D. Amaral, MD; Vishal Sarwahi, MD
USA

Summary: X-ray-based evaluation of pedicle screw misplacement is severely limited in spine deformity and better evaluation methods are needed.

Introduction: Intra and post-op x-rays are routinely used to detect misplaced pedicle screws. Kim, et al. have defined x ray criteria for evaluation of screw placement in spinal deformity. This study evaluates pedicle screw misplacement on x-ray using these criteria as well as anterior placement on lateral x-R, and compared to post-op CT scan.

Methods: Post-op XR and low dose CT scans of 104 spinal deformity patients who underwent PSF were reviewed. Blinded review of screw placement on x-ray was done by 6 observers using Kim et al.'s criteria: 1)violation of the harmonious change; 2)no crossing of medial pedicle wall by screw tip; 3)

violation of imaginary midline of vertebral body. Anterior violation was recorded when anterior breach screw length was $\geq 80\%$ of the width of the vertebral body. Overall and independent assessment of sensitivity, specificity, accuracy and concordance was done.

Results: 2034 screws were evaluated on x-ray and CT. CT classified 1772 screws as acceptable, 142 lateral, 30 medial, and 90 anterior. Overall sensitivity, specificity and accuracy for diagnosis of correct screw placement with x ray was 0.52(0.36-0.72),0.69(0.45-0.84) and 0.67(0.48-0.78) respectively. X-R overestimated the number of misplaced screws and had poor reliability for detecting properly placed screws. Overall agreement among six observers (kappa value) was 0.23 (95% CI: 0.23 - 0.24), indicating poor correlation. Overall concordance of plain radiograph as compared to CT scan for diagnosis of correct anterior, lateral, medial and normal screw position was 0.53(0.13-0.84), 0.25(0.19-0.51),0.13(0.13-0.20) and 0.70 (0.45-0.84) respectively.

Conclusion: X-ray evaluation of screw placement showed poor correlation with CT data and very poor interobserver correlation. X-rays were found to be inadequate to evaluate screw misplacement .Low dose CT scan or intra-op 3D image and/or navigation should be used for reliable evaluation of screw placement.

118. Outcomes of Patients with Syringomyelia Undergoing Spine Deformity Surgery: Do Large Syringes Behave Differently than Small?

Amer F. Samdani, MD; Steven W. Hwang, MD; Anuj Singla, MD; James T. Bennett, MD; Robert J. Ames, BA; Jeff S. Kimball, BS
USA

Summary: We hypothesized that outcomes of patients with syringomyelia undergoing spine deformity surgery differed based on syrinx size. Patients with large syringes (≥ 4 mm) are fused longer with higher EBL, and there is a trend toward less correction when compared to those with small syringes. In addition, patients with large syringes have less reliable neuromonitoring with more intraoperative signal changes.

Introduction: There is a paucity of data studying outcomes of patients with syringomyelia undergoing spinal deformity correction. Furthermore, the literature does not stratify patients by syrinx size, which is likely a major contributor of outcomes. We sought to compare differences in outcomes between patients with large (≥ 4 mm) and small syringes (< 4 mm) undergoing spinal deformity correction.

Methods: A retrospective review was undertaken to identify patients with syringomyelia who underwent spine deformity surgery with 2 year follow-up. Patients were divided into two groups: 1) Large Syrinx (LS) ≥ 4 mm and 2) Small Syrinx (SS) < 4 mm. Demographic, surgical, and radiographic data were collected preoperatively and at 2 years, and the groups were compared using unpaired Student's t-test and Fisher's exact test.

Results: 28 patients met our inclusion criteria with 11 having LS and 17 SS. The patients were similar with respect to age (LS=13.2 years, SM=14.5 years, $p=0.20$), and gender (LS=55% female, SS=65% female, $p=0.70$). The LS group had a trend toward more left sided thoracic curves (36% vs. 18%, $p=0.38$) and was more likely to have had a Chiari decompression (45% vs. 12%, $p=0.08$). In addition, the LS patients had larger preoperative major curves (LS=66° vs. SS=57°, $p=0.05$), more thoracic kyphosis (LS=42°, SS=24°,

PODIUM PRESENTATION ABSTRACTS

$p < 0.01$) and greater rib prominences ($LS=16^\circ$, $SS=13^\circ$, $p=0.04$). The LS patients had more levels fused ($LS=12.2$, $SS=11.2$, $p=0.05$) and a higher EBL ($LS=1068$ cc, $SS=832$ cc, $p=0.04$), with a trend toward less percent correction of the major curve ($LS=57\%$, $SS=65\%$, $p=0.18$). Intraoperative baseline SSEPs and MEPs were obtained in 100% of patients with SS, whereas 4/11 (36%) LS patients did not have SSEPs, and one of these also did not have MEPS. Neuromonitoring changes occurred in 3/11 (27%) of the LS patients and in none of the SS, with no postoperative deficits.

Conclusion: Outcomes of patients with syringomyelia undergoing spine deformity surgery are dependent on the size of their syrinx. Those with large syringomyelia are fused longer with more EBL and less correction. In addition, the spine surgeon should be aware that these patients are more likely to have less reliable neuromonitoring, with a higher chance of experiencing a change.

119. Long-Term Functional Outcomes in Duchenne Muscular Dystrophy Scoliosis: Comparing the Differences between Surgery and No Surgery
Jeong Ho Seo; Byung Ho Lee, MD, PhD; Seong-Hwan Moon, MD, PhD; Dong-Eun Shin, PhD; Joong Won Ha; KiChan An, MD, PhD; Hak-Sun Kim, MD
Republic of Korea

Summary: Surgery in Duchenne muscular dystrophy (DMD) scoliosis improves activity of daily living (ADL) compared to that of patients treated conservatively and improvement of ADL mainly depends on sitting-related questions. The muscle power and forced vital capacity (FVC) were decreased in both groups at the final evaluation point, but the ratio of FVC deterioration was significantly slowed in the surgery group.

Introduction: Most studies of DMD scoliosis focus on technical and radiographic indices, not the more important functional status using validated questionnaires. The only Oxford level 2 study presented so far is by the authors 2 years ago. This study extends upon the previous paper, with over 6 years of data. The objectives of this study are to compare FVC, radiographic outcome, and ADL using validated questionnaires between surgically and non-surgically treated DMD patients over a long term period

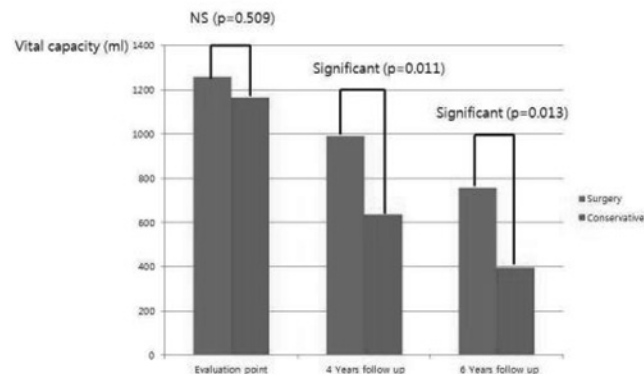
Methods: In this prospective study, we assessed 77 DMD scoliosis male patients for an average of 6 years. As DMD surgeries are considered high risk, both the advantages and consequences of the surgery were explained extensively to patients. Patients then choose whether to do surgery or non-surgery, which controls for some selection bias. There were 7 deaths and 6 follow up losses. 66 patients (39 surgical and 25 non-surgical patients) were included in this study after satisfying a minimum follow-up of 4 years (mean 6.1 years). FVC, Cobb's angle, lordosis, pelvic obliquity, and functional status using the modified Rancho scale (MRS), and manual muscle test (MMT), and muscular dystrophy spine questionnaire (MDSQ) were measured on consultation for surgery and minimal 4 years follow-up.

Results: Functional parameters (MMT, MRS) and radiographic measurements, except for lordosis, were similar for both groups at the time of consultation ($p > 0.05$). On final follow-up, all radiographic parameters were significantly improved in the surgical group (SG) compared to the non-surgical group (NSG). The MMT and MRS were not significantly different between the SG and NSG. Interestingly, the SG (31.4 ± 13.4) had higher MDSQ scores than those of the

NSG (24.4 ± 9.7 , $p=0.001$). On the starting point, FVC was arithmetically large in SG, but there was no statistical difference (SG 1258.0 ± 514.0 ml vs. NSG 1164.4 ± 637.4 ml, $p=0.510$). Both groups showed a decrease in FVC on final follow up, but there was a significantly slower deterioration of FVC in the SG (758 ± 323 ml in NSG versus 396 ± 216 ml in SG, $p=0.013$, Fig. 1).

Conclusion: Surgery in DMD scoliosis improves function and decreases the rate of deterioration of FVC compared to patients treated conservatively and it maintained mean 6 years

Comparison of Vital Capacity Between Surgery and Conservative Group



120. Spinal Cord Monitoring in Patients with Spinal Muscular Atrophy Undergoing Spinal Fusion: A 19-Year Experience

Ryan Miller, MD; Patricia L. Rampy, MS, REPT, CNIM; Steven Sparagana, MD; Daniel J. Sucato, MD, MS
USA

Summary: A consecutive series of 41 SMA patients undergoing fusion surgery for scoliosis were reviewed to analyze the utility of spinal cord monitoring. Transcranial MEP data was obtained in all patients while SSEP data was obtained in 80% of type 2, and 100% of type 3 patients. No critical changes or neurologic deficits were seen. Spinal cord monitoring is safe and reliable in SMA, however, caution is necessary for type 2 patients since baseline data may be unobtainable.

Introduction: Somatosensory evoked potentials (SSEPs), Mixed Motor Evoked Potentials (MMEPs) and transcranial motor evoked potentials (TcMEPs) are established modalities for monitoring intraoperative spinal cord physiology during spinal fusion operations for spinal deformity. There are no studies which have analyzed a large group of patients with spinal muscular atrophy (SMA).

Methods: This is an IRB - approved retrospective review of a consecutive series of patients with SMA (Types 2 and 3) at a single institution who underwent spinal fusion and instrumentation over a 19 year period. A detailed analysis of the TcMEPs, SSEPs, and MMEPs included the ability to obtain baseline data, the incidence of critical changes and subsequent postoperative neurologic deficits.

Results: There were 41 patients with SMA who had surgery between 1993 and 2012 (29 SMA Type 2, 9 SMA Type 3, 3 undiagnosed type). All 41 had SSEPs performed, 17 had both SSEPs and TcMEPs, and 4 patients had SSEP/MMEPs. There were 22 females and 19 males, at an average age of 11.8 years, with a preop curve of 85° , postop of 39° and 2 year of 38° . Patients with type 2

PODIUM PRESENTATION ABSTRACTS

were younger at surgery (10.9 vs 14.3 yrs), had larger preop curves (90.4 vs 74.5°), greater residual curve (43.6 vs 26.4°) and were more commonly fused to the pelvis (79.3% vs 44.4%) ($p < 0.05$). Baseline SSEP data were obtained in 34 of 41 (85%) patients without critical change in SSEPs during the procedure. Baseline motor evoked potential data was obtained in 100% of patients for both TcMEP (17 of 17) and MMEP (4 of 4) patients without subsequent critical changes. It was more difficult to obtain baseline SSEP data for type 2 compared to type 3 patients (79.3 vs 100%) ($p = .159$). No patients had a neurologic deficit postoperatively.

Conclusion: In the largest series reported on SMA patients, spinal cord monitoring with SSEPs is reliably obtained in all patients with SMA type 3 and 80% in type 2 while all patients had TcMEPs and MMEPs despite this condition which primarily involves the motor tracts. Spinal deformity surgeons should be aware of these trends especially for the more severely affected type 2 patient and may need to rely solely on motor evoked potential data in these patients.

121. Are S1 Screws a Useful Adjunct to Iliac Screws in Long Paralytic Fusions to the Sacrum

Scott Schoenleber, MD; Harry L. Shufflebarger, MD; Jahangir Asghar, MD; Tracey Bastrom, MA; Harms Study Group
USA

Summary: Addition of S1 screws to iliac screws in NM fusions improves radiographic results in patients with cerebral palsy who underwent long posterior spinal fusion.

Introduction: The addition of S1 screws to a posterior spinal fusion to the pelvis adds time and difficulty. This study compares radiographic parameters at 2 years in cerebral palsy (CP) patients who underwent fusions to the pelvis with iliac fixation alone, or with the addition of bilateral S1 screws.

Methods: A prospective, IRB-approved, multicenter registry was used to identify patients with CP who underwent undergone long posterior spinal fusions to the pelvis. Distal fixation was with either iliac screws alone or a combination of iliac and bilateral S1 screws. Preoperative, first erect postoperative, and 2-year followup radiographic measurements were analyzed. Statistical analysis was performed using ANOVA and repeated measures ANOVA (RMA) with significance set at $p < 0.05$.

Results: 88 patients were identified, 52 with iliac screws (I) and 36 with iliac and S1 screws (IS). There were no differences with respect to gender or age. Scoliosis was the primary deformity in greater than 90% of patients in both groups ($p = 0.837$). Preoperative deformity magnitude was similar (I=85.7°, IS=89.5°, $p = 0.473$), but correction was better with the use of S1 screws on the first erect radiograph (I=35.3°, IS=24.9°, $p = 0.008$), and at 2 years (I=37.8°, IS=25.8°, $p = 0.002$). Iliac and S1 screws demonstrated better overall percentage of deformity correction at 2 years (I=58%, IS=74%, $p < 0.001$, RMA=0.01). Preoperative pelvic obliquity (PO) was similar (I=28.5°, IS=29.9°, $p = 0.708$). Initial percent correction of PO was similar (I=68%, IS=71%, $p = 0.63$) but at 2 years the addition of S1 screws demonstrated less loss of correction (I=60%, IS=77%, $p = 0.018$, RMA=0.022). There was no difference in the rate of major ($p = 0.266$) or minor ($p = 0.645$) complications due to instrumentation ($p = 0.71$).

Conclusion: The addition of S1 screws in cerebral palsy patients with posterior spinal fusions to the pelvis is associated with better two year correction of both coronal deformity and pelvic obliquity as well as less loss of correction from the first postoperative radiograph. Mechanical factors during correction with and without S1 screws may explain the correction difference. Two points of distal fixation, S1 and ilium, should be considered for this population.

122. The Pros and Cons of Operating Early versus Late in the Progression of CP Scoliosis

Steven M. Hollenbeck; Burt Yaszay, MD; Paul D. Sponseller, MD; Suken A. Shah, MD; Jahangir Asghar, MD; Mark F. Abel, MD; Firoz Miyani, MD, FRCSC; Peter O. Newton, MD
USA

Summary: The range of magnitude for the treatment of CP scoliosis varies considerably (40-144°). This study demonstrated that there was no advantage to operating on patients with CP scoliosis less than 70° (proactive) compared to 70-90°; however, operating on curves greater than 90° (reactive) increased the risks. 70-90° is an acceptable "trigger" for surgery in the absence of problems earlier.

Introduction: There are 2 approaches to the management of CP scoliosis: a proactive one similar to AIS where surgery is recommended once there is a risk of progression (Cobb >50o) and a reactive one where surgery is recommended after the patient/caregiver may have significant challenges secondary to a large deformity. The purpose of this study was to compare these different management styles and to delineate a curve threshold where further delay significantly increased the risk of surgery.

Methods: A prospectively collected CP scoliosis surgical registry was queried for patients with a minimum f/u of 2 yrs. Three groups were delineated based on the distribution of curve magnitudes: <70o (proactive), 70-90o, and >90o (reactive). Radiographic, surgical, and quality of life outcome data were compared between the three groups using ANOVA and chi-square analyses.

Results: There were 38 patients in the <70o group, 44 in the 70-90o group, and 42 in the >90o group. They were similar in age. The >90o group had significantly longer operative time ($p < 0.001$) likely secondary to the increased percentage of anterior/posterior procedures (31%) compared to the other two groups (5%; Table). The % blood volume loss was also significantly higher in the >90o group compared to the <70o. The infection rate requiring I&D was significantly higher in the >90o group (16.7%) than the <70o (5.3%, $p = 0.03$) and the 70-90o (6.8%, $p < 0.05$). Preop, the CPchild QOL score was significantly higher for the <70o group. Interestingly, at 2 years postop the <70o and 70-90o group reached similar QOL scores (72 and 71, respectively), while the >90o trended toward a lower postop QOL (63.5). There was no difference in length of hospitalization or ICU stay.

Conclusion: When recommending surgery for CP scoliosis, being proactive (Cobb <70o) has no advantage in terms of decreasing risks or improving outcomes compared to curves 70-90°. However, delaying surgery to a curve greater than 90° increases the risk of infection, blood loss, and the need for anterior/posterior procedures. Ideally, we should be recommending surgery for our CP patients below 90°.

PODIUM PRESENTATION ABSTRACTS

123. Long-Term Maintenance of Spontaneous Lumbar Curve Correction following Selective Thoracic Fusion of Lenke 1 Curves in AIS: Radiographic and Clinical Results 13 Years after ASF

Heiko Koller, MD; Manabu Ito, MD, PhD; Christian Pirkahn; Oliver Meier, MD; Susana Núñez Pereira, MD, PhD; Hideki Sudo
Germany

Summary: A 13-years follow-up study on patients with selective thoracic fusion (STF) using anterior spinal fusion (ASF) for Lenke 1 curves showed that spontaneous lumbar curve correction (SLCC) maintained stable in 71% of patients. Pulmonary function (PF) declined by 8%. Maintenance of thoracic curve (TC) correction was demonstrated protective for loss of SLCC.

Introduction: STF is used to correct AIS in patients with a major TC and flexible lumbar curve (LC). Information on the maintenance of SLCC during the long-term run is sparse. The aims of our study were to extend long-term information on the LC behavior after ASF and the pulmonary burden of ASF.

Methods: Scoliosis measures and PF tests of 47 patients at minimum F/U of 10 yrs were compared to preop and postop measures. PF value reported was predicted forced vital capacity (FVC%). Classification of pulmonary impairment was into 'no' impairment ($FVC > 80-100\%$), mild ($FVC > 65 \leq 80\%$), moderate ($FVC > 50 \leq 65$) and 'severe' ($FVC \leq 50\%$). The subjacent disc angle of the lowest instrumented vertebra (LIVDA) and the C7-CSVL were measured. Clinical outcomes included the SRS-22 questionnaire.

Results: 41 pts were females. F/U was 13.5 yrs (10-18yrs), patients' age was 15.9 yrs (11-30 yrs) and fusion levels were 6.6 ± 0.7 . Preop FVC was $80 \pm 13\%$ and at F/U $72 \pm 12\%$. Preoperatively 50% of patients had no pulmonary impairment, 33% mild, 14% moderate and 2.5% severe. At F/U, these numbers were 24%, 55%, 13% and 7%. Radiographic results are summarized in table 1. For the LIVDA and C7-CSVL, there was no sig. postop worsening. Lumbar lordosis and thoracic kyphosis improved until F/U ($p < .05$). TC-correction showed a sig. loss from postop to F/U ($p < .01$). LC-flexibility was $77 \pm 18\%$, but SLCC showed no sig. loss. 71% of pts showed no LC-worsening, while in 29% LC increased. SRS score was 4 ± 0.3 . Comparing patients with LC-worsening to patients without, preop LC, postop LC, LC at F/U and loss of TC were $34 \pm 7^\circ / 35 \pm 7^\circ$, $18 \pm 6^\circ / 17 \pm 7^\circ$, $23 \pm 6^\circ / 14 \pm 8^\circ$ and $13 \pm 5^\circ / 8 \pm 5^\circ$ ($p < .05$). LC-worsening occurred mainly in pts with semi-rigid ASF and a related loss of TC-correction. Patients with smaller postop TC-correction or larger TC at F/U were more likely to reveal loss of SLCC ($r = 0.4, p = .005 / r = -0.5, p = .001$).

Conclusion: A study of STF showed that SLCC maintained stable as long as 18 yrs after surgery in most pts. SLCC showed sign. correlation w/ TC-correction. Maintenance of TC-correction using rigid instrumentation was shown mandatory to provide stable SLCC. PF was shown to be effected 13 yrs after ASF. A mean decrease of FVC by 8% indicates that ASF should be reserved for patients with no to mild pulmonary impairment.

124. SRS7: A Valid, Reliable, Responsive and Unidimensional Functional Outcome Measure for Operatively Treated Patients with AIS

Amit Jain, MD; Paul D. Sponseller, MD; Stefano Negrini, MD; Peter O. Newton, MD; Patrick J. Cahill, MD; Tracey Bastrom, MA; Michelle C. Marks, PT, MA; Harms Study Group
USA

Summary: SRS22 has not been shown to possess internal construct validity; i.e. it lacks unidimensionality (there is no 1 underlying latent trait being measured) and linearity (missing 1 point in two different domains is not equivalent). To address this, a refinement of SRS22 containing 7 Rasch-derived items (SRS7) was recently proposed. We find that SRS7 demonstrates excellent concurrent and discriminative validity, reasonable internal reliability, and better responsiveness than SRS22, and may be better for quantifying changes in the overall functional status.

Introduction: SRS22 was developed for functional outcome evaluation in adolescent idiopathic scoliosis (AIS). Because it pools scores from various domains, SRS22 has not been shown to possess internal construct validity; i.e. it lacks unidimensionality (there is no 1 underlying latent trait being measured) and linearity (missing 1 point in two different domains is not equivalent). To address this, a refinement of the SRS22 containing 7 Rasch-derived items (SRS7) was recently proposed. The aim of our study is to assess the validity, reliability, responsiveness, and dimensionality of SRS7 vs SRS22 in an operative population.

Methods: A large AIS database was queried for 712 patients who underwent spinal fusion (mean age: 14.7 yrs, mean coronal Cobb $55 \pm 13^\circ$). SRS22 (scale range: 22-110) and SRS7 (scale range: 7-28) scores were calculated from preop and 1 year post surgery (followup) questionnaires. Significance was set at $P < 0.05$.

Results: Validity: SRS7 demonstrated strong concurrent validity against SRS22: preop Spearman correlation was $\rho = 0.80$ ($P < 0.01$) and at followup was $\rho = 0.82$ ($P < 0.01$). Both SRS7 and SRS22 demonstrated strong discriminative validity; they successfully differentiated between varying magnitudes of preop coronal curves ($F = 9.4, P < 0.01$ and $F = 10.7, P < 0.01$, respectively).

Reliability: SRS7 preop and followup scores showed reasonable internal consistency, Cronbach $\alpha = 0.67$ and 0.72 (vs 0.85 and 0.86 for SRS22).

Responsiveness: With surgery, at 1 year followup, the SRS7 scores improved by 4.9 points, $P < 0.01$ (vs SRS22 by 11.8 points, $P < 0.01$). Both SRS7 and SRS22 demonstrated large effect size; for SRS7, Cohen's $d = 1.55$ (vs 1.23 for SRS22), Hedge's $g = 1.55$ (vs 1.23), and effect size correlation $r = 0.61$ (vs 0.53).

Dimensionality: On factor analysis, both preop and followup SRS7 measurements demonstrated unidimensionality, while SRS22 showed multidimensionality (Figure 1).

Conclusion: SRS7 demonstrates excellent concurrent and discriminative validity, reasonable internal reliability, and better responsiveness than SRS22. Its strength is that it is a short, unidimensional and linear instrument, which can be computed from SRS-22 items, and may be better for quantifying changes in the overall functional status.

PODIUM PRESENTATION ABSTRACTS

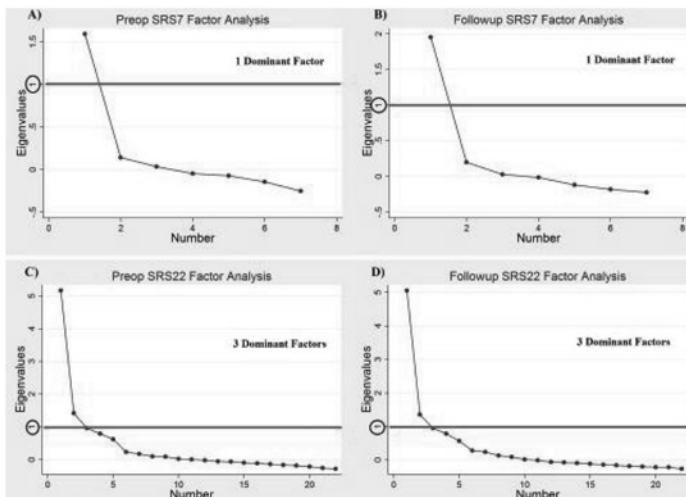


Figure 1. A and B) Scree plots of SRS-7 at preop and followup demonstrating scale unidimensionality with presence of a single latent trait (single factor with eigenvalue >1). C and D) Scree plots of SRS-22 at preop and followup demonstrating scale multidimensionality with presence of multiple latent traits with eigenvalues ≥ 1 .

125. Correlation of Pre-Operative Deformity Magnitude and Pulmonary Function Tests (PFT) Revisited: A Study of 492 Scoliosis Patients to Improve the Prediction of PFT using Radiographs

Heiko Koller, MD; Oliver Meier, MD; Juliane Zenner, MD; Marc Dreimann Germany

Summary: Analysis of 492 pts stressed that pulmonary function (PF) is a dependant of the deformity magnitude in the coronal and sagittal plane: Extended statistics revealed that the major impact of thoracic kyphosis (TK) on PF resides in the lower and upper spectrum of TK in combination with the magnitude of the thoracic curve. Prediction models were established that enable improved estimation of PF by the radiographic deformity. This can facilitate treatment of patients that do not comply with PFT.

Introduction: Preoperative PF study is of importance to calculate the individual burden of the selected procedure. A spirometer is the standard of reference for PFT. However, calculation of PF based on the radiographic deformity is important, because some patients cannot comply with spirometer tests.

Methods: 492 patients with a structural thoracic or thoracolumbar curve (TC) were assessed. Patients had preop PFT using a spirometer and radiographic analysis of standard scoliosis and kyphosis measures. PF value reported was forced vital capacity expressed as a percentage of the predicted value (FVC%). According to the American Thoracic Society, classification of pulmonary impairment was into 'no' impairment (FVC: $>80-100\%$), mild (FVC: $>65\leq 80\%$), moderate (FVC: $>50\leq 65\%$), and severe impairment (FVC: $\leq 50\%$).

Results: Patients' age averaged 17 years. 94% had adolescent idiopathic scoliosis. All patients were ambulatory. 20% had lordoscoliosis (TK $<10^\circ$). FVC% was $75\pm 17\%$, TC was $57\pm 21^\circ$ and TK was $26\pm 25^\circ$. 38% of patients had no PF impairment, 37% mild, 15% moderate, and 10% severe impairment. Radiographic spinal and chest cage deformities (TC, TC-flexibility, apical vertebral

rotation of TC, and rib hump) significantly influenced FVC% ($p<.01$), as did the level of scoliosis apex ($p<.001$). The impact of radiographic deformity on PFT was stressed in patients with a FVC $\leq 50\%$ and included significantly increased TC ($p<.001$) and TC-bending ($p<.001$). Linear discriminant analysis with TC, TC-bending and TK indicated that TC-bending was the best predictor of a FVC $\leq 50\%$ (OR=1.04). For TK, logistic regression analysis revealed that the following factors are predictive for a FVC $\leq 50\%$: Increased scoliosis with a low TK (lordoscoliosis $<0^\circ$, OR=7.3) or a high TK (kyphoscoliosis $>60^\circ$, OR=20). For the combined influence of TK and TC on severe pulmonary impairment (FVC $\leq 50\%$) a prediction model could be established with a high correct classification rate (93%).

Conclusion: Scoliosis patients with a large TC and either high or low TK (kyphoscoliosis & lordoscoliosis) and a proximal apex of the TC are at highest risk for inferior FVC%. The developed models provide improved estimations of PF based on the magnitude of radiographic deformity. This is of particular use in pts that do not comply with PFT.

126. Relationship between Post-Operative Correction Rate and Screw Placement into Narrow Pedicles: Should We Challenge Narrow Pedicles in Adolescent Idiopathic Scoliosis?

Tsutomu Akazawa, MD; Toshiaki Kotani; Tsuyoshi Sakuma, MD, PhD; Shohei Minami

Japan

Summary: This study aimed to examine whether screw placement into narrow pedicles would affect the postoperative correction rates. The failure rate of screw placement increased as the pedicle channels became narrower. Pedicles with a "cortical channel" (inner diameter of less than 1 mm) resulted in a high failure rate of 31.5% but did not affect the postoperative correction rate. Screw placement should be performed in pedicles with an inner diameter of at least 1 mm.

Introduction: It is not yet known whether screw placement into narrow pedicles would improve the postoperative correction rate. This study aimed to examine whether screw placement into narrow pedicles would affect the postoperative correction rates.

Methods: The subjects were 55 patients with adolescent idiopathic scoliosis who had undergone posterior correction and fusion. Pre- and postoperative CT scans were used to evaluate 810 pedicles probed for screw placement using O-arm-based navigation. Pedicles were considered to have failed screw placement if probing was performed but screws could not be placed because of perforation, if screws were placed but were subsequently removed intraoperatively because imaging confirmed their malposition, or if postoperative CT showed a deviation of screw of at least 2 mm. The failure rate was defined as the percentage of pedicles with failed placement among the probed pedicles. The pedicle channel classification was used to evaluate the pedicle size. The inner diameter of the pedicle was measured on the preoperative CT scan. The pedicle channel was defined as type A (≥ 4 mm), as type B-1 (2.0-3.9 mm), as type B-2 (1.0-1.9 mm), as type C (< 1 mm). The failure rate was calculated by pedicle channel classification. An examination was conducted on how the percentage of

PODIUM PRESENTATION ABSTRACTS

each type among treated pedicles affected the postoperative correction rate of scoliosis.

Results: The failure rate was 0.5% for type A, 2.9% for type B-1, 12.0% for type B-2, and 31.5% for C. The failure rate of screw placement increased as the pedicle channels became narrower ($p < 0.001$). The postoperative correction rate was positively and significantly correlated only with the percentage of type B-2 ($r = 0.27$, $p = 0.049$). There was no significant correlation with type A, B-1, or C. **Conclusion:** The failure rate of screw placement increased as the pedicle channels became narrower. The postoperative correction rate increased as the percentage of type B-2 of the pedicle channel classification increased. However, pedicles with type C (inner diameter of less than 1 mm) resulted in a high failure rate of 31.5% but did not affect the postoperative correction rate. Screw placement should be performed in pedicles with an inner diameter of at least 1 mm.

127. Toei Study: Age Distribution and Health Related QOL of High Age Volunteers Evaluated by SRS Schwab Classification (Sagittal Modifiers)

Daisuke Togawa, MD, PhD; Yu Yamato; Tatsuya Yasuda; Sho Kobayashi, PhD; Hideyuki Arima; Tomohiko Hasegawa; Yukihiko Matsuyama, MD
Japan

Summary: Six-hundred-ninety-four high age volunteers (age over 50) with average age of 73 were participated in musculoskeletal examination in Toei town of Aichi prefecture in Japan. Sagittal spinopelvic parameters, Visual analogue scale (VAS), and health related QOL (EuroQOL and Oswestry disability index (ODI)) were evaluated. According to the SRS Schwab Classification, worse QOL results were observed in worse sagittal modifier level in all 3 modifiers. Aging and sagittal mal-alignment cause impairment of health related QOL and pain.

Introduction: The purpose of this study was to investigate age distribution and health related QOL of high age volunteers according to SRS Schwab Classification with special reference to 3 sagittal modifiers.

Methods: 746 volunteers with age of more than 50 were participated in this IRB approved study in Toei town of Aichi prefecture in Japan. There were 295 males and 451 females with average age of 73. Lateral whole spine and pelvic X-rays were digitally taken in neutral standing position. Radiographic parameters included Sacral Slope (SS), Pelvic Tilt (PT), Pelvic Incidence (PI), Lumbar Lordosis (LL), Thoracic Kyphosis (TK), Sagittal Vertical Axis (SVA) were measured by computer software. PI minus LL was also calculated. Visual analogue scale (VAS) for back pain and health related QOL (EuroQOL and Oswestry disability index (ODI)) were evaluated. According to the SRS Schwab Classification, with special reference to sagittal modifiers, age distribution in each decade (60s or less, 70s, 80s or over) and health related QOL by each modifier level were investigated.

Results: Digitized radiographs were successfully evaluated in 694 volunteers (274 male, 420 female, average age 73). Age distribution by each decade and results of health related QOL questionnaires (VAS, EuroQOL, and ODI) evaluated by SRS Schwab Classification (Sagittal Modifiers) were showed in Table 1. Higher age group had significantly larger percentages of population in worse sagittal modifier level in all 3 modifiers (PI minus LL, SVA, PT, $p < 0.0001$). Percentages of 'Two Plus' cases in PI minus LL, SVA, PT in age 80s or over were 31.6, 30.2, and 24.8, respectively. In VAS, EuroQOL, and ODI scoring,

worse results were observed in worse modifier level in all 3 modifiers, that was statistically significant ($p = 0.001$).

Conclusion: This is the first and largest investigation targeting on high age population with sagittal spinopelvic alignment associated with health related QOL. The results of this study suggested that the rate of sagittal spinopelvic malalignment in older population was much higher (up to approximately 30%) compared to the younger population reported in previous literatures. Sagittal spinopelvic mal-alignment causes impairment of health related QOL and pain.

128. Post-Operative Perfection: Ceiling Effects and Lack of Discrimination with Both SRS-22 and -24 in Adolescent Idiopathic Scoliosis Patients

Tracey Bastrom, MA; Carrie E. Bartley, MA; Michelle C. Marks, PT, MA; Burt Yaszay, MD; Peter O. Newton, MD; Harms Study Group
USA

Summary: Scores in domains shared by the SRS-22 and 24 differ significantly in adolescent idiopathic scoliosis patients and thus are not translatable. Both versions perform well in discriminating disease severity preoperatively with minimal ceiling effects. Frequent postoperative ceiling effects and the inability to discriminate between patients with different magnitudes of residual deformity brings into question the sensitivity of both versions in critically evaluating operative success.

Introduction: Despite improvements noted with the SRS-22, the SRS-24 is still occasionally utilized prospectively and for comparisons to previous studies reporting SRS-24 scores. The purpose of this study was to compare the SRS-22 and 24 in terms of scores, rate of ceiling effects, and discriminant ability in pre and post-operative settings in adolescent idiopathic scoliosis (AIS) patients.

Methods: A multi-center prospective registry of patients who underwent surgical correction of AIS was queried for pre-op and 2 year post-operative SRS-22 and 24 domain and total scores. Patients enrolled respond to 30 questions, which allows for generation of the 22 and 24 scores. Scores were compared for common domains (Pain, Self-Image, General Function) and total. Domains with $\geq 15\%$ patients scoring a perfect 5 were defined as meeting definition for ceiling effect. Groups of deformity severity were created based on Cobb > 1 standard deviation (SD) of the mean (high) and Cobb < 1 SD of the mean (low) at pre and post-op.

Results: 829 patients were identified. The SRS-22 scores for pain and general function were significantly greater than those of the SRS-24 ($p < 0.001$), whereas the 22 scores were significantly lower than the 24 for self-image ($p < 0.001$). No difference on total score was noted. Pre-operative ceiling effect was only noted in one domain each. Both versions were able to discriminate between large ($80^\circ+$) and small ($< 45^\circ$) preop curves in all shared domains and total scores ($p < 0.05$). Post-op, the SRS-22 scores for all shared domains and total score were significantly greater than the 24 scores ($p < 0.001$). Ceiling effects in 5 of 6 domain/total scores were noted post-op for the 22 and in 4 of 7 for the 24. With a smaller range of deformity post-op, only the 22 self-image domain was able to discriminate between large ($29^\circ+$) and small ($\leq 11^\circ$) curves ($p < 0.05$).

Conclusion: The scores obtained by the 22 and the 24 are not translatable despite shared domains. Despite discriminating disease severity pre-operatively, post-operative discrimination of residual deformity is lacking in both tools.

PODIUM PRESENTATION ABSTRACTS

Patient reported outcomes of treatment are crucial in advancing treatment and improvement in the ability to assess is essential.

129. Observational Analysis of Changing Trends in Level of Evidence (LoE) of SRS Annual Meeting Podium Presentations in the New Millennium (2001-2013)

Nanjundappa S. Harshavardhana, MD, MS(Orth), Dip SICOT; John P. Dormans, MD
USA

Summary: Scoliosis research society annual meeting (SRS-AM) podium presentations disseminates best quality research results prior to their publication amongst professionals. We found a statistically significant increase in Levels of Evidence (LoE) I & II studies in current decade (2011-13) in comparison to previous decade (2001-03). SRS happens to be the first sub-specialty society affiliated to AAOS to have undertaken an exhaustive analysis of its annual meeting presentations in its commitment to evidence based medicine and excellence in research.

Introduction: Acceptance of an abstract for SRS-AM as a podium presentation (PP) is a benchmark of quality. Levels of evidence (LoE) are rating systems introduced by the AAOS to reflect quality of research studies. The objectives of this study were to:

- i) Report the LoE of all SRS-AM PP in the new millennium and analyse changing trends in LoE over a 13 year period (2001-13)
- ii) To compare the LoE over a three year period between first and second decade of new millennium

Methods: The SRS-AM proceedings books over three years from 2001-03 (Gr. I) and 2011-13 (Gr. II) were retrieved and two orthopaedic surgeons independently graded LoE of each abstract as per AAOS LoE grading system on two separate occasions one month apart. All clinical studies were assigned a LoE (between I to V) and categorised as either therapeutic, prognostic, diagnostic or decision-making / economic. Basic science, animal, biomechanical and lab based studies were marked as LoE not applicable. Any disparity in grading of LoE was discussed and agreed by consensus. Thus analysed abstracts of the two groups were subjected to Fischer's exact test to determine statistical significance.

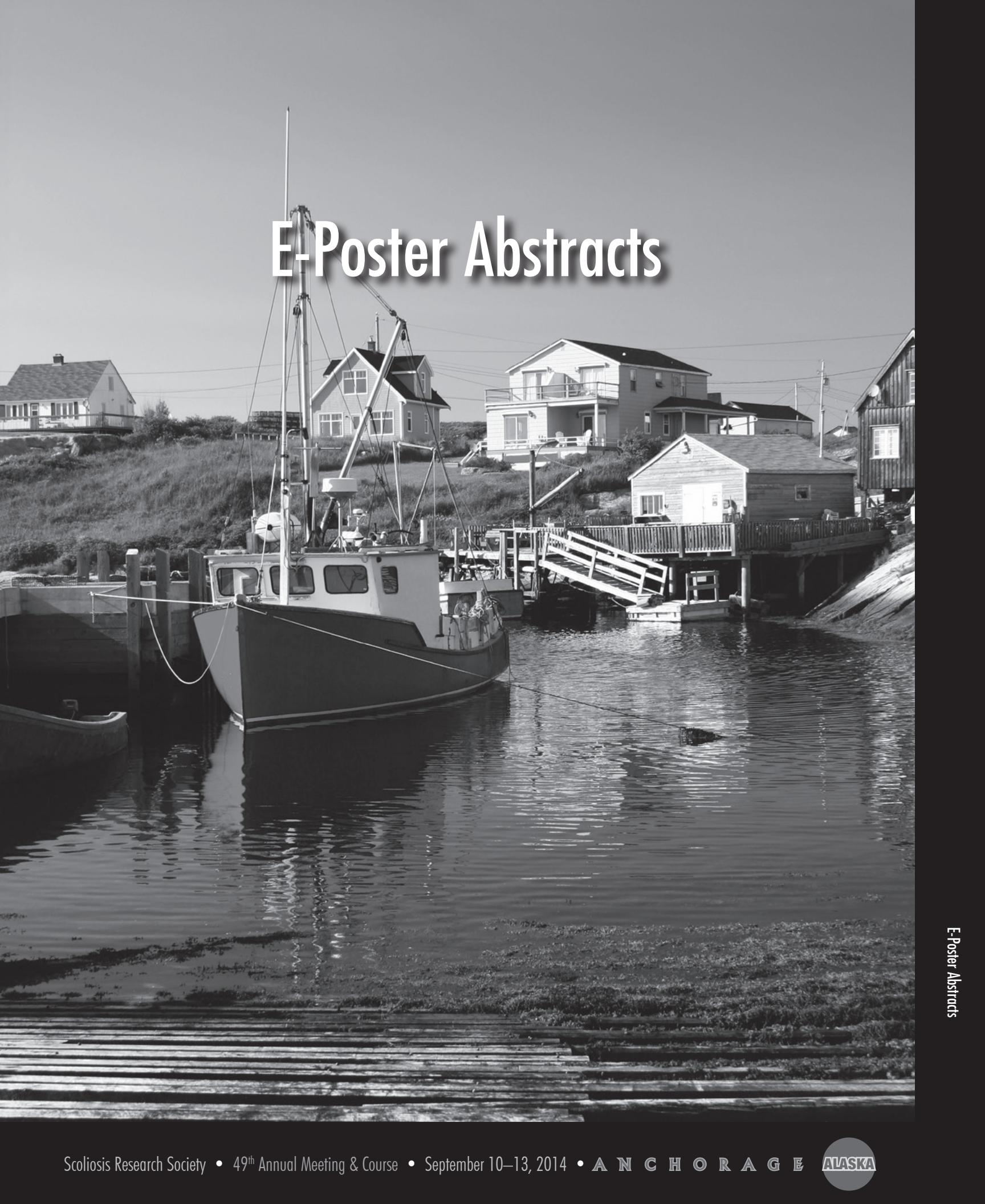
Results: 637 abstracts from six annual meetings were reviewed (264 in Gr. I vs. 373 in Gr. II). Majority of SRS-AM PP were therapeutic clinical studies (61% in both groups). The number of LoE I & II studies had doubled from 21.2% in Gr. I to 42.1% in Gr. II which was statistically significant (Fischer's two tailed $p < 0.0001$). There was a decline in LoE III & IV studies from 61.75% in Gr. I to 50.4% in Gr. II. The detailed analysis of all 637 abstracts with year-wise and group-wise breakdown is summarised in Table 1.

Conclusion: The LoE of SRS-AM PP in the new millennium between the first and second decade has substantially improved with a statistically significant increase in number of LoE I & II studies. This is a reflection of SRS leadership and presidential line's commitment to continuing quality improvement and evidence based practice of spinal deformity surgery. This is the first study by a specialist society affiliated to AAOS to have undertaken an in-depth analysis of its annual meeting PP. This study will serve as a baseline comparative tool to evaluate SRS' presentations in forthcoming years / decades.

Fig 1: Year-wise and group-wise breakdown of SRS-AM podium presentations for levels of evidence (LoE)

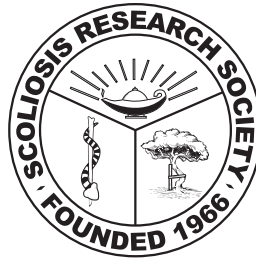
Year	Total abstracts	LoE not applicable	Clinical Studies							
			LoE I	LoE II	LoE III	LoE IV	Therapeutic	Prognostic	Diagnostic	Economic
2001	88	18	4	16	14	36	53	15	2	--
2002	86	13	1	17	18	37	54	18	1	--
2003	90	14	5	13	17	41	55	19	2	--
Group I	264	45	56		163		162	52	5	--
2011	115	10	9	42	26	28	73	28	3	1
2012	129	6	8	49	37	29	75	39	6	3
2013	129	12	8	41	39	29	79	33	2	3
Group II	373	28	157		188		227	100	11	7

E-Poster Abstracts



E-Poster Abstracts





The Scoliosis Research Society gratefully acknowledges
OrthoPediatrics for support of the
Farewell Reception.



E-POSTER ABSTRACTS

E-POSTER INDEX

This index includes all accepted E-Posters whose authors confirmed participation prior to publication. If provided by the author, E-Posters are available for viewing at the E-Poster kiosks in Idlught 3 located across from registration and on the CD-ROM provided with your registration materials.

E-Posters may be viewed at specialized kiosks, in Idlught 3, as well as the CD-ROM included with your registration materials, supported, in part, by a grant from K2M.

E-Poster Categories

Adolescent Idiopathic Scoliosis
 Adult Spinal Deformity
 Basic Science
 Cervical Deformity
 Complications/Infections
 Congenital Deformity
 Diagnostic Methods
 EOS
 Etiology/Genetics
 Innovative Methods
 Kyphosis
 Lumbar Degenerative
 Misc
 Natural History
 Neuromuscular Deformity
 Non-Operative Treatment Methods
 Spondylolisthesis
 Trauma
 Tumors

E-Poster Numbers

201-217
 218-232
 233-237
 238-239
 240-254
 255-257
 258-261
 262-267
 268
 269-277
 278-279
 280
 281-288
 289-290
 291-293
 294-295
 296-297
 298-300
 301-303

201. Most Lenke II & IV Concave Proximal Thoracic Pedicles Lack a Cancellous Channel for Pedicle Screw Cannulation

*Nanjundappa S. Harshavardhana, MD, MS(Orth), Dip SICOT; Eric J. Sarkissian, BS; John M. Flynn, MD
 USA*

Summary: While using image guided navigation over the past 5 years, we have observed that Lenke II and IV concave upper thoracic pedicles are often extremely narrow. Reviewing the navigation CT data from a consecutive series of 33 Lenke II and IV cases, we found that the concave upper thoracic pedicles in structural PT curves have neither cancellous channel (62.5%) nor adequate minimum transverse diameter of at least 4mm (73.6%) to be cannulated by commercially available pedicle screws.

Introduction: The purposes of our study were to evaluate the length and diameter of pedicles in UTV in Lenke II & IV AIS and to perform qualitative evaluation of pedicle channels.

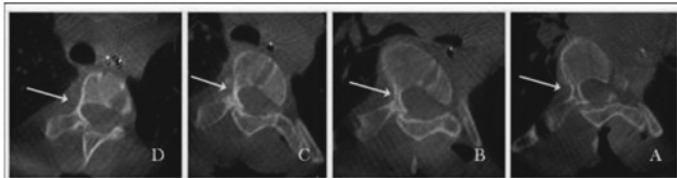
Methods: 262 consecutive patients operated at a single tertiary center for AIS were reviewed. 33 patients (15M;18F) who had Lenke II(30) and Lenke IV(3) structural upper thoracic curves formed the study cohort. The mean age at surgery was 14.5 years (range 11.3-19.3); the mean Cobb angle 40° (range 26°-57°). All PT curves were convex to left. Two independent observers evaluated upper thoracic spine (T1-T6) recording:

- i) Maximum transverse diameter of pedicle from outer cortex of inner wall to outer cortex of outer wall of pedicle
- ii) Maximum length of pedicle from outer cortex of entry point to anterior vertebral cortex along its trajectory.
- iii) Qualitative evaluation of pedicle channels into 4 sub-types (A-D) as per Fig 1: Adequate cancellous(A); Small cancellous(B); Cortical(C) and No channel(D). Descriptive statistics and Intra-class correlation coefficient(ICC) was performed using SPSS v.16 to account for inter-observer variability.

Results: Intra-op CT (i.e. O-Arm II) images were available and measurements possible for 144 concave and 146 convex out of 192 pedicles. The mean diameter of concave pedicles at T3, T4 & T5 was <3.0 mm in comparison to their convex counterparts which were >4.0mm. 82.5% of convex pedicles had cancellous channels (types A & B). Majority of concave pedicles (62.5%) either had cortical or no channels (types C & D). The pedicle length, diameter and channel characteristics for each vertebral level is as per table1. The Cronbach's α was 0.81 (excellent agreement between the two observers).

Conclusion: Most of concave upper thoracic pedicles in structural PT curves have neither a cancellous channel (62.5%) nor adequate minimum transverse diameter of at least 4mm (73.6%) to accept commercially available pedicle screws. Although pedicle screws can be safely placed alongside these cortical concave pedicles (in-out-in technique), fixation may be poor; concave upper thoracic hooks may be a better choice.

E-POSTER ABSTRACTS



- Type D:** No Pedicle channel. No cortex or one cortex seen
Juxta pedicular placement
- Type C:** Cortical channel. Both inner & outer cortex seen
Needs tapping for screw insertion
- Type B:** Narrow cancellous channel. Will accept pedicle screw
Expansion / plastic deformation of channel occurs
- Type A:** Normal cancellous channel. Will accept a pedicle screw easily

Table 1: Morphometric characteristics of UTV pedicles (T1-T6) in Lenke II & IV AIS curves

Channel Morphology	Concave Side				Vertebra	Diameter	Convex Side				
	A	B	C	D			Length	Diameter	Length	D	C
1	X	2	3		T1	5.08 ± 1.23	29.17 ± 4.86	x	x	2	1
5	5	4	3		T2	4.77 ± 1.47	30.93 ± 4.21	x	3	4	5
4	4	11	6		T3	4.16 ± 1.36	31.60 ± 4.00	x	3	12	14
3	2	14	13		T4	4.28 ± 1.37	32.18 ± 3.95	x	5	9	18
4	6	12	11		T5	4.20 ± 1.25	31.73 ± 4.22	x	6	7	20
5	15	5	8		T6	3.96 ± 1.32	32.54 ± 4.38	3	6	7	17

Pedicle channels A-D and dimensions (width & length)

202. Spinal Deformity Surgery: In Cases of Intraoperative Monitoring Alert, the Use of a Flexible Epidural Spinal Electrode Allows the Determination of a Lesional Level

Jean-Luc Jouve, MD; Sebastien Pesenti; Elie Choufani; Isabelle Suprano; Gérard Bollini; Martine Gavaret, MD, PhD

France

Summary: Analysis of a prospective series of 800 consecutive cases (2004-2014) undergoing intraoperative monitoring in paediatric orthopaedic spinal surgery.

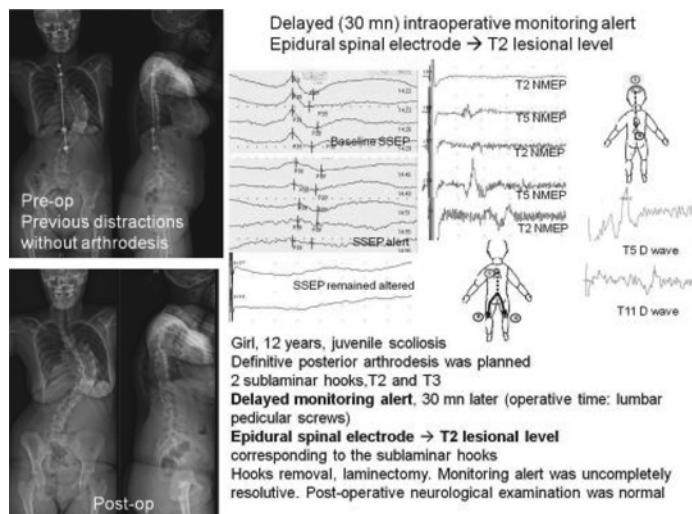
Introduction: The objective of this study was to demonstrate that in case of monitoring alert, the use of a spinal electrode allows the determination of a lesional level.

Methods: Methods consist in: 1/ somatosensory evoked potentials (SSEP), 2/ neurogenic mixed evoked potentials (NMEP) with a spinal electrode, 3/ D waves were practised with the same spinal electrode, in order to assess selectively corticospinal tracts 4/ testing of pedicular screws. A uniform total intravenous anaesthesia was practised. In case of monitoring alert that remained during few minutes, the lesional level was diagnosed either with NMEP either with D waves, by displacing the spinal electrode along the inter-vertebral spaces.

Results: 60 monitoring alerts considered as true positive occurred (7.5%). Pathologic values (<10 mA) of pedicular screws testing were not considered here in spinal monitoring alerts. Several monitoring alerts with determination of a lesional level are presented. We particularly illustrate (Fig) the case of a girl, 12 years old who had previous distractions without arthrodesis. Two sublaminar hooks were positioned at the levels T2 and T3. The monitoring alert occurred half an hour later, while surgeons positioned the lumbar pedicular screws. Displacement of the epidural electrode allowed the determination of a lesional level T2, corresponding to sublaminar hooks positions. Monitoring alert was uncompletely resolvable after hooks removal and laminectomy T2. After removal

of the instrumentation, her spine was subsequently bone graft and closed. Post-operative neurological examination was normal.

Conclusion: In case of monitoring alert, it is usually considered that the surgeon has to evaluate what he/she was doing 1-10 minutes earlier. The identification of a lesional level appears to be particularly important when the alert of the monitoring is delayed with regard to the surgical act which was harmful. We report, with different monitoring alerts examples, that determination of a lesional level, with NMEP (or D waves), moving the flexible epidural spinal electrode along open inter-vertebral spaces, helps the surgical team to identify the monitoring alert etiology and thus to react in the most informed and appropriate way.



Delayed monitoring alert, 30 mn after the positionnement of two sublaminar hooks T2-T3. A lesional level T2 was diagnosed with an epidural spinal electrode. Normal post-operative neurological examination.

203. Implementation of an Accelerated Pathway Reduced Hospital Stay following Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis by Nearly 50 Percent: A Multicenter Comparative Study

Nicholas D. Fletcher, MD; Lindsay Andras, MD; David E. Lazarus, MD; Robert J. Owen, BS; Benjamin Geddes; Jessica Cao, BS; David L. Skaggs, MD, MMM; Timothy S. Oswald, MD; Robert W. Bruce, MD

USA

Summary: Hospital stay was 48% shorter in patients managed with an accelerated discharge pathway following posterior spinal fusion for adolescent idiopathic scoliosis without any increase in complications. This study supports the use of a coordinated, multidisciplinary pathway to improve efficiencies in post operative care of AIS patients.

Introduction: Hospital stay following posterior spinal fusion (PSF) for adolescent idiopathic scoliosis (AIS) has decreased only modestly over time despite a healthy patient population. The purpose of this study was to evaluate the impact of a novel post operative pathway on length of stay (LOS) and complications.

Methods: A retrospective review of patients undergoing PSF for AIS in 2011-12 was performed at two institutions evaluating demographics, preoperative Cobb angles, surgical duration, blood loss, length of stay, and post operative

E-POSTER ABSTRACTS

complications. Patients at one center were managed using an accelerated discharge pathway emphasizing transition to oral pain medications on post operative day 1, mobilization with PT 2-3 times/day, and discharge prior to complete return of bowel function. Patients at the other center were managed without a standardized pathway.

Results: 105 patients underwent PSF and were treated by an accelerated discharge pathway (AD) while 45 patients were managed using a traditional discharge pathway (TD). There was no difference in proximal thoracic and main thoracic Cobb magnitudes and a small difference in thoracolumbar curve magnitudes ($35\pm 13^\circ$ AD vs $42\pm 13^\circ$ TD, $p=0.004$) between groups. AD patients were treated using 16% fewer pedicle screws (mean pedicle screw density 1.34 vs 1.58, $p<0.0001$), with 9% fewer levels fused (mean 10.2 ± 2 vs 11.2 ± 2 , $p=0.02$) and had a slightly shorter surgical time (median 3.1 hours vs 3.9 hours, $p=0.0003$) with a similar EBL (median 275cc (AD) vs 400cc (TD), $p=0.06$). Length of stay was 48% shorter in the AD group (2.2 days vs 4.2 days, $p<0.0001$). Length of surgery (Spearman rho (r)= 0.22 , $p=0.007$) and levels fused ($r=0.22$, $p=0.009$) showed weak correlation with length of stay and there was no correlation between length of stay and EBL. There was no difference in readmissions or wound complications between groups.

Conclusion: Hospital stay was nearly 50% shorter in patients managed by the AD pathway without any increase in readmissions or early complications.

204. Study of Neural Connectivity using DTI-Tractography of the Sensorimotor Network in Idiopathic Scoliosis

Julio Doménech, MD, PhD; Angel Alberich-Bayarri; Luis Martí-Bonmati; Gracian Garcia; Maria de la Iglesia-Vaya; Jose M. Tormos, MD, PhD; Daniel Bonete, MD; Alvaro Pascual-Leone
Spain

Summary: Diffusion tensor imaging (DTI) and probabilistic tractography was used to identify the specific circuit abnormalities in idiopathic scoliosis in adolescents as compared to healthy controls. Idiopathic scoliosis patients showed a significant reduction in maximal diffusivity of the cerebello-thalamo-cortical tract suggesting a connectivity alteration similar to that found in dystonic disorder.

Introduction: The aetiology of idiopathic scoliosis (IS) remains largely unknown, but growing evidence suggests an underlying CNS disorder. IS patients have an asymmetric interhemispheric motor cortex hyperexcitability evidenced with paired pulse transcranial magnetic stimulation. They also show an increased activation of the supplementary motor cortex as revealed by functional MR imaging. Such findings are consistent with a subclinical sensorimotor integration disorder, reminiscent of idiopathic dystonia in which a sensorimotor integration disorder may be a causative factor.

Diffusion tensor imaging (DTI) allows identification of white matter fibres within fascicles, which appear grouped in compact packages and thus limit the movement of water molecules primarily to a direction parallel to the main vector of axons structure. This characteristic allows the creation of a synthetic reconstruction of the brain nervous routes (tractography) using probabilistic approaches.

Methods: Twenty patients with IS and 20 healthy age- and gender-matched controls were studied using 3T MR imaging probabilistic diffusion tractography.

The MR acquisition parameters for DTI imaging included a spin-echo echo-planar imaging (SE-EPI) single-shot pulse sequence with a b-value of 1300 s/mm²; 64 different space directions; TR: 6200 ms; TE: 67 ms; voxel size 2 x 2 x 2 mm; 60 axial slices. Fractional anisotropy, diffusivity, length and number of reconstructed fibers were analyzed for each defined tract

Results: The main finding of this study is a significant reduction in maximal diffusivity of the cerebello-thalamo-cortical tract in IS patients as compared with healthy controls. No differences were found in the corticospinal tract.

Conclusion: These findings suggest the hypothesis of a defective motor control at central level, involving cortico-subcortical-cerebellar circuitries, in IS patients reminiscent to that found in idiopathic dystonia, that may be related to the pathophysiology of the spinal deformity.

205. National Trends in Spinal Fusion for Pediatric Patients with Idiopathic Scoliosis: Demographics, Blood Transfusions and Complications *Hiroyuki Yoshihara, MD, PhD; Daisuke Yoneoka, MS*

USA

Summary: The purpose of this study was to analyze the trends in spinal fusion for pediatric patients with idiopathic scoliosis on a national level. During the last decade, 30% of pediatric patients with idiopathic scoliosis who underwent spinal fusion received any type of blood transfusion and strategies for blood transfusion methods have changed since. A decreasing trend in the respiratory complication rate and reduction in length of hospital stay may indicate better postoperative care.

Introduction: Spinal fusion for pediatric patients with idiopathic scoliosis is required for rapid curve progression. For such patients, blood transfusions and complications are important aspects of the surgery. The purpose of this study was to analyze the trends in spinal fusion for pediatric patients with idiopathic scoliosis on a national level with regard to demographics, blood transfusions, and complications.

Methods: A retrospective analysis using hospital discharge data from the NIS was performed from 2000 to 2009. The International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) codes were used to identify discharges. Patients aged ≤ 17 years who were primarily diagnosed with idiopathic scoliosis (ICD9 code: 737.30) and who underwent spinal fusion surgery (CCS code: 158) were included in this analysis. Demographics of the patients were retrieved. Trends in demographics, blood transfusion methods, and complications were analyzed.

Results: The total number of patients included in this study was 43983. A total of 30.4% of patients received any blood transfusion. Predonated autologous blood transfusions decreased over time, whereas perioperative autologous blood transfusions increased over time ($p < 0.05$, respectively). The overall complication rate was 14.4%. The respiratory complication rate was the highest among complications; however, the rate decreased over time ($p = 0.003$). The mean length of hospital stay decreased over time ($p = 0.043$).

Conclusion: During the last decade, 30% of pediatric patients with idiopathic scoliosis who underwent spinal fusion received any type of blood transfusion and strategies for blood transfusion methods have changed since. A decreasing trend in the respiratory complication rate and reduction in length of hospital stay may indicate better postoperative care.

E-POSTER ABSTRACTS

206. A Prospectively Collected Multicenter Cohort Analysis of Anterior versus Posterior Spinal Fusion for Lenke 5 (Thoracolumbar/Lumbar) Adolescent Idiopathic Scoliosis

Mark A. Erickson, MD; Brendan Caprio; Sumeet Garg, MD; Cameron Niswander; Zhaoxing Pan, PhD; John B. Emans, MD
USA

Summary: ASF and PSF provide equivalent outcomes for patients with Lenke 5 AIS. ASF may save a fusion level, but has longer operative time than PSF.

Introduction: Both ASF and PSF are utilized for treatment of Lenke 5 AIS patients. A comparative analysis was done to determine if any differences in outcomes or complications are present between techniques.

Methods: A prospectively collected multicenter database of patients treated surgically for AIS was retrospectively reviewed and identified 152 patients with Lenke 5 AIS and two year follow-up (98 ASF, 51 PSF, 3 ASF/PSF). Combined ASF/PSF patients excluded. Clinical and radiographic data was reviewed.

Results: There was no difference between groups in demographics, estimated blood loss, intra-operative blood transfusions, or length of stay. PSF patients had significantly less operative time (223 min vs 297 min, $p<0.0001$) and were fused one level longer than the ASF group (5.9 vs 4.6, $p<0.0001$). The PSF group had more frequent post-operative blood transfusions (45% vs 5%, $p<0.0001$). There were no significant differences between radiographic measures (Table 1). Percent surgical correction was not different between groups (66% PSF, 62% ASF, $p=0.2591$). The lowest end vertebra (LEV) was selected as the lowest instrumented vertebra (LIV) in 73% of PSF and 61% of ASF subjects. The LIV was cephalad to the LEV in 16% of PSF and 35% of ASF subjects. The LIV was caudal to the LEV in 11% of PSF and 4% of ASF subjects. There was no difference in overall or domain specific SRS 22 scores between groups.

Conclusion: There are no differences in radiographic or clinical outcomes between patients having ASF or PSF for Lenke 5 AIS. The average number of levels fused is greater with PSF and operative time is longer with ASF.

207. Selective versus Non-Selective Thoracic Fusion in Lenke 1C Curves: A Meta-Analysis of Baseline Characteristics and Postoperative Outcomes

Anthony J. Boniello, BS; Sun Yang, BA; Saqib Hasan, MD; Michael C. Gerling, MD; Peter G. Passias, MD
USA

Summary: A meta-analysis of case-control studies was conducted, evaluating selective versus non-selective thoracic fusion of Lenke 1C curves. Baseline and postoperative demographic variables, patient-reported health scores and radiographic parameters were compared. Patients treated with non-selective fusion had significantly worse appearance and pain scores and radiographic measurements at baseline than those treated with selective fusion. Radiographic parameters improved in both groups and were equivalent between groups post-operatively. These findings suggest surgeon preference for longer fusion in patients with greater deformity.

Introduction: Lenke 1C curves are challenging due to the structural thoracic deformity and nonstructural lumbar curve. Selective thoracic fusion (STF) is considered standard as it preserves motion of the lumbar segment, yet Non-STF

remains prevalent. This study aims to identify baseline patient characteristics that drive treatment and compare postoperative outcomes.

Methods: Studies were identified for meta-analysis that compared baseline and postoperative demographics, health-related questionnaires (HRQL) and radiographic parameters of Lenke 1C curve patients undergoing STF or Non-STF. The effect measure was expressed as a Mean Difference (MD) with 95% CI. A positive MD meant a greater STF value, or a mean increase within the group. Variables reported in only one study were compared with a t-test.

Results: 1 prospective and 5 retrospective case-control studies with sample size of 453 (309 STF, 144 Non-STF) were identified. Baseline age, gender and HRQLs were equivalent, except for better scores in STF group for SAQ: Unrelated to Deformity (3.47 vs 3.88, $p=0.01$) and SRS-22 Pain (4.13 vs 3.92, $p=0.04$). Radiographs were significantly worse in Non-STF, as measured by TL/L Cobb (MD: -4.29, $p<0.01$) and TL/L AVT (MD: -6.08, $p<0.01$). Radiographs significantly improved in STF, as measured in MT Cobb (MD: -28.84, $p<0.01$), TL/L Cobb (MD: -16.24, $p<0.01$), MT:TL/L Cobb Ratio (MD: -0.21, $p<0.01$) and TK (MD: 7.87, $p<0.01$); and in Non-STF in PT Cobb (24 vs 14.1, $p<0.01$), MT Cobb (53.5 vs 20.5, $p<0.01$) and TL/L Cobb (41.6 vs 16.6, $p<0.01$). Post-op TL/L Cobb (23.1 vs 16.6, $p<0.01$) was significantly higher in STF; but PT Cobb, MT Cobb and MT:TL/L Cobb ratio were equivalent.

Conclusion: Lenke 1C curves treated with Non-STF had significantly worse baseline appearance and pain scores, and radiographic parameters. Radiographic parameters improved in both groups, and were equivalent between groups postoperatively. These findings suggest surgeon preference for Non-STF for greater deformity. Few studies offer a comprehensive assessment of patient characteristics and radiographic measurements of Lenke 1C curves, which are needed to guide surgical decision-making.

E-POSTER ABSTRACTS

Preop Demographics: STF vs Non-STF (¥)			
Variable	STF (SD)	Non-STF (SD)	p values
Age	14.7	14.8	0.377
Female (%)	89.8	86.4	0.379
SAQ: Severity of Deformity	2.49 (0.58)	2.56 (0.55)	0.36
SAQ: Unrelated to Deformity	3.47 (1.18)	3.88 (1.04)	0.010*
SAQ: Related to Deformity	1.97 (1.02)	1.83 (0.94)	0.286
SRS-22: Total	3.86 (0.48)	3.81 (0.49)	0.426
SRS-22: Pain	4.13 (0.77)	3.92 (0.79)	0.038*
SRS-22: Appearance	3.31 (0.62)	3.32 (0.63)	0.933
SRS-22: Activity	4.17 (0.50)	4.13 (0.64)	0.553
SRS-22: Mental	3.93 (0.73)	3.92 (0.69)	0.874
SRS-22: Satisfaction	3.61 (0.97)	3.69 (0.90)	0.519
Radiographic Parameters for STF: Preop vs Postop			
Parameter	MD	95% CI	p-value
MT Cobb	-28.84	-31.25, -26.44	<0.01*
TL/L Cobb	-16.24	-17.99, -14.48	<0.01*
(MT:TL/L) Cobb Ratio	-0.21	-0.29, -0.12	<0.01*
TL/L AVT (mm)	0.98	-2.09, 4.04	0.53
Coronal Balance (cm)	0.4	-0.11, 0.90	0.12
TL/L AVR	-1.45	-3.74, 0.85	0.22
Thoracic Kyphosis	7.87	3.36, 12.39	<0.01*
Lumbar Lordosis	-1.43	-5.59, 2.73	0.5
Radiographic Parameters for Non-STF: Preop vs Postop (†)			
Parameter	Preop (SD)	Postop (SD)	p-value
Proximal Thoracic Cobb	24 (6.8)	14.1 (6.9)	<0.01*
MT Cobb	53.5 (12.0)	20.5 (8.6)	<0.01*
TL/L Cobb	41.6 (7.8)	16.6 (7.6)	<0.01*
Ratio (MT:TL/L) Cobb	1.2 (0.2)	1.5 (1.0)	0.21
Postop Radiographs: STF vs Non-STF (†)			
Parameter	STF (SD)	Non-STF (SD)	p-value
Proximal Thoracic Cobb	13.1 (6.1)	14.1 (6.9)	0.58
MT Cobb	22.3 (6.8)	20.5 (8.6)	0.42
TL/L Cobb	23.1 (5.5)	16.6 (7.6)	<0.01*
Ratio (MT:TL/L) Cobb	1.0 (0.3)	1.5 (1.0)	0.29

Note: (*) denotes statistical significance. (¥) Crawford, 2013. P-value from paired Student's t-test. (†)Demura, 2013. P-value from paired Student's t-test.

Demographic, health related quality of life scores, and radiographic parameters.

208. Analysis of Angle Velocity Fluctuation Triggered by the Pubertal Spinal Growth Peak in Bracing Female Idiopathic Scoliosis: Implications for Classification and Management

Saihu Mao, MD; Shi Benlong; Zhu Ze-zhang; Bangping Qian, MD; Feng Zhu; Zhen Liu; Xu Sun, MD, PhD; Yong Qiu
China

Summary: The rate of scoliosis deterioration is believed to keep pace with the rate of growth velocity in the natural history of IS. However, curve magnitude doesn't always rise in parallel with the rapid spinal growth in braced patients, with immediate curve reduction occasionally occurred following growth spurt.

Introduction: To testify if timing and magnitude of growth peak have significant impacts upon the angle velocity fluctuation or bracing outcome, and to define the evolutionary patterns of braced curves during rapid longitudinal growth.

Methods: Physically immature bracing female IS patients with open triradiate cartilage were evaluated every three to four months through their growth spurt with serial measurements of Cobb angle and multi-dimensional maturity indicators. The timing and magnitude of peak height growth velocity (PHGV), peak spinal growth velocity (PSGV) were identified and correlated to the peak angle velocity (PAV), the angle velocity (AV) by onset of PSGV and the outcome of brace treatment to determine if these growth parameters exert decisive impacts upon either the angle velocity fluctuation or the brace effectiveness. In addition, the AV by onset of PSGV was also defined as progressive, alleviative

and stable for the corresponding magnitude beyond 6°/y, beneath 0°/y (negative) and in between, respectively.

Results: Brace treatment through the pubertal growth spurt demonstrated a failure rate of 68.75%. Patients in the failure group were associated with advanced timing of PHGV (p=0.046) and PSGV (p=0.025), but not greater growth magnitude (p>0.05). The PAV was relatively higher and earlier in the failure group but with no statistical difference. Onset of PSGV triggered the sharp AV acceleration in 43.75% of the recruited patients with the magnitude being 10.67°/y, and those for the stable and alleviative group were 25.0% and 31.25%, respectively. 70.0% of the alleviating angle velocity at PSGV was subsequently reversed to a sharp progressive one at relatively low growth velocity following growth peak, while that for the progressive AV being reversed to be alleviative was 28.6%. The time gap between PAV and PSGV was significantly longer in the alleviative group as compared with the other two groups (p=0.026).

Conclusion: This finding corroborated that the AV fluctuation at PSGV were not firmly decisive of bracing outcome, while relatively advanced onset of PHGV and PSGV were a crucial determinant of failed brace treatment.

209. Lenke 5 AIS Treated by Selective Posterior Fusion with Minimum Five-Year Follow Up

Brice Ilharreborde, MD; Keyvan Mazda
France

Summary: Lenke 5 curves often require a distal fusion leaving only 2 or 3 lumbar mobile segments. 40 patients treated by selective posterior fusions were reviewed with EOS radiographs and SRS-22 questionnaires. Outcomes were satisfactory at 8-year follow-up, even in fusions extending to L4. Revision rate was 15%, and L4L5 disc height remained stable over time.

Introduction: Most of the studies on AIS outcomes report only 2-year follow-up. Lenke 5 curves often require a distal fusion leaving only 2 or 3 mobile segments at risk of adjacent degeneration. Aim of this study was to report the radiological and functional outcomes of Lenke 5 AIS treated by selective posterior fusion, with a minimum 5-year follow-up.

Methods: 40 patients were included with a mean follow-up of 8 years (5 to 10.5 years). Spinal and pelvic parameters were measured using EOS low-dose stereoradiography, and surgical corrections were calculated. Aims of surgery were to obtain a postoperative frontal imbalance < 2cm, a remaining iliolumbar angle < 5° and a restored sagittal alignment. Adjacent complications, such as proximal junctional kyphosis (PJK), progression of the unfused thoracic curve and distal adding on were reported. In addition, lumbar disc heights were measured at each evaluation, and SRS-22 scores were obtained at latest follow-up.

Results: Significant improvement of coronal Cobb angle was reported, without loss of correction. Frontal imbalance was significantly reduced, and progressive improvement continued during follow-up. Lumbar lordosis averaged 60° at follow-up, but was adapted to pelvic incidence in only 50%, with a tendency towards overcorrection. Iliolumbar angle was reduced but remained >5° in 42.5%, without significant influence on the SRS score. Average SRS-22 score was 4.06, with no correlation to any radiological parameter. No progression of the unfused thoracic curves was observed, but 8 patients (20%) developed radiological PJK. Only 2

E-POSTER ABSTRACTS

patients (5%) required revision. Distal disc heights increased after surgery, and remained unchanged at follow-up. One patient developed symptomatic distal adding-on and required 2 revisions. Overall revision rate was 15%, and 73.5% of the patients reported no use of pain medication.

Conclusion: Posterior selective fusion provides satisfactory outcomes at 8-year follow-up, even when extending to L4. Only 7.5% underwent revision for adjacent complications, and L4L5 disc height remained stable over time. However, correlation between radiological parameters and SRS-22 scores needs to be further studied.

210. Prevention of Adding On with the Surgical Correction of Thoracolumbar / Lumbar Curves in AIS

Heiko Koller, MD; Michael Mayer, PhD; Juliane Zenner, MD; Oliver Meier, MD Germany

Summary: A study was conducted to analyse the risk factors for adding-on (AO) in a series of 245 patients that underwent anterior fusion for thoracolumbar/lumbar (TL/L) curves. The risk for AO was significantly increased if the lowest instrumented vertebra (LIV) was rotated, 2 levels short off the stable vertebra (SV) or 1 level short off the end-vertebra (EV), and particularly if the LIV was selected at a lumbar level with an albeit parallel subadjacent disc.

Introduction: In TL/L curves failure to select the appropriate LIV can result in AO in the lumbar curve (LC) with the need for distal extension of fusion. The purpose of this study was to determine predictors for AO that can improve the selection of LIV.

Methods: Retrospective analysis of 245 patients that had anterior fusion for TL/L curves. The distance of LIV to SV and LIV to EV was recorded. An increase of the LIV subadjacent disc angle (LIVDA) $\geq 5^\circ$ was defined as AO. Rotation of the LIV (LIV-ROT) was measured according to Nash&Moe. Among standard scoliosis measures, the tilt of the L4 vertebra (L4-Tilt) was analyzed. Multivariate statistical analyses were done to determine strongest predictors for AO.

Results: Mean patients' age was 17yrs, mean fusion length was 4.6 levels, F/U averaged 32 months. Preop Cobb angle at fusion levels was corrected from preop 48° to 16° at F/U (67%). For scoliosis measures see table 1. 68% of patients had LIV at SV-2 (=2 levels above SV), 28% had LIV at SV-1. Preop L4-Tilt was $21 \pm 7^\circ$ and at F/U $10 \pm 6^\circ$ ($p < .01$). The magnitude of the L4-Tilt at F/U was largely predicted by the resolution of LC until F/U ($p < .01$, $r = 0.5$). The preop LIVDA was $4.7 \pm 3.5^\circ$, postop $4.6 \pm 2.9^\circ$, and at follow-up $6.1 \pm 3.8^\circ$. 31% of patients had AO. Patients with AO had a LIVDA at F/U averaging 9.8° compared to 4.4° for patients without AO ($p < .001$), LIVDA-increase averaged 7.6° vs -1.3° ($p < .001$). Patients with AO had smaller preop LIVDA (5.7° vs 2.3° , $p < .001$), while postop LIVDA was greater (3.9° vs 6.2° , $p < .001$). The risk of AO increased in patients failing to achieve a $LC \leq 20^\circ$ at F/U ($p = .008$). AO was more likely with LIV-SV=2 (40%) compared to LIV-SV=1 (20%) ($p < .0001$). The risk for AO with a LIV-EV=1 was twice that with LIV-EV=0 (Odds:2.0) or LIV-EV=1 (Odds:1.8). The incidence of AO was 14% with LIV-ROT=0, 31% with LIV-ROT=1 and 45% with LIV-ROT=2 ($p = .02$). Statistical analysis for the risk of AO established a cut-off value for a preop LIVDA at $< 3.5^\circ$ (specificity (71%) / sensitivity (86%)). 9 patients required late posterior fusion for AO.

Conclusion: The risk for AO is promoted by the difference between LIV and EV/SV, the preop LIV-ROT and the preop LIVDA. AO can be prevented by not stopping fusion at a level with nearly parallel subadjacent disc (LIVDA $< 3.5^\circ$).

211. Characteristics of Patients with AIS at the Lower and Upper Curve Severity Ranges: Implications for Outcomes

Stefan Parent, MD, PhD; Hubert Labelle, MD; Jean-Marc Mac-Thiong, MD, PhD; Randal R. Betz, MD; Amer F. Samdani, MD; Harry L. Shufflebarger, MD; David H. Clements, MD; Suken A. Shah, MD; Baron S. Lonner, MD; Peter O. Newton, MD Canada

Summary: The objective of this study was to determine the characteristics of patients at the extreme curve severity ranges. Smaller curves was composed mostly of Lenke 1 and 5 whereas larger curves had a higher proportion of double and triple curves. SRS-22 scores varied pre-operatively between small and large curves but post-operatively, these differences disappeared except for lower self-image in the large curve group. These results should be taken into account when discussing surgical correction with specific patients.

Introduction: Several studies have looked at overall complications and outcomes in large cohorts of AIS patients. However, is it possible that some factors that have a significant influence on outcome may be overlooked in a large cohort? The objective of this study was to determine the characteristics of patients at the extreme curve severity ranges.

Methods: All consecutive patients with AIS enrolled in a large, prospective database with minimum two-year follow-up were analyzed. Pre-operative and post-operative curve characteristics and SRS-22 data were reviewed. The cohort was then divided into the lowest 5% of curve severity (LCS) group and the upper 5% of curve severity (UCS) group; the typical group (TC) was comprised of patients at the median ± 1 degree ($51-53^\circ$) which is the calculated approximate 95% CI of the median.

Results: The upper cut-off point for the LCS group was 40° which represented about 7% of the cohort (80 patients Cobb angle = 40°) and included 22 patients $< 40^\circ$. The UCS group was composed of 72 patients with curves ranging from 78° to 128° and represented the most severe 5% of the cohort. All but one of the 22 patients $< 40^\circ$ were Lenke 5 and the LCS was composed mostly of Lenke 1 and 5. There was a higher proportion of double and triple major curves in the UCS group compared to the LCS group. Trunk shift was greater in the UCS group when compared to the LCS and the TC group. Post-operative Cobb differed between the UCS and the LCS and the UCS and the TC groups (LCS $16 \pm 6^\circ$, TC $18 \pm 7^\circ$ and UCS $30 \pm 11^\circ$). Pre-operatively, SRS-22 scores differed significantly with patients in the UCS group exhibiting more pain, decreased self-image, decreased general function and total scores compared to the TC and LCS groups (table 1) MCID was reached for pain and general function only. At 2 years post-op, there was no difference among groups except for lower self-image for the UCS group.

Conclusion: These results should be taken into account when discussing surgical planning, expectations and outcomes with a specific patient especially at the upper and lower end of curves that are surgically treated. This would allow the clinician, patient and family to set realistic expectations tailored to curve severity.

E-POSTER ABSTRACTS

212. Children with Medicaid Requiring Spinal Fusion for Scoliosis Present with Larger Curves than Patients with Private Insurance

Nicholas D. Fletcher, MD; David E. Lazarus, MD; Mihir J. Desai, MD; Nick Patel, BS; Robert W. Bruce, MD
USA

Summary: Patients with AIS and Medicaid insurance presented with larger curves and waited longer for surgery than patients with private insurance.

Introduction: Children with Medicaid may have difficulty accessing care for adolescent idiopathic scoliosis (AIS), a condition that may worsen with time. The purpose of this study is to determine whether patients with Medicaid present with a larger curve magnitude and wait longer for surgery.

Methods: A review of patients treated with spinal fusion (SF) for AIS was performed. Children seen as a second opinion were excluded. Charts were evaluated to assess the time from evaluation to the determination for surgery, the time from the recommendation for surgery until the actual procedure, and insurance status. Radiographs were reviewed to determine the Cobb angle at initial presentation. Patients were scheduled for surgery sequentially without preference for any insurance carrier.

Results: Between January 2008 and December 2012, there were 135 patients with newly diagnosed AIS that underwent SF by our group. Of these, 61% were privately insured and 39% carried Medicaid insurance. The mean Cobb angle at initial presentation of the privately insured patients was $47.5 \pm 14.3^\circ$ (range 18.0° - 86.0°) and $57.2 \pm 15.7^\circ$ (range 23.0° - 95.0°) for the patients with Medicaid ($p < 0.0001$). At time of surgery the Cobb angles were $54.6 \pm 11.7^\circ$ and $60.6 \pm 13.9^\circ$ for the private and Medicaid patients respectively ($p = 0.008$). Patients with Medicaid waited longer from the time surgical intervention was proposed until their surgical procedure (168 ± 181 days vs 102 ± 40 days, $p = 0.03$) and had a longer surgical wait time (115 ± 37 days vs 97 ± 3 days, $p = 0.06$) than those with private insurance although there was no difference in the duration of time from initial diagnosis until surgery. There was no statistically significant difference in the number of levels fused between patients with Medicaid and those with private insurance (10.3 ± 2.2 Medicaid vs 9.7 ± 2.3 Private, $p = 0.16$). There was no difference in length of hospital stay between patient groups (2.6 ± 0.8 days (Medicaid) vs 2.4 ± 0.5 days (Private), $p = 0.11$).
Conclusion: Patients with Medicaid who underwent spinal fusion for AIS had 10 degree larger presenting Cobb angles and longer delays until surgery than those with private insurance.

213. Increased Risk of Infection in Obese Adolescents after Pedicle Screw Instrumentation for Idiopathic Scoliosis

Chhavi Katyal, MD; Seth A. Grossman, MD; Aviva G. Dworkin, BS; Lewis P. Singer, MD; Terry D. Amaral, MD; Adam L. Wollowick, MD; Vishal Sarwahi, MD
USA

Summary: Few studies have evaluated the effects of increased BMI in children undergoing surgery. Adolescent idiopathic scoliosis (AIS) represents 80% of idiopathic scoliosis cases and is the most common indication for surgery.

Introduction: The purpose of this study was to evaluate perioperative risk factors associated with obesity in children undergoing posterior spinal fusion for AIS. We

hypothesized that patients with a high BMI would be associated with increased morbidity as measured by various intraoperative parameters.

Methods: Patients were divided into three groups: normal weight (144) (BMI $< 85\%$), overweight (25) (BMI $> 85\%$ - 95%), and obese group (38) (BMI $> 95\%$). Patients with BMI $< 5\%$ were excluded from this study. Perioperative data was collected and analyzed based on differences between groups.

Results: 207 patients were included in this study. There was a significant difference in the length of Anesthesia ($p = 0.032$). The rate of infection was 11% in obese group, 12% in the overweight group and 3% in normal weight group ($p = 0.03$).

Conclusion: In this study even with all pedicle screw instrumentation an increase in infection was seen in overweight and obese patients. Patients should be counseled prior to surgery for weight loss to limit surgical complications such as post-operative wound infection.

214. Scoliosis School Screening in the US: What is the Current Lay of the Land?

Charles T. Mehlman, DO, MPH; Kelly S. Falcone, MS; Sarah Wolff, BSN; Donna R. McAtee
USA

Summary: Only one state in the USA (Texas) currently lists scoliosis school screening standards on their governmental website that are in compliance with the SRS/POSNA/AAOS/AAP guidelines.

Introduction: Significant decreases in brace-able curves along with significant increases in the need for scoliosis surgery have been documented following cessation of school screening programs [Adolar et al 2012 Scoliosis]. The BraIST study has also established that we have an efficacious early intervention (bracing) for identified patients [Weinstein, Dolan et al 2013 NEJM]. The purpose of our study was to assess the status of scoliosis school screening programs in all 50 states in the United States of America.

Methods: The SRS, POSNA, AAOS, and AAP support scoliosis screening and these four professional societies suggest that females be screened twice at age 10 and 12 (grades 5 and 7), and boys once, at age 13 or 14 (grades 8 or 9). The governmental websites of all 50 states were systematically searched using the terms "scoliosis," "scoliosis screening," and "postural screening." The perspective of these searches was that of a school nurse interested in developing or improving a scoliosis school screening program. Websites that yielded no scoliosis information were searched by at least two different researchers. Pertinent information from each website was analyzed and compared to the SRS/POSNA/AAOS/AAP standard.

Results: Following recently repealed laws in three states (Indiana, Maryland, Washington), 18 states in the USA have legislatively supported scoliosis school screening, and an additional 4 states have strong website support for schools who wish to screen voluntarily. Only one state (Texas) is in compliance with the SRS/POSNA/AAOS/AAP guidelines.

Conclusion: A major reason for discontinuation of scoliosis school screening programs was insufficient evidence of an effective early intervention (i.e. bracing). Following the publication of the BraIST study, it is time for renewed discussion of such screening programs.

E-POSTER ABSTRACTS

215. Parental Anxiety with Posterior Spinal Instrumentation and Fusions for Adolescent Idiopathic Scoliosis

Jeffrey Kessler, MD; Samvel Gyurdzhyan

USA

Summary: We investigated the effect of communication on parental anxiety during their child's posterior spinal instrumentation and fusion (PSIF) for adolescent idiopathic scoliosis (AIS). State anxiety was measured preop and intraop. Fathers who did receive communication had a significant decrease in anxiety.

Introduction: Parents of children undergoing surgery experience considerable anxiety. The present study's purpose is to assess parental anxiety before and during PSIF for AIS, and determine whether communication with parents during PSIF decreases anxiety.

Methods: A randomized prospective study was conducted over 3 years on 50 patients with AIS undergoing PSIF. Each patient was randomized such that their parents would either receive communication (group C) via standardized script or no communication (group NC) during surgery. 25 sets of parents were assigned to each group. The state portion of the State-Trait Anxiety Inventory was given to parents preop and near the end of the surgery. The results were analyzed for statistically significant differences between the 2 groups and further stratified by parent gender.

Results: Groups C and NC were matched in terms of patient age, surgery time, and levels fused. There were no differences in preop anxiety scores between the 2 groups. In the NC group, fathers had a statistically significant increase in intraop anxiety scores (32.7 vs. 43.0, $p=.02$); no significant difference in intraop score was seen with mothers or with combined scores of both parents. In both groups, intraop anxiety scores were significantly lower than preop for all parents. However, the extent of the anxiety score decrease from preop to intraop was not significantly different between the 2 groups. Although more patients in group C (24 of 36 parents) had decreased anxiety scores from preop to intraop, as compared to those in group NC (20 of 36 parents), this difference was not significant. No relationship was found between surgery time and anxiety score.

Conclusion: Anxiety levels tend to decrease from preop to intraop in the parents of adolescents having PSIF for AIS. Regular communication with parents during surgery seems to decrease these anxiety levels in fathers.

216. The Use of Scoliosis Research Society and Other Patient Centered Outcome Instruments in Pediatric Spinal Deformity: A Bibliometric Analysis of Published Literature 2004-2013

Javier Guzman, BS; Holt Cutler, BSE; Motasem Al Maaieh; James Connolly; Branko Skovrlj, MD; Samuel K. Cho, MD

USA

Summary: Patient centered health measures have become the gold standard to assess efficacy of surgical spine procedures and are an essential component of cost-effectiveness research. Currently, however, there is an expansive range of patient reported outcome instruments without an established consensus as to which should be used for a particular diagnosis or procedure.

Introduction: There is currently no agreement as to what patient centered

outcome instruments should be used in pediatric spinal deformity surgery. This study aims to assess incidence, trends and use of patient centered health measures over the past decade to better define various instruments used in pediatric spinal deformity research.

Methods: A search was conducted on PubMed with time frame from 2004-2013 of 5 orthopaedic Journals (The Journal of Bone and Joint Surgery, The Bone and Joint Journal, The Spine Journal, The European Spine Journal, and Spine). All journal abstracts were inspected for pediatric spinal deformity surgery and inclusion of patient centered outcome instruments. Articles were then analyzed for diagnosis, procedure and level of evidence. Prevalence of outcome instruments and level of evidence were reported as percentage of total studies included.

Results: From 19,736 studies published, 1,090 articles included patient outcomes. A total of 70 articles addressed pediatric spinal deformity surgery with most coming from Spine (57.1%). In total, there were 11 unique outcome measures utilized. The top 6 most used outcome measures in descending order were Scoliosis Research Society-22 (SRS-22, 30.0%), Scoliosis Research Society-24 (SRS-24, 24.3%), visual analog score (VAS, 11.4%) for pain, Oswestry Disability Index (ODI, 5.7%), Short Form-36 (SF-36, 5.7%) and Scoliosis Research Society-30 (SRS-30, 5.7%). Most articles were of Level III evidence (37.1%), while only 2.9% of all articles were of Level I evidence.

Conclusion: We identified 11 distinct outcome measures used in pediatric spinal deformity surgery research. The majority of articles used SRS scores, making it possible for more effective communication and comparison. A consensus may be needed among researchers to consistently use a fewer number of most relevant instruments and lessen the burden placed on patients with each office visit in the future.

217. Surgical Infection in Adolescent Idiopathic Scoliosis Surgery

Mikhail Mikhailovsky, MD; Denis Dolotin

Russian Federation

Summary: A study of the current total score of patients with postoperative surgical site infections (SSI) in a large prospective series of surgical cases adolescent idiopathic scoliosis (AIS)

Introduction: An infection has detrimental effects on the outcome on surgical correction of adolescent idiopathic scoliosis. It can often lead to instrumentation removal and loss of coronal correction. Multiple studies have reported the rates of early and delayed postoperative infection after the surgical correction of spinal deformity in AIS, which range from 1.4% to 6.9%

Methods: To define the current rate of postoperative SSIs in a large prospective series of surgical AIS cases, treated in one center

Results: A single-center, prospective database of patients who underwent surgical correction of AIS was reviewed. Early SSIs were defined as occurring within 90 days after surgery, as per the Center for Disease Control's definitions. Treatment and outcome information on all confirmed SSIs was compiled

Conclusion: Of the 1973 patients analyzed, 12 developed an SSI within the first 90 days postoperatively (0.6%). The average occurrence time was 19 days postoperatively, with a range of 7 - 38 days. Average length of follow-up for the 12 patients with infections was 2.2 years (range, 1.3 to 4.1 years). Of the 12

E-POSTER ABSTRACTS

infections, 10 resolved with surgery and/or antibiotics and did not need implant removal. Only 2 patients had late pain. In addition to the 12 confirmed SSIs, there were an additional 2 wound issues (0.1%) that did not meet the Center for Disease Control criteria for an SSI

218. Topical, Intra-Wound Vancomycin Powder Decreases the Risk of Surgical Site Infections in Complex Adult Deformity Reconstruction: A Cost-Benefit Analysis

Gokhan H. Demirkiran; Murat Pekmezci, MD; Alexander A. Theologis, MD; Christopher P. Ames, MD; Vedat Deviren, MD

USA

Summary: The rates of surgical site infection (SSI) remain unacceptably high in complex adult spinal deformity surgery despite routine intravenous antibiotics. Vancomycin powder applied directly to the wound intra-operatively has shown promise for decreasing SSI. This study is the first to present cost effectiveness data of vancomycin powder in thoracolumbar deformity surgery

Introduction: SSI is a source of significant morbidity in spine surgery. Intra-operative application of vancomycin powder lowers the infection risk following posterior spinal fusion. The goal of this study is to evaluate the rate of SSI and cost effectiveness of the use of intra-operative vancomycin powder in thoracolumbar adult deformity procedures

Methods: Adults who underwent complex adult deformity reconstruction by 2 surgeons between 2008 and 2012 were retrospectively reviewed. The patients were sub-divided into those who had received only routine peri-operative intravenous antibiotics (control) and those who received intravenous antibiotics and 2-grams of vancomycin powder applied to the surgical wound. The primary outcome was surgical site infection within 90 days. Secondary outcomes included surgical and clinical parameters and surgical site infection-related medical costs based on hospital billing records

Results: Two hundred thirty six patients were evaluated - controls (n=70) and study group (n=166) (Table 1). The average number of levels fused was 9.8 (5-17) in the control group and 11.6 (6-17) in the study group. The mean follow up was 34.8 months (12-68) for the control group and 18.6 months (12-34) for the study group. There were no additional SSI observed at the final follow-up for either group. There were no reported adverse events related to the topical vancomycin treatment. There were significantly fewer hospital re-admissions within 90-days for SSI in patients treated with topical vancomycin powder (11.4%; 8/70) compared to controls (2.3%; 4/166) (p=0.004). The average cost per patient of treating a post-operative SSI was higher in the control group (\$36,397) than the study group (\$28,186). With the use of vancomycin powder there was a cost saving of \$341,547 per 100 complex spinal procedures

Conclusion: Local application of vancomycin powder significantly decreased surgical site infections for adults undergoing complex spinal reconstructive surgery performed by two surgeons. This resulted in cost savings of \$341,547 per 100 thoracolumbar adult deformity procedures

219. PJK and PJF following Spinal Deformity Surgery: The ASD Committee Systematic Review of the Literature as a Background to SRS PJK Classification Development

Christopher P. Ames, MD; Darryl Lau, MD; Michael D. Daubs, MD; Jeffrey D. Coe, MD; Kenneth J. Paonessa, MD; Michael O. LaGrone, MD; Michael D. Kasten, MD; Rodrigo A. Amaral; Per D. Trobisch, MD; Jung-Hee Lee, MD; Daniele Fabris-Monterumici, MD; Neel Anand, MD; Andrew K. Cree, MD; Robert A. Hart, MD; Lloyd A. Hey, MD, MS

USA

Summary: Proximal junctional kyphosis (PJK) and proximal junctional failure (PJF) frequently occur following surgery for adult spinal deformity (ASD). There is a lack of consensus in the literature on the incidence and optimal methods for treatment, and prevention. Classification systems have been proposed but not prospectively validated. The adult deformity committee of the SRS presents a systematic literature review of PJK and its classification in preparation for the development of an SRS PJK classification.

Introduction: Proximal junctional kyphosis (PJK) and proximal junctional failure (PJF) are well described clinical pathologies. PJF is a frequent cause of revision surgery and often results in protracted patient recovery with impact on the cost effectiveness of surgical treatment for ASD. The development of an SRS PJK classification which correlates with clinical outcomes and guides treatment decisions and possible prevention strategies would be of significant benefit to patients and surgeons.

Methods: The 2014 ASD Committee performed a comprehensive English language systematic literature review of PJF and PJK incidence, risk factors, HRQOL impact, prevention strategy efficacy, outcomes of revision surgery and classification systems. The words "proximal junctional kyphosis" and "proximal junctional failure" were used as search terms in PubMed for all years up to 2013 to identify all articles that included at least one of these terms.

Results: 64 articles were identified overall. 14 articles assessed for risk factors. 9 studies reviewed prevention strategies. There were no randomized prospective studies. There are two published studies that have attempt to classify PJK. The reported incidence of PJK ranged widely, from 5% to 46% in patients undergoing spinal instrumentation and fusion for ASD. It is reported that 66% of PJK occurs within 3 months postoperatively, and 80% within 18 months. Reported revision rates due to PJK range from 13% to 55%. Modifiable and non-modifiable risk factors for PJK have been characterized (Table 1).

Conclusion: PJK/PJF affects many patients following long segment instrumentation following the correction of ASD. The epidemiology and risk factors for the disease are well defined. Preoperative risk factor scoring may help guide prevention strategy recommendations. The development and prospective validation of an SRS PJK Classification system is important considering the prevalence of the problem and its clinical and economic impact.

E-POSTER ABSTRACTS

220. Magnitude, Location and Factors Related to Regional and Global Correction Loss in Long Adult Deformity Constructs: Report of 183 Patients with Two-Year Follow Up

Christopher P. Ames, MD; Virginie Lafage, PhD; Justin K. Scheer, BS; Michael P. Kelly, MD; Richard Hostin, MD; Robert A. Hart, MD; Eric Klineberg, MD; Themistocles S. Protopsaltis, MD; Vedat Deviren, MD; Daniel M. Sciubba, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Justin S. Smith, MD, PhD; International Spine Study Group
USA

Summary: Adult deformity pts have previously been shown to lose sagittal spino-pelvic correction over time. The goal of this study was to analyze the source of this correction loss. Of 183 TL deformity pts undergoing surgery, 63.9% had TH correction loss and 56.8% had LL correction loss from 6wk-2yr postop. 13.8% of pts experienced >10 degree change inside the instrumented lumbar segments. Risk factors for correction loss inside instrumented segments include age >65, preop SVA >5cm and interbody fusion.

Introduction: Adult deformity patients(pts) have previously been shown to lose spino-pelvic correction over time especially in the sagittal plane. The goal of this study was to analyze the source of this correction loss and specifically to quantitate the change that occurs in fused verses unfused segments. Variables examined include presence of interbody fusion, rod diameter, rod material, age and preop sagittal alignment.

Methods: A retrospective review of a multicenter, prospective ASD database was conducted. Inclusion criteria: age \geq 18yr, ASD, no revisions between >6wk and <2yrs postop. Spinal pelvic parameters, Thoracic kyphosis (TK:T2-T12) and lumbar lordosis (LL:L1-S1) were both measured overall as well as within and outside of the instrumented segments. Overall SVA, PT, Pi-LL change and TK and LL change between 6wks-2yrs postop was calculated. Of these pts, the amount of TH loss and TL loss within and outside of the instrumented segments was also determined as well as a percentage of the total loss for each region.

Results: 183 pts met criteria. Between 6wk-2yr postop 61.7% of pts lost SVA (4.4 \pm 4.3cm), 65.0% lost PT (4.7 \pm 4.0deg), and 40.4% lost Pi-LL (16.2 \pm 9.3deg). 63.9% had TH loss (8.0 \pm 8.9deg) and 56.8% had LL loss (5.8 \pm 4.5deg). 41.5% lost >2cm SVA. Of the pts with >2cm SVA loss, 60.5% had LL loss, and of those, 82.6% was within instrumented segments. Of the pts with LL loss 13.8% had >10deg loss. Pts with an interbody fusion have a 2.3x (p=0.0076) likelihood of having any LL loss but interbody fusion was protective against >10deg change (7.1%). Pts \geq 65 yrs old are 9.4x (p<0.0001) more likely to have LL loss than pts \leq 45 yrs old (4.4%). Pts with preop C7 SVA>5cm are 2.4x (p=0.0035) more likely to have LL loss.

Conclusion: Loss of initial regional and global sagittal correction is common in ASD surgery and also occurs inside the instrumented segments between 6wk-2yrs postop. Older age and preop sagittal deformity are risk factors for overall loss of correction and for loss of correction within the instrumented segments. In our study interbody fusion was only protective for LL loss >10deg.

221. Major Revision Surgery as a Result of Pseudarthrosis or Proximal Junctional Kyphosis is the Most Likely Complication to Negatively Impact Patient Reported Outcome Scores in Adult Spinal Deformity

Patrick A. Sugrue, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Azeem Ahmad, BA, BS; Jeffrey L. Gum, MD; David B. Bumpass, MD; Isaac Karikari, MD; Kevin R. O'Neill, MD, MS; Sang D. Kim, MD, MS; Leah Y. Carreon, MD, MSc
USA

Summary: Patients who underwent instrumented posterior spinal fusion from T11 or above to the sacrum/pelvis overall had a complication rate of 46.8%, but experienced statistically significant clinical improvement in ODI and SRS outcome scores. While not statistically significant due to the low prevalence of major revisions, patients with pseudarthrosis or proximal junctional failure requiring major revision surgery experienced less improvement than those who did not require revision surgery.

Introduction: The prevalence of complications following adult spinal deformity surgery has been reported as over 40%. With this study we aim to assess the specific impact of individual complications on patient reported outcomes (PRO).

Methods: Retrospective review of a prospectively collected database. All patients who underwent primary or revision instrumented fusion (T11 or above) to the sacrum/pelvis with 5 year follow-up at a single institution. A multivariate stepwise logistic regression analysis was done to determine if there were specific complications that were predictive of the change in SRS Total or Subscore at five years.

Results: 185 patients (158F, 27M) underwent long construct (T11 or above) posterior spinal fusion to the sacrum/pelvis with 5 years of follow-up with a mean age of 53.7 years. 91 (53.2%) patients had no complications, 58 (33.9%) patients experienced 1 complication, 20 (11.7%) patients experienced 2 complications, 1 (0.6%) patient experienced 3 complications, and 1 (0.6%) patient experienced 4 complications for a total of 171 complications. ODI improved in all patients at 5 years (37.62 vs 21.69, p<0.0001), as did SRS average score (2.96 vs 3.98, p<0.0001), and SRS subscore (3.03 vs 3.71, p<0.0001). Paired t-tests showed that there was a statistically significant improvement in all SRS domain scores and total scores at five years post-op compared to baseline. Stepwise logistic regression analysis showed while not statistically significant patients with pseudarthrosis or proximal junctional kyphosis requiring major revision surgery (n=16) experienced less improvement in SRS Average (0.55 vs 0.82, p=0.171), SRS Subscore (0.41 vs 0.71, p=0.129), and ODI (9.06 vs 16.59, p=0.105) at five years.

Conclusion: Patients who have undergone long construct fusions to the sacrum/pelvis have statistically significant improvements in SRS and ODI scores at 5 years despite complications. However, patients who undergo a major revision due to pseudarthrosis or proximal junctional kyphosis experience less improvement, though not significant likely due to the low prevalence (16 out of 185, 8.6%) of major revisions.

E-POSTER ABSTRACTS

222. Time Course Changes of Health Related Quality of Life after Three-Column Osteotomies in Adult Spinal Deformity

Haruki Funao, MD; Floreana A. Naef; Virginie Lafage, PhD; Frank J. Schwab, MD; Gregory M. Mundis, MD; Ian McCarthy, PhD; Robert A. Hart, MD; Richard Hostin, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Christopher P. Ames, MD; Khaled Kebaish, MD

USA

Summary: Health related quality of life (HRQoL) at several time points were reviewed in patients following 3 column osteotomies in adult spinal deformity surgery. HRQoL significantly improved and stabilized almost at 1-year after 3 column osteotomies. There is no significant differences between patients over 60-year and under 60-year old, and no difference between revision surgery and primary in HRQoL. Inadequate correction may contribute to worse outcome. **Introduction:** Although health related quality of life (HRQoL) measurements are important in evaluating patients following adult deformity surgery, there is no report describing time-course changes following 3 column osteotomies. The aim was to assess HRQoL following 3 column osteotomies at several time points, and to elucidate factors impacting HRQoL data.

Methods: Retrospective review from multi-center prospectively collected database. Patients who underwent 3 column osteotomies, such as pedicle subtraction osteotomy (PSO) or vertebral column resection (VCR) with a minimum 2-year follow-up were included. HRQoL was evaluated using SRS-22, ODI, SF-12 physical and mental component score (pcs, mcs) at several time points; baseline, 3-months, 1-year, 2-year postoperatively. Statistical analyses were performed using one way ANOVA.

Results: A total of 110 patients were identified. Mean age at surgery was 57.4 years (21-82). 84 were females and 51 patients were over 60-year old. 75 PSOs were performed in 72 patients, 43 VCRs were performed in 41. Using a repeated measures model, all SRS-22 domains were improved at all-intervals from baseline (baseline/3-month/1-year/2-year): activity (2.8/3.0/3.3/3.2), pain (2.6/3.0/3.2/3.1), self-image (2.3/3.6/3.5/3.2), mental (3.4/3.7/3.8/3.7), and satisfaction (2.8/3.8/3.9/3.8). SF-12 pcs (31.1/34.5/38.0/38.0), SF-12 mcs (45.0/49.9/48.6/47.6), and ODI also showed significant improvement (43.4/37.0/32.4/31.0). There is no significant differences in the degree of improvement in patients over 60-year and under 60-year old in HRQoL. Although there is significant differences between revision surgery and primary in ODI at baseline ($P=0.04$), no significant differences were observed between revision surgery and primary in HRQoL at all postoperative time points. Patients who had pelvic incidence (PI) to LL mismatch ($PI-LL > 10^\circ$) postoperatively showed significantly worse scores in SRS-22 activity at 1- and 2-year, SRS-22 pain at 1- and 2-year, SRS-22 self-image at 1- and 2-year, ODI at baseline, 3-month, 1- and 2-year.

Conclusion: HRQoL significantly improved and stabilized at almost 1-year after 3 column osteotomies in adult spinal deformity. Patients with postoperative PI-LL mismatch showed significantly worse outcome.

223. PT Modifier of SRS-Schwab Adult Spinal Deformity Classification and Mode of Pelvic Compensation

Tetsuya Kobayashi, MD, PhD

Japan

Summary: 159 community-based female subjects (mean age of 64.9 years) were recruited and classified according to SRS-Schwab adult spinal deformity PT modifier. PT++ was associated with; 15.2° decrease in LL, 18% loss of trunk muscle power, 40.9mm forward shift in SVA, and increased trunk inclination angle at walk (wTIA) which was equivalent to additional 13 mm of SVA, compared to PT 0. Clinical importance of pelvic parameters should be emphasized for the management of adult spinal deformity.

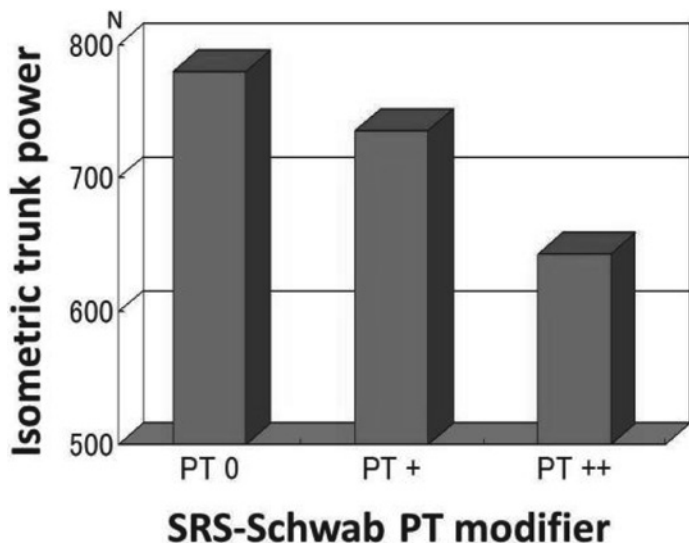
Introduction: Pelvic tilt (PT) represents pelvic retroversion and compensation for sagittal spinal deformity, however, the magnitude of compensation has not been well-documented. Purpose of this study was to clarify the mode of pelvic compensation among community-based volunteers using SRS-Schwab classification.

Methods: A final total of 159 healthy female subjects were recruited from population register. Upright entire spine radiographs were used to measure sagittal spinopelvic parameters including lumbar lordosis (LL), sacral slope (SS), pelvic incidence (PI), sagittal vertical axis (SVA) and PT. Clinical evaluation included HRQoL, range of spinal movement, trunk flexor and extensor muscle power using isometric device, and trunk inclination angle at standing (sTIA) and walking (wTIA) using surface markers.

Results: Subjects' age was 50-79 (mean 64.9) years, and radiographic parameters were as follows; LL $39.6 \pm 15.2^\circ$, SS $30.7 \pm 11.8^\circ$, PI $55.2 \pm 10.3^\circ$, SVA 22.0 ± 35.4 mm, and PT $24.0 \pm 11.0^\circ$. SVA correlated with both standing TIA (sTIA; $r=0.31$, $p=0.0001$) and walking TIA (wTIA; $r=0.42$, $p<0.0001$). PT correlated not with sTIA but with wTIA ($r=0.48$, $p<0.0001$). SRS-Schwab PT modifier (0 for $PT < 20^\circ$; + for $PT 20-30^\circ$; ++ for $PT > 30^\circ$) showed significant correlation with wTIA (PT0 $6.1 \pm 3.4^\circ$; PT+ $7.4 \pm 4.3^\circ$; PT++ $10.5 \pm 6.6^\circ$, $p<0.0001$), LL ($44.4 \pm 9.9^\circ$; $42.2 \pm 12.9^\circ$; $29.2 \pm 20.5^\circ$, $p<0.0001$), PI ($50.6 \pm 7.9^\circ$; $55.8 \pm 7.9^\circ$; $60.9 \pm 12.7^\circ$, $p<0.0001$), SVA (10.1 ± 23.1 mm; 14.1 ± 25.4 mm; 51.0 ± 46.7 mm, $p<0.0001$), trunk muscle (sum of flexor and extensor, 780.4 ± 237.3 N; 736.5 ± 195.9 N; 643.7 ± 224.5 N, $p=0.0046$), and HRQoL ($p=0.0031$).

Conclusion: Pelvic compensation with PT++ was associated with; 15.2° decrease in LL, 18% loss of trunk muscle power, 40.9mm forward shift in SVA, and increased wTIA equivalent to additional 13 mm of SVA at walk, compared to PT 0. Along with kyphotic changes in radiographs, PT modifier was related with significant decrease in trunk muscle power which could lead to worsening gait posture. Clinical importance of pelvic parameters should be emphasized for the management of adult spinal deformity.

E-POSTER ABSTRACTS



224. Decompression in Adult Lumbar Deformity Surgery is Associated with Increased Perioperative Complications but Favorable Long-Term Outcomes

Isaac Karikari, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Patrick A. Sgrue, MD; David B. Bumpass, MD; Azeem Ahmad, BA, BS; Jeffrey L. Gum, MD USA

Summary: Adult patients undergoing complex spinal deformity surgery who require formal decompression for severe spinal stenosis have increased perioperative complications in the short term but their functional outcomes at 5 years are good and comparable to patients who do not undergo a decompression.

Introduction: Formal decompression for symptomatic spinal stenosis in patients undergoing spinal deformity surgery is not uncommon and can be challenging. The impact on perioperative complications and long term clinical outcomes has not been previously reported.

Methods: Adult patients undergoing at least 5 levels of fusion to the sacrum with iliac fixation from 2002-2008 who had a minimum of 5 years follow-up at one institution were studied. Patients who had 3-column osteotomies were excluded from the study. Perioperative complications and clinical outcomes (SRS, NRS back/leg pain, and ODI) were analyzed. Patients who underwent formal laminectomy/decompressions were compared with those that did not. Differences between the two groups were analyzed using the Student t-test.

Results: A total of 147 patients were included in the study. Fifty-five (37%) patients underwent a decompression and 92 (63%) patients did not. The mean age and follow-up were 57 years and 76 months respectively. A comparison of the two groups is illustrated in attached Table.

Conclusion: Performing a formal decompression in adult deformity surgery is associated with increased EBL, operative time and higher incidence of intra-operative durotomies. Despite this however, there is a significant improvement in the NRS leg pain scores. The long-term patient reported outcome measures appear to be similar in both groups.

225. The Correction of Lower Lumbar Curve is More Important for Optimal Sagittal Spinopelvic Alignment in Adult Spinal Deformity
Tatsuya Yasuda; Tomohiko Hasegawa; Yu Yamato; Sho Kobayashi, PhD; Daisuke Togawa, MD, PhD; Hideyuki Arima; Yukihiko Matsuyama, MD Japan

Summary: We investigate correlation between lumbar lordosis (LL) and spinopelvic parameter in adult spinal deformity patients who underwent posterior corrective surgery. In this study, upper LL (L1-3) and lower LL (L4-S1) were separately measured. Lower LL had significant correlation with spinopelvic parameter. Upper LL had no significant correlation with spinopelvic parameters. While the sagittal curve correction, lower lumbar lordosis had a greater impact on the total sagittal alignment, including pelvis, compared to upper lumbar lordosis.

Introduction: Recent researches have shown that sagittal spinal alignment plays critical role on the health related quality of life of adult spinal deformity (ASD) patients. Lumbar lordosis is one of the important parameters for optimal sagittal alignment. However, the optimum lordosis in upper and/or lower lumbar lesions is still unknown. The objective of this study was to investigate how much correction of lower lumbar lordosis is necessary for optimal sagittal spinopelvic alignment in adult spinal deformity.

Methods: This study consists of 87 adult patients with average age of 70.1 (45-84). All patients underwent posterior corrective surgery with at least 6 fusion levels or more. Distal fusion end was either sacrum or ilium as the lowest instrumented vertebra. Pre- and post operative radiographic parameters included sagittal vertical axis (SVA), L1-S1 lumbar lordosis (LL), sacral slope (SS), pelvic tilt (PT), pelvic incidence (PI) were measured by software in the lateral whole spine digitized X-ray in standing position. Pre- and postoperative upper LL (L1-L3) and lower LL (L4-S) were separately measured. Correlation between lumbar curves (total, upper and lower) and spinopelvic parameters were statistically analyzed.

Results: SVA improved from 122mm to 48.9mm in average after the corrective surgery. LL increased from 10.9° to 40.9°. Postoperative SS, PT, PI were changed from 16.8°, 34.5°, 50.4° to 28.2°, 22.9°, 51.6°, respectively. Post operative upper LL was increased from -6.2° to 9.8°. Post operative lower LL was also increased from 17.2° to 31.1°. Among the postoperative parameters, SVA was significantly associated with LL ($r=-0.38$, $p<0.001$) and lower LL ($r=-0.32$, $p<0.01$). PT was also correlated with LL ($r=-0.29$, $p<0.01$) and lower LL ($r=-0.39$, $p<0.001$). Upper LL had no significant correlation with postoperative spinopelvic parameters.

Conclusion: Analysis of sagittal plane must integrate not only spinal parameter but also those related the pelvis. While the sagittal curve correction, lower lumbar lordosis had a greater impact on the total sagittal alignment, including pelvis, compared to upper lumbar lordosis. Therefore, we must pay attention more to the correction of lower lumbar curve.

E-POSTER ABSTRACTS

226. Clinical Results and Functional Outcome of Revision Surgery for Distal Junctional Failure in the Lumbo-Sacral Spine

Haruki Funao, MD; Floreana A. Naef; Jaysson T. Brooks, MD; Richard L. Skolasky, ScD; Khaled Kebaish, MD
USA

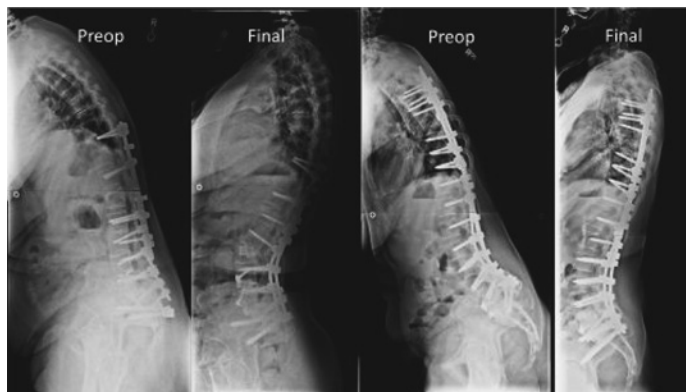
Summary: Patients undergoing revision surgery for distal junctional failure (DJF) in the lumbo-sacral spine were reviewed. A new anatomical spinopelvic parameter, named lumbo-sacral angle (LSA) was defined to evaluate lumbo-sacral sagittal alignment. Corrective osteotomies were performed in all patients, with significant improvement in lumbar lordosis (LL), LSA, and SVA. Clinical outcome also showed significant improvement. Patients who remained sagittally imbalanced showed worse outcome.

Introduction: Distal junctional failure (DJF) in the lumbo-sacral spine can occur as a complication following posterior spinal fusion. Although it is associated with significant back pain, deformity, and may require surgical treatment, there is no reports focused on the outcome of revision surgery for DJF with the assessments of spinopelvic radiographic parameters and health related quality of life.

Methods: A retrospective review from a prospectively collected database was performed. Inclusion criteria were: patients who developed DJF after posterior spinal fusion and the following criteria; intractable pain in the lumbo-sacral area, sagittal imbalance (SVA>5.0cm), and LSA was less than 25°. LSA was defined as the angle between the inferior endplate of T12, and the perpendicular line connecting the endplates of S3-S4. Radiographic/clinical assessment was conducted with a minimum 2-year follow-up. Statistical analyses were performed using one way ANOVA.

Results: A total of 33 patients met our inclusion criteria. Mean age at surgery was 55 years (26-76). 27 were females, and mean BMI was 29.4. Pedicle subtraction osteotomies were performed in 24 patients, vertebral column resection in 2. Mean fused level was 7.7 (3-17) vertebrae. 32 patients were fused to the pelvis. Mean radiographic changes were (pre/post/final); thoracic major (22.7/20.5/21.8°), lumbar major (28.0/20.6/21.4°), thoracic kyphosis (26.1/30.0/32.8°), LL (-21.0/-48.9/-47.1°), LSA (0.2/30.1/28.3°), and SVA (16.7/3.9/4.6cm). There was significant improvement in LL, LSA, and SVA at postoperative and final follow-up (P<0.001). All SRS 22 domains were significantly improved; (pre/final); activity (2.9/3.9), pain (2.5/3.7), self-image (2.7/3.5), mental (2.6/3.7), and satisfaction (3.0/3.7) (P<0.001). ODI also showed a significant decrease (63.4/40.7) (P<0.001). SVA>5cm was associated with less improvement in SRS22 self-image and satisfaction at final follow-up. Revision surgery was performed on 10 patients; PJK (4), junctional stenosis (1), pseudoarthrosis (2), and broken rod (2).

Conclusion: Revision surgery for DJF significantly improved both radiographic and clinical outcomes. Patients who remained sagittally imbalanced had a worse outcome.



227. Spinal Pelvic Radiographic Thresholds for Regional Lumbar Disability are Age Dependent: Analysis of Multicenter Database of 833 patients

Justin S. Smith, MD, PhD; Virginie Lafage, PhD; Justin K. Scheer, BS; Christopher I. Shaffrey, MD; Renaud Lafage, MS; Eric Klineberg, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled Kebaish, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher P. Ames, MD; International Spine Study Group
USA

Summary: Previous analysis have demonstrated significant correlation of SVA, PT and PI-LL values to disability scores. This work has been used to set modifier values in the Schwab SRS adult deformity classification. In the current study, new thresholds were determined based on patients ages and were found to increase as patients' age increases. These results suggest that pre-operative deformity correction planning should consider the patients age.

Introduction: The sagittal plane is the primary driver of disability in patients with ASD and spinopelvic radiographic thresholds have been established for pelvic tilt (PT), pelvic incidence (PI) and lumbar lordosis mismatch (PI-LL), and C7 sagittal vertical axis (SVA) in which disability occurs based on an ODI of ≥ 40 . However, the patients' age was not accounted for in determining these thresholds and ODI has been shown to vary with age. The objective was to determine new thresholds based on age.

Methods: This is a multicenter, prospective study of consecutive ASD patients. Inclusion criteria included: age>18yr, ASD. Patients were stratified into the following age groups: ≤ 45 yr, 46-64, 65-74, ≥ 75 . Multivariate linear regressions were conducted for baseline PT, PI-LL, and SVA with baseline ODI and age on all patients. Based on previous studies, an ODI of 40 was used as the threshold for disability. Individual patient thresholds were calculated based on their age. The thresholds were averaged across the age groups.

Results: 833 patients were included, (396 op, 437 nonop). Patients with only sagittal deformity for the age groups were the following: ≤ 45 (18.8%), 46-64 (19.4%), 65-74 (40.1%), ≥ 75 (50%). Age alone significantly predicted ODI ($r^2=0.17$, $p<0.0001$). Regressions for PT ($r^2=0.27$, $p<0.0001$), PI-LL ($r^2=0.27$, $p<0.0001$), SVA ($r^2=0.32$, $p<0.0001$) including age were all predictive of ODI. Thresholds for the entire cohort were the following: PT=21.9 \pm 4.7deg, PI-LL=11.6 \pm 7deg, SVA=6.7 \pm 2.5cm. Thresholds for the age groups were the following: PT(deg): ≤ 45 (15.3 \pm 2.3), 46-64 (22.6 \pm 1.5), 65-74 (26.2 \pm 0.8), ≥ 75 (29.1 \pm 0.8). PI-LL(deg): ≤ 45 (1.7 \pm 3.5), 46-64 (12.5 \pm 2.2), 65-74 (18 \pm 1.2), ≥ 75 (22.4 \pm 1.3). SVA(cm): ≤ 45 (3.3 \pm 1.2),

E-POSTER ABSTRACTS

46-64(7.1±0.8), 65-74(9.0±0.4), ≥75(10.5±0.4).

Conclusion: Spinopelvic radiographic thresholds correlated to moderate to severe regional low back disability increase as patients age. These results suggest that pre-operative surgery planning and patient counseling should consider the patients age. Further study of Schwab SRS sagittal modifier correction goals for individual age groups is warranted.

228. NIS: Revision Adult Spinal Deformity Surgery Associated with Greater Morbidity and Length of Stay

Peter G. Passias, MD; Bryan J. Marascalchi, BS; Thomas J. Errico USA

Summary: This study compares patient demographics, incidence of comorbidities, procedure-related complications, and mortality following primary vs. revision adult spinal deformity surgery. Relative to primary cases, those undergoing revision correction of spinal deformity have a higher risk of many procedure-related complications with a longer hospital course despite having the same baseline comorbidity burden and in-hospital mortality rate.

Introduction: This study compares patient demographics, incidence of comorbidities, procedure-related complications, and mortality following primary vs. revision adult spinal deformity surgery. No previous study has provided nationwide estimates of patient characteristics and procedure-related complications for primary vs. revision spinal deformity surgery comparatively.

Methods: Nationwide Inpatient Sample data collected between 2001 and 2010 was analyzed. Discharges with procedural codes for anterior and/or posterior thoracic and/or lumbar spinal fusion and refusion were included for patients aged 25+ and 4+ levels fused with any diagnoses specific for scoliosis. Patient demographics, incidence of comorbidities and procedure-related complications were determined for primary vs. revision cohorts. Multivariate analysis reported as (OR[95% CI]).

Results: Discharges for 10,158 primary and 1,824 revision cases were identified. Differences between cohorts were found for demographic and hospital data. Average comorbidity indices for the cohorts were similar ($p=0.282$), as was in-hospital mortality ($p=0.163$). The incidence of procedure-related complications was higher for the revision cohort (50.51% vs. 52.41%, $p=0.002$). The mean hospital course for the revision cohort was longer (6.51 vs. 7.31 days, $p<0.0001$). Revisions were associated with increased risk of nervous system (1.46[1.23-1.75]), hematoma/seroma formation (2.18[1.84-2.60]), accidental vessel or nerve puncture (1.41[1.27-1.56]), wound dehiscence (2.28[1.61-3.22]), post-op infection (3.26[2.69-3.96]) and ARDS complications (1.40[1.27-1.55]). Alternatively, the primary cohort was associated with a decreased risk for GI (0.65[0.56-0.75]) and GU complications (0.71[0.52-0.97]).

Conclusion: Relative to primary cases, those undergoing revision correction of spinal deformity have a higher risk of many procedure-related complications with a longer hospital course despite having the same baseline comorbidity burden and in-hospital mortality rate. This study provides clinically useful data for surgeons to educate patients at risk for morbidity and mortality and direct future research to improve patient outcomes.

229. Factors Affecting Postoperative Progression of Thoracic Kyphosis in Surgically Treated Patient with Degenerative Lumbar Scoliosis

Mitsuru Yagi, MD, PhD; Naobumi Hosogane, MD; Eijiro Okada, MD; Kota Watanabe; Masafumi Machida, MD; Morio Matsumoto, MD; Takashi Asazuma, MD, PhD; Keio Spine Research Group Japan

Summary: We here present the first report of the incidence and risk factors for progression of kyphosis in unfused segments of the spine above the UIV, in patients who have undergone surgical correction for DLS. Large correction in LL, a UIV below the sagittal apex, or an LIV at the sacro-pelvis will result in progressive GTK after the surgical correction of DLS. Long-term follow-up of this patient population will further elucidate the clinical impact of postoperative pGTK in the elderly population.

Introduction: Sagittal balance affects the surgical treatment of spinal deformity in adults. Little is known about loss of the sagittal balance due to progressive global thoracic kyphosis (pGTK), or about the risk factors for pGTK, after correction surgery for degenerative lumbar scoliosis (DLS). The purpose of this study was to determine the incidence and the risk factors of pGTK after correction surgery for DLS.

Methods: We reviewed records from a multi-center database of patients with DLS, treated with posterior spinal fusion. Inclusion required an age of 50 years or more at the time of surgery, an upper instrumented vertebrae (UIV) below T9, more than 5 fused segments, and at least 2 years of follow-up. We included 73 patients with the mean age of 68.3 years (range 51-77 years) and the mean follow-up period of 3.6 years (range 2-11 years). Significant pGTK was defined as an increase in thoracic kyphosis of more than 10° from before surgery to the time of final follow-up. Demographic and radiographic data were studied. To investigate the effect of trunk muscles for pGTK, cross-sectional area of psoas (PS) and multifidus muscle (MF) were measured on MRI images. Independent risk factors for pGTK were identified by logistic regression analysis. The outcomes of interest were: (1) age, (2) gender, (3) LIV level, (4) preoperative SVA, (5) preoperative PI + LL, and (6) GSA.

Results: Significant pGTK was observed in 41% of the patients. Loss of the sagittal vertical axis (SVA) was larger in patients with pGTK than without (4.7 vs. 1.5 cm; $p=0.02$). Correlation coefficient test showed the correlation between pGTK and age, BMI, change in LL, and mean MF area ($R^2=0.22$, $R^2=0.20$, $R^2=0.3$, $R^2=0.28$, respectively). Multivariate logistic regression analysis identified an age greater than 75 (odds ratio [OR], 5.53; $p=0.02$) and sacro-pelvic fusion (OR=2.66, $p=0.02$) as independent risk factors for pGTK.

Conclusion: The pGTK incidence after surgery for DLS was 41%. Age, sacro-pelvic fusion, and a larger sagittal correction were identified as pGTK risk factors. Long-term follow-up will provide more data on the clinical impact of pGTK in elderly patients.

E-POSTER ABSTRACTS

230. SRS Appearance Domain Correlates the most with Patient Satisfaction after Adult Deformity Surgery to the Sacrum at Five-Year Follow Up

Jeffrey L. Gum, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; David B. Bumpass, MD; Patrick A. Sugrue, MD; Isaac Karikari, MD; Sang D. Kim, MD, MS; Kevin R. O'Neill, MD, MS; Leah Y. Carreon, MD, MSc
USA

Summary: In 135 patients undergoing instrumented posterior spinal fusion for correction of adult spinal deformity, a statistically significant improvement at five years was seen in all the domains and total scores of the SRS22R. SRS Appearance, SubScore, and ODI had a moderate correlation with patient satisfaction, while all other SRS domains, radiographic, and operative parameters only had very weak or weak correlations.

Introduction: The Scoliosis Research Society-22R (SRS22R) is commonly used to measure clinical outcomes in adult spine deformity patients. The relationship between patient satisfaction after surgery and changes in the SRS22R domain scores, the Oswestry Disability Index (ODI) and radiographic parameters has not been reported at 5-year follow-up.

Methods: This is a longitudinal cohort of 135 patients with adult spinal deformity at one institution who underwent a posterior spinal fusion of ≥ 5 levels to the sacrum and had complete SRS22R pre- and minimum 5 years post-op. Wilcoxon tests were used to compare preop and 5-year postop scores. Spearman correlations were used to evaluate associations between the 5-year SRS Satisfaction score and changes in SRS22R domain scores, SubScore (SRS Total - Satisfaction), ODI, and radiographic parameters. Radiographic parameters analyzed included major Cobb, coronal balance, sagittal balance, thoracic kyphosis (TK), lumbar lordosis (LL), pelvic incidence (PI), LL-PI mismatch, and the TK-LL-PI sagittal ideal. Correlation coefficients <0.20 were deemed very weak, 0.20 to 0.40 as weak, 0.40 to 0.60 as moderate, 0.60 to 0.80 as strong, and >0.80 as very strong.

Results: There were 125 females and 10 males with a mean BMI of 26.6 kg/m² and mean age of 53.6 years. There were 74 primary and 61 revision surgeries with a mean 9.9 levels fused and mean follow-up of 67 months. There was a statistically significant improvement between paired pre- and 5-year post-op SRS domain scores and most radiographic parameters, commonly $p \leq 0.001$. The majority of patients had an SRS Satisfaction score of ≥ 3.0 (88%) or ≥ 4.0 (67%), consistent with a moderate ceiling effect. Correlations for SRS domain scores were all statistically significant and either weak (Mental (0.26), Activity (0.27), Pain (0.35)) or moderate (Appearance (0.59)). SRS SubScore (0.54) and ODI (0.43) also had a moderate correlation. Correlations for all radiographic and operative parameters were either very weak or weak.

Conclusion: SRS Appearance, SubScore, and ODI correlate most with patient satisfaction in adult deformity patients undergoing ≥ 5 level fusion to the sacrum at 5-year follow-up.

231. The Fate of L5-S1 with Low Dose BMP-2 and Pelvic Fixation in Adult Deformity Surgery

Prokopis Annis, MD; William R. Spiker, MD; Brandon Lawrence, MD; Michael D. Daubs, MD; Darrel S. Brodke, MD
USA

Summary: The fusion rate at the lumbosacral junction in adult deformity surgery was high when using pelvic fixation and low dose bone morphogenetic protein-2 (BMP-2) posterolaterally. There was no additional benefit seen by adding interbody fusion. The overall revision rate for L5-S1 nonunion, after 38 months follow-up, was 1.6%.

Introduction: Pseudarthrosis at L5-S1 is one of the most common complications of long fusions to the sacrum in adult deformity surgery. Strategies for decreasing this include interbody fusion, use of high-dose BMP-2 at the lumbosacral junction, and the use of sacro-pelvic fixation, individually or in combination. High-dose BMP-2 (20-40mg) posterolaterally, has shown comparable fusion rates to interbody fusion. The purpose of the study was to evaluate L5-S1 fusion rates when lower dose BMP-2 (4mg) and pelvic fixation were used, with or without interbody fusion.

Methods: Retrospective review of 61 consecutive patients with minimum 2-year follow-up at a single institution. All patients were required to have a posterior approach only, ≥ 5 levels fused including L5-S1, use of pelvic fixation, and no prior L5-S1 procedures. The patients were divided in 2 groups for comparison based on the use of an interbody cage/fusion at the L5-S1 level. Radiographic union was assessed by 3 independent reviewers using Bridwell's criteria. Revision rates and implant related complications were also reported.

Results: The fusion rate at L5-S1 was 95% (58/61) with no difference between the 2 groups (94.3% vs 96.2%, $p=0.6$). There were no significant differences in the radiographic parameters or deformity correction between the groups. The mean amount of BMP-2 inserted in the disc space in the interbody group was 2.5mg (0-8). In both groups a mean of 3.5mg (2-4) of BMP-2 was used posterolaterally, along with allograft and local autograft. The overall revision rate for L5-S1 nonunion was 1.6%.

Conclusion: The use of low dose of BMP-2 at the L5-S1 level in combination with sacro-pelvic fixation achieved satisfactory fusion rates in adult deformity surgery. No additional benefit was encountered by adding an interbody cage.

232. Elderly Patients Over 75 Years Undergoing Reconstructive Spinal Deformity Surgery have Significantly Improved Health-Related Quality of Life Measures versus Those Managed Non-Operatively Despite High Surgical Complication Rate

Daniel M. Sciubba, MD; Justin K. Scheer, BS; Justin S. Smith, MD, PhD; Eric Klineberg, MD; Munish C. Gupta, MD; Gregory M. Mundis, MD; Themistocles S. Protopsaltis, MD; Virginie Lafage, PhD; Han Jo Kim, MD; Tyler Koski, MD; Khaled Kebaish, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Christopher P. Ames, MD; International Spine Study Group
USA

Summary: Increasing age is associated with increased surgical morbidity. A retrospective review of a multicenter prospective ASD database was conducted

E-POSTER ABSTRACTS

to compare the outcomes of patients with ASD over 75 years of age managed operatively and non-operatively. Elderly patients ≥ 75 years undergoing ASD surgery had significantly improved HRQOL and radiographic measures over baseline at two years compared to a similar non-operative cohort, despite substantial operative morbidity and higher preop SVA.

Introduction: Elderly adult spinal deformity (ASD) patients often report worse health-related quality of life (HRQOL) than younger patients. Increasing age is associated with increased surgical morbidity. The objective of the present study was to compare the outcomes of patients with ASD over 75 years of age managed operatively (OP) and non-operatively (NONOP).

Methods: A retrospective review of a multicenter prospective ASD database was conducted. Inclusion criteria included age ≥ 75 yrs, ASD. Demographics, comorbidities, radiographs, complications and HRQOL measures collected included pain with visual analog scale (VAS), Oswestry Disability Index (ODI), Short Form-36 (SF-36), and Scoliosis Research Society-22 (SRS22) at baseline, 1 and 2 yrs.

Results: 32 patients met criteria (OP:17, NONOP:15), all had a minimum 2yr clinical and radiographic follow-up. 13 out of the 32 were at least 80 years of age. There were no significant differences between OP and NONOP for age, BMI, and Charlson Comorbidity Index ($p > 0.05$ for all). OP had worse baseline ODI, PCS, SRS Activity, Appearance, and Total than NONOP ($p < 0.05$ for all). There were no significant differences in any baseline radiographic parameters. OP had significant improvement in LL, C7SVA, PI-LL, ODI, PCS, and all SRS subdomains except mental compared with preop ($p < 0.05$ for all). OP had significantly higher 2yr SRS appearance and Satisfaction ($p < 0.05$) than NONOP. There were no significant differences between baseline and 2yr HRQOL for NONOP ($p > 0.05$). 10/17 (58.8%) OP patients had at least 1 complication with a total of 27 complications including a 64.7% rate of PJK and a 35.3% rate of reoperation.

Conclusion: Elderly patients ≥ 75 years undergoing ASD surgery had significantly improved HRQOL and radiographic measures over baseline at two years compared to a similar non-operative cohort, despite substantial operative morbidity. This data may be used for preoperative patient counseling in this high-risk elderly population.

233. Secreted Phosphoprotein 24 kD (Spp24) Inhibits Nerve Root Inflammation Induced by Bone Morphogenetic Protein-2

Haijun Tian, Chenshuang Li, Trevor P. Scott, MD; Scott R. Montgomery, MD; Kevin H. Phan, BS; Lifeng Lao, MD; Wei Zhang; Yawei Li, MD; Tetsuo Hayashi, MD; Shinji Takahashi, MD, PhD; Raed M. Alobaidan, MBBS; Monchai Ruangchainikom, MD; Ke-Wei Zhao, PhD; Elsa J. Brochmann, PhD; Samuel S. Murray, MD; Jeffrey C. Wang, MD; Michael D. Daubs, MD
China

Summary: To investigate the direct neurotoxic effects of BMP-2 and test the hypotheses that the use of BMP binding proteins, such as secreted phosphoprotein 24 kD (Spp24), can reduce or eliminate these effects, in vitro experiments and in vivo analysis in a rodent model were carried out. The results confirm that BMP binding proteins have great potential as adjuvant therapies to limit BMP-2 related side effects in spine surgery.

Introduction: Recently the potential for an inflammatory effect of BMP-2 on exposed nerve roots has been raised. No reliable solution for this obstacle to the

application of BMP-2 in this setting has been promulgated. We have undertaken studies of the use of a BMP-2 binding protein, secreted phosphoprotein 24 kD (Spp24), as a potential therapeutic molecule to dampen the inflammatory effects of BMP-2.

Methods: Dorsal root ganglion cells were cultured with BMP-2 and markers of neuro-inflammation were measured by immunohistochemistry. Rats were randomized into four different groups according to the implantation they received: collagen sponge only, BMP-2 only, BMP-2 + collagen sponge, and BMP-2 + Spp24 and received a left unilateral L5 laminotomy and protein implantation. Functional evaluation was done using the Basso-Beattie-Bresnahan (BBB) scale. Routine H&E staining and immunohistochemical analyses using CGRP and Substance P staining were done.

Results: Treatment of DRG cells in vitro with BMP-2 significantly increased CGRP expression whereas treatment with Spp24 did not. The CGRP inductive effect of BMP-2 was blocked by the addition of Spp24 into the culture medium (Fig 1). Two days after surgery the BBB score for the subjects from the BMP-2 and BMP-2+Sponge groups decreased to a value that was significantly less than that of the control group. The neurologic function of the BMP-2+Spp24 group was not different from that of the control group and was higher than both the BMP-2 and BMP-2+Sponge groups. H&E staining revealed that the myelin sheath was swollen in the treatment BMP-2 group. Immunohistochemical analyses demonstrated that the BMP-2 only and the BMP-2+ Sponge groups had increased expression of both CGRP and Substance P, while the addition of the Spp24 effectively blocked this effect.

Conclusion: By binding to BMP-2, Spp24 can reduce BMP-2 induced neuro-inflammation both in vitro and in animal subjects treated with BMP-2 in vivo. These results confirm that BMP binding proteins have great potential as adjuvant therapies to limit BMP-2 related side effects in spine surgery.

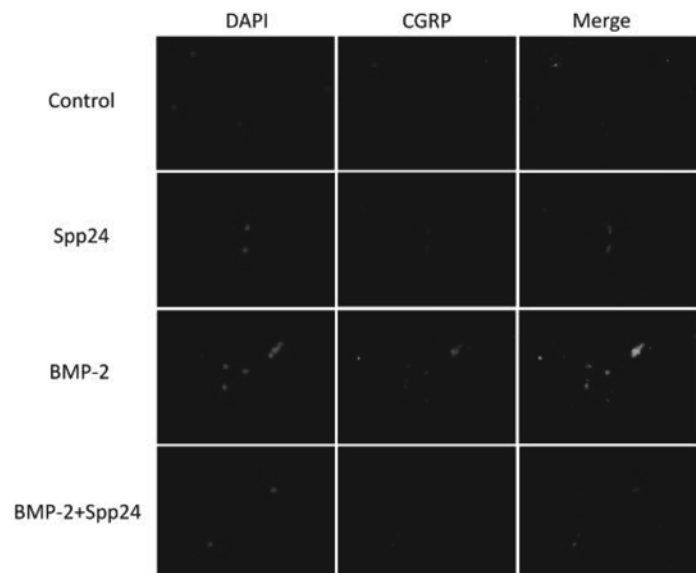


Fig 1. Immunohistochemical analysis of CGRP expression in DRG cells treated with BMP-2 with or without Spp24.

E-POSTER ABSTRACTS

234. When Does Growth Stop? Results of a Longitudinal Study Comparing Menarche and Skeletal Maturation of the Pelvis, Hand and Elbow to Growth Completion

James O. Sanders, MD; Debbie Y. Dang, MD, PhD; Xing Qiu, PhD; Mariano E. Menendez, MD; P. Christopher Cook, MD; Sarah D. Hans, MD; Daniel Cooperman, MD
USA

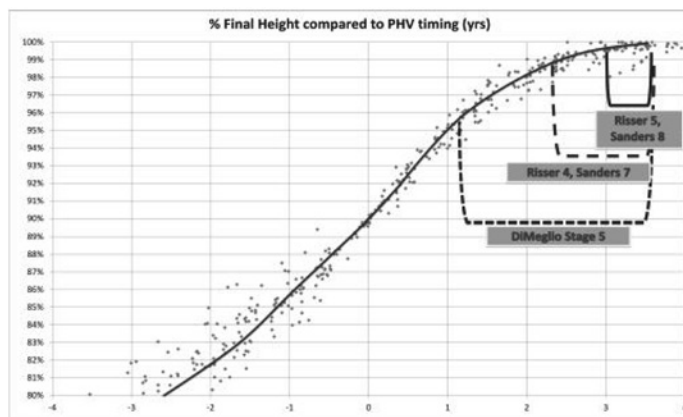
Summary: From a longitudinal study of growth in children, growth cessation for boys and girls follows a similar pattern with 99.0% of final growth at 2.5 years and 99.5% at 3.0 years after PHV. Neither the elbow or menarche are reliable indicators of maturity, but the Risser sign and Sanders stage are. Risser 4 and Sanders 7 indicate at least 98.6% growth completion and Risser 5 and Sanders 8 more than 99% of growth completed. Skeletal maturation of the pelvis and hand closely reflect growth completion.

Introduction: This study's purpose is to determine growth termination versus maturity indicators commonly used in scoliosis care using a longitudinal cohort.

Methods: A longitudinal series of children were followed through growth with annual stadiometric height measurements, evaluation of menarche and concurrent radiographs of their left hand, elbow, and hemipelvis had their menarche and skeletal maturity using the Risser sign, DiMeglio elbow scale, and the Sanders hand method compared to their peak height velocity (PHV), terminal growth and final height.

Results: 36 females and 24 males completed growth during the study. The PHV occurred at age 11.3 yrs in girls (range 9.2-14.2) and 13.0 yrs in boys (range 11.5-14.4). The pattern of growth relative to the PHV was similar for boys and girls with 99% of final height occurring 2.5 years and 99.5% at 3.0 years after PHV. Menarche averaged age 12.5yr or 1.2yr after PVH (range -0.5 to 2.3yrs) and was not reliably related to remaining growth. The elbow matured (DiMeglio 5) before the hand or pelvis reached their final stages. Earliest elbow maturation occurred at 95.3% final growth. Earliest Risser 4 occurred at 98.4% final height in both girls and boys. For the hand, Sanders stage 7 occurred at a minimum 98.4% final height in girls and 98.3% in boys. Both Risser 5 and Sanders 8 occurred at a minimum of 99% final height. One girl (1.7%), was an exception and grew 2.7cm after Risser 4, Sanders 7 and 1.7cm after Risser 5, Sanders 8.

Conclusion: Girls and boys both cease growth 2.5 to 3 years after their PHV and have similar growth patterns and skeletal maturity after PHV. The olecranon matures before growth is completed and its closure does not represent growth completion. Risser 4 and Sanders 7 both indicate growth is within 1.6% or 13mm of completion. Both Risser 5 and Sanders 8 are reliable indicators of growth cessation for both treatment and research. Menarche is not reliably related to growth cessation. Skeletal maturation using the pelvis or hand closely reflects the end of growth and boys and girls have similar final skeletal maturation.



235. Multilevel Ponte Osteotomies Increases Spinal Flexibility: Biomechanical Quantification using Human Cadaveric Specimens

John W. Kemppainen, MD; Todd F. Ritzman, MD
USA

Summary: This is the first human cadaveric biomechanical study to evaluate the effect of multiple adjacent thoracic Ponte osteotomies on increasing spinal range of motion (ROM) and flexibility in three planes of motion. Ponte osteotomies produced a significant increase in ROM in all planes when compared to both the intact and the facetectomized thoracic spine.

Introduction: The use of Ponte osteotomies to mobilize the spine and facilitate deformity correction is growing in popularity. This study aims to quantitate the effect of multilevel adjacent thoracic Ponte osteotomies in mobilizing long-segment human cadaveric specimens in all three planes of motion.

Methods: Utilizing intact fresh-frozen human cadaveric thoracic spines, three-dimensional flexibility tests under ± 4 Nm of applied pure moments were conducted in axial rotation (AR), flexion-extension (FE) and lateral bending (LB) on eight T4-T10 human cadaveric specimens utilizing a validated custom spine testing machine. Tests were conducted on the intact specimens and were repeated, sequentially, following standard inferior articular facetectomy and then following Ponte osteotomy. Ponte osteotomies were performed at each of the six levels within the thoracic segment via resection of the interspinous ligament, ligamentum flavum, superior and inferior articular facet and facet capsule. Total ROM across T4-T10 in each of the three planes of motion were compared between intact, facetectomy and Ponte osteotomy using paired T-tests with $\alpha = 0.05$.

Results: Compared to intact specimens, facetectomy produced a statistically insignificant increase in ROM in all planes [AR (5.5°, 117% of intact), FE (2.1°, 114%) and LB (3.3°, 114%)]. Ponte osteotomies produced statistically significant increase in ROM in all planes when compared to both intact and post-facetectomy specimens [AR (14.0°, 142% of intact, $p = 0.0006$), FE (9.6°, 158%, $p = 0.0001$) and LB (5.7°, 123%, $p = 0.03$)].

Conclusion: The results substantiate the utility of thoracic Ponte osteotomies in achieving increased spinal flexibility in all planes of motion.

E-POSTER ABSTRACTS

236. When is Expansion Thoracoplasty Beneficial? Lessons Learned From a Rabbit Model of Thoracic Insufficiency Syndrome

John C. Olson, MS; Brian D. Snyder, MD, PhD; Michael Glotzbecker, MD USA

Summary: Using a previously established rabbit model we demonstrate 1) prolonged inhibition of thoracic growth induces pulmonary hypoplasia and respiratory insufficiency 2) the extent of deformity induced in a growing rabbit determines the deformity and respiratory dysfunction in the adult rabbit and 3) Expansion thoracoplasty using VEPTR stabilizes decline in lung growth but does not normalize function - the expanded thorax remains rigid and the diaphragm surface remains smaller.

Introduction: TIS is the failure of the thorax to support normal lung growth or respiration. We used a rabbit model of TIS to evaluate the effect of early vs. late treatment with VEPTR on correcting spinal deformity and improving thoracic volume, lung growth, and respiratory function compared to untreated and healthy control rabbits.

Methods: To constrict the right hemithorax right ribs 2-10 were tethered in 3-wk-old rabbits (n=24). VEPTR was performed early, @ 7-wks-old (n=7), or late, @ 11-wks-old (n=7), with repeat expansion in the early group @ 11-wks. Sequential CT scans of the thorax and PFT's were performed @ age 6, 10, 14, and 28 wks (completion of somatic growth) to evaluate 3D spine curve, lung mass/volume, diaphragm surface area, FVC, FRC, and respiratory elastance. These outcomes were compared between groups using ANCOVA, with spine deformity @ age 6-wks as the covariate, to determine the effect of treatment on deformity, function, and growth in the adult rabbit.

Results: In untreated TIS rabbits, spine deformity @ age 6 wks predicted 88% of spine deformity and 76% of lung growth in the adult rabbits (Fig 1). VEPTR, performed early or late controlled spine deformity (Fig 1B), but only early treatment prevented expected decline in lung growth and only for rabbits with a spine deformity >43° @ age 6 wks (Fig 1A). A similar relation was found for diaphragm surface area (p<0.01).

Conclusion: These results lend credence to the clinical concept that early treatment of spine deformity in children will prevent deformity and pulmonary complications in adulthood. However, while early treatment with VEPTR stabilized the decline in lung growth, it did not normalize function.

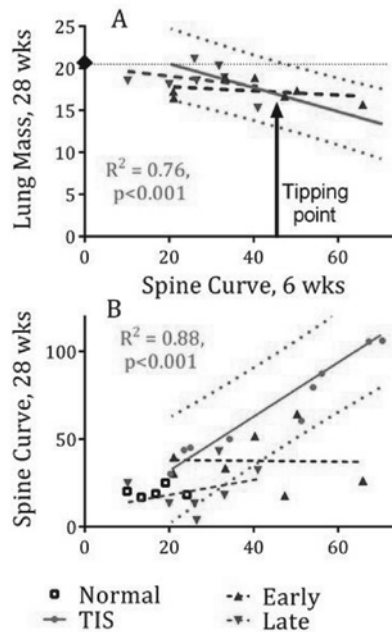


Fig 1: (A) Lung mass and (B) spine curve of adult rabbits versus spine curve at 6-wks for each group. Line of best fit shown for each group. 95% prediction interval, R^2 , and p-value shown for untreated TIS rabbits.

237. Genome-Wide Association Study in Adolescent Idiopathic Scoliosis: Identification of a New Locus

Yoji Ogura, MD; Ikuyo Kou; Yohei Takahashi; Katsuki Kono; Noriaki Kawakami, MD, DMSc; Koki Uno, MD, PhD; Manabu Ito, MD, PhD; Shohei Minami; Haruhisa Yanagida, MD; Ikuho Yonezawa, MD, PhD; Hiroshi Taneichi, MD; Taichi Tsujii, MD; Teppei Suzuki; Hideki Suda; Toshiaki Kotani; Kota Watanabe; Eijiro Okada, MD; Yoshiaki Toyama; Morio Matsumoto, MD; Shiro Ikegawa, MD, PhD Japan

Summary: We previously conducted genome-wide association study of Japanese adolescent idiopathic scoliosis, and already identified a locus on chromosome 10q24. To identify new locus, we extended the study. We identified new locus in GPR126 gene. This locus was first case which was replicated in multiple populations. Knockdown experiments of zebrafish gpr126 showed shorter body length and delayed ossification of the vertebrae. These results suggested that abnormal skeletal growth could induce scoliosis.

Introduction: We previously conducted a genome-wide association study (GWAS) of Japanese adolescent idiopathic scoliosis (AIS), and identified rs11190870 on chromosome 10q24 that had a genome-wide significance level association with AIS. In this study, we extended the GWAS to identify additional loci.

Methods: We recruited AIS subjects with Cobb angle $\geq 15^\circ$ who were diagnosed with AIS between 10 and 18 year-old. In the GWAS, we genotyped approximately 460,000 SNPs in 1,033 cases and 1,474 controls, and analyzed the association using the Cochran-Armitage trend test. We selected SNPs with

E-POSTER ABSTRACTS

$5 \times 10^{-8} < P < 1 \times 10^{-5}$ in the GWAS, and conducted a replication study using independent Japanese subjects (786 cases and 24,466 controls).

Results: Combining the results of the GWAS and replication study, rs6570507 reached a genome-wide significance threshold (Combined $P=2.25 \times 10^{-10}$; odds ratio=1.28). As a further evaluation, we genotyped rs6570507 in populations of Han Chinese (743 cases and 1,209 controls) and European ancestry (447 cases and 737 controls). The association was replicated in both populations; the P-values were 3.36×10^{-3} and 4.83×10^{-4} , respectively. The combined P-value was 1.27×10^{-14} . rs6570507 is located in GPR126 gene. In RT-PCR, GPR126 mRNA was highly expressed in human cartilage. Mouse Gpr126 was also expressed in proliferating chondrocytes of vertebrae by in situ hybridization. In knockdown experiments, zebrafish gpr126 morphants had shorter body lengths and delayed ossification of the vertebrae.

Conclusion: rs6570507 in GPR126 was associated with AIS susceptibility in multiple populations. The results of GPR126 functional analysis suggested that abnormal skeletal growth could induce scoliosis.

238. Do We Need Full-Spine Standing Radiographs to Assess the Cervical Spine in the Era of Sagittal Balance? A Comparative Study of Cervical Alignment on Standing Radiographs versus Sitting Radiographs

Heiko Koller, MD; Oliver Meier, MD; Juliane Zenner, MD; Michael Mayer, PhD Germany

Summary: Mostly, cervical radiographs are performed in sitting position. Whether these are sufficient to evaluate cervical sagittal balance and alignment of the cervicothoracic junction (CTJ) in terms of C7-slope (C7S) is under debate. We performed a study on 45 patients comparing measures of cervical alignment and sagittal balance on radiographs in sitting position (RSP) and on full-spine radiographs in standing (FSP). There were significant differences for all measures, particularly for the C7-Slope. FSR are indicated for correct evaluation of cervical sagittal balance and planning of cervical deformity surgery.

Introduction: Appreciating the impact sagittal balance has on outcomes, there is increasing interest in cervical alignment and correction of cervical deformity (CD). These developments mandate a critical analysis of the tools we use to describe cervical alignment, its changes and outcomes. In the sitting position, lumbopelvic alignment changes. These changes might affect the cervical spine levels too. The objective of our study was the comparison of cervical alignment measures and indices for cervicothoracic sagittal balance on full-spine radiographs in standing (FSP) compared to radiographs in sitting position (RSP).

Methods: Retrospective case series study. 45 patients fulfilling following criteria were included: Digital good quality FSP and RSP done within 1 week and visualization of spinal levels C0-7 including the os palatum. Patients with >1 fusion-level between C2-C7 were excluded. Age of patients was 58 ± 12 years (33-82yr), 31 were females. Radiographic measures included the C0-C2 angle according to McGregor, C1-C2 angle, Cobb angle of C2-C7, lordosis of C2-C7 according to Harris, and C7-slope (C7S). Radiographic measures on FSP and RSP were compared and absolute differences calculated.

Results: The C0-C2 angle was $21.2 \pm 12^\circ$ on RSP and $20 \pm 12^\circ$ on FSP (Difference: $5 \pm 3^\circ$). The C1-C2 angle was $29.6 \pm 10^\circ$ on RSP and $29.7 \pm 9^\circ$ on

FSP (Difference: $4.4 \pm 3.4^\circ$). The C2-C7 Cobb angle was $6 \pm 17^\circ$ on RSP and $4.9 \pm 16^\circ$ on FSP (Difference: $5.9 \pm 4.5^\circ$). The C2-C7 angle according to Harris was $12.6 \pm 16^\circ$ on RSP and $9.8 \pm 15^\circ$ on FSP (Difference: $6.1 \pm 4.5^\circ$). The C7S was $24.7 \pm 11.1^\circ$ on RSP and $26.9 \pm 11^\circ$ on FSP (Difference: $6.2 \pm 6.3^\circ$). All differences were significant at $p < .001$.

Conclusion: We observed significant differences between the measurements used for assessing cervical alignment and sagittal balance on FSP and RSP. Our findings indicate that the postural changes that occur at the lumbopelvic transition in sitting position and the strong interdependencies between the pelvic and lumbar positional parameters are transferred to the CTJ and cervical spine. Although the mean differences were small between FSP and RSP ($\sim 5^\circ$), the level of significance and meaningful standard deviations indicate that for detailed analysis of sagittal balance and surgical planning of CD surgery, FSR are a useful tool.

239. Validation of Correlation between CBVA, SLS and McGregor's Slope

Renaud Lafage, MS; Vincent Chailier, MD; Emmanuelle Ferrero; Barthelemy Liabaud, MD; Bassel G. Diebo, MD; Shian Liu, BS; Jean-marc Vital; Keyvan Mazda; Themistocles S. Protopsaltis, MD; Thomas J. Errico; Frank J. Schwab, MD; Virginie Lafage, PhD USA

Summary: Maintenance of horizontal gaze is an essential postural function. It is classically assessed by the Chin Brow Vertical Angle (CBVA), which is not readily measured on most lateral spine radiographs. This study demonstrated that CBVA can be substituted by 2 other angles: the Slope of Line of Sight (SLS) (angle of Frankfort line: anterior/inferior margin of orbit to the top of the external auditory meatus) and the slope McGregor's line (McGS) and that these 3 angles correlate with HRQOL parameters.

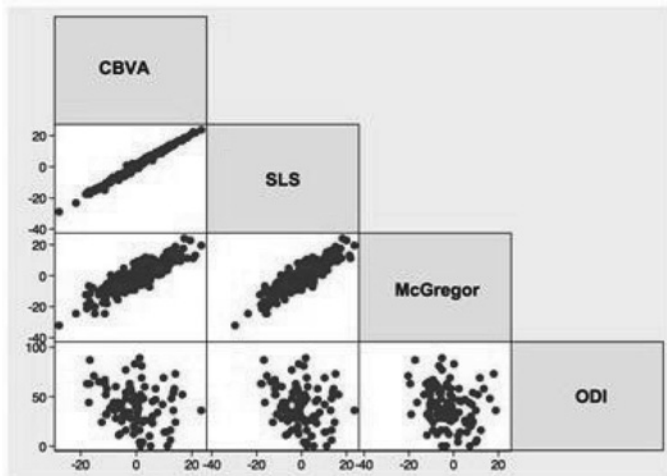
Introduction: The maintenance of horizontal gaze is an essential function of upright posture and global sagittal spinal alignment. One of the parameters allowing measurement of the horizontal gaze is the CBVA, which is not evident on most standard lateral X-rays. This study proposes to evaluate the correlation of CBVA with two more accessible angles: the SLS and slope McGS, and also to correlate these cranial parameters with HRQOL.

Methods: Patients were identified from a multicenter database of 531 spine patients who underwent full body EOS X-rays with a variety of presenting complaints (primary cervical, lumbar, or adult scoliosis). Exclusion criteria were age < 18y, THA, TKA, neuropathic scoliosis, fractures, and tumor. Correlations between CBVA, SLS, and McGS and were assessed. Using a quadratic regression with ODI and CBVA, we established a low disability range of values for the CBVA and then, by simple regression, a low disability range of values for SLS and McGS.

Results: 435 patients were included (67% females, mean age 57 ± 15 yo, mean BMI 27.4 ± 6.4 kg/m²). CBVA strongly correlated with SLS ($r = .996$, $p < .001$) and McGS ($r = .862$, $p < .001$). A significant negative correlation was observed between ODI and all 3 angles (Table). By applying a quadratic regression on the ODI and CBVA establishing range of values corresponding to low disability (-4.7° to 17.7°). A simple regression demonstrated the following low disability ranges for SLS (-5.1° to 18.5°), and for McGS (-5.7° to 14.3°).

E-POSTER ABSTRACTS

Conclusion: The maintenance of horizontal gaze, classically measured by the CBVA, is an essential element of cranio-cervical alignment. This study showed that the SLS and slope of McGregor's line correlate strongly to CBVA and can be used as surrogate measures. The range of values for these measures corresponding to low disability was identified. Further studies should be undertaken to evaluate these angles in severe cases of specific spinal pathologies.



	CBVA	SLS	McGregor	ODI
CBVA	1.0000			
SLS	0.9958 0.0000	1.0000		
McGregor	0.8620 0.0000	0.8716 0.0000	1.0000	
ODI	-0.2322 0.0221	-0.2285 0.0244	-0.2132 0.0360	1.0000

240. Association of Low Von Willebrand Activity (VWA) with Increased Intraoperative Bleeding (IOB) in Pediatric Posterior Spinal Fusion (PSF)
Jeff Cassidy; Matthew A. Halanski, MD; Nabil Hassan, MD
 USA

Summary: Von Willebrand disease is an inherited bleeding disorder that manifests as impaired platelet adhesion in the early phase of clot formation. Surgical treatment of scoliosis in children can be associated with significant blood loss which could be worsened by the presence of an underlying bleeding disorder. Low VWA levels were found in the absence of bleeding history and correlated with increased intra-operative blood loss. Losses were significant despite the use of antifibrinolytics and VW Factor Complex replacement.

Introduction: Von Willebrand disease (VWD) is an inherited bleeding disorder that manifests as impaired platelet adhesion in the early phase of clot formation. Surgical treatment of scoliosis in children can be associated with significant blood loss which could be worsened by the presence of an underlying bleeding disorder. We hypothesized that screening for VW activity (VWA) and treating low levels with Von Willebrand Factor Complex (Humate-P®) may decrease blood loss.

Methods: Following IRB approval, we conducted a retrospective review of prospectively collected data of all patients that underwent PSF. Chi-square and ANOVA were utilized to compare various groups. Logistic regression was used to examine correlation of blood loss with VWA.

Results: 169 patients with VWA >70% were matched to 59 patients with activity <70% by type of scoliosis and maximum Cobb angle range. Among those 59 patients, 16 received Humate-P (matched with 71 controls); 43 did not (matched with 98 controls). Overall transfusion rate was 50/228 (21.9%). Blood loss was examined at various VWA levels: patients with VWA levels < 50% had the most intra-operative bleeding 1265 ± 925mls compared to 717 ± 678mls in patients with 50-69% and 787 ± 718mls in patients > 70% (p < 0.012). Blood loss was standardized according to number of segments repaired: blood loss was 119 ± 133mls per level with VWA < 50% compared to 81 ± 60mls in 50-59%, 72 ± 47mls in 60-70% and 78 ± 47mls in patients > 70% (p < 0.044). 7 Of 16 with VWA < 50% (44%) had no family or personal bleeding history but bled intra-operatively. Logistic regression revealed a significant correlation of higher intra-operative blood loss per segment with lower VWA in the study group (r=-0.268, p<0.044). Despite 15 of 16 patients with VWA <50% receiving VW Factor Complex pre-operatively.

Conclusion: Pre-operative screening for VWA levels could identify patients at risk for increased intraoperative bleeding. Low VWA levels were found in the absence of bleeding history and correlate with increased intra-operative blood loss. Losses were significant despite the use of antifibrinolytics and VW Factor Complex replacement.

241. Incidence and Risk Factors for Venous Thromboembolism after Spine Surgery

Katsuhito Yoshioka, MD; Hideki Murakami; Satoru Demura; Satoshi Kato, MD; Hiroyuki Hayashi; Noriaki Yokogawa; Hiroyuki Tsuchiya
 Japan

Summary: This is the first report of prospective comparative study on DVT and PE after spine surgery. DVT and PE screening was performed for all 605 patients. The overall incidence of VTE was 10.6% (64/604 patients). 1.8% (11/604 patients) showed PE, and no DVT was found in 8 of these 11. Cervical degenerative disease have low risk of VTE, which is 3.0% (5/167 cases). On the other hand, lumbar degenerative disease have 11.6% (23/199 cases) of VTE.

Introduction: This is the first report of prospective comparative study on venous thromboembolism (VTE) after spine surgery.

Methods: A total of 604 patients who underwent elective spine surgery between 2007 and 2012 at the authors' institution were considered for inclusion in this study and divided into 7 groups. : Group 1) 108 patients with cervical degenerative disease treated with laminoplasty; Group 2) 59 patients with

E-POSTER ABSTRACTS

cervical degenerative disease treated with cervical fusion surgery; Group 3) 93 patients with thoracic/lumbar degenerative disease treated with three levels or more posterior fusion surgery; Group 4) 79 patients with lumbar degenerative disease treated with one level posterior lumbar interbody fusion (PLIF); Group 5) 120 patients with lumbar decompression surgery without fusion; Group 6) 53 patients with spinal tumor treated with piecemeal excision with stabilization; Group 7) 92 patients with spinal tumor treated with total en bloc spondylectomy. Deep venous thrombosis (DVT) and pulmonary thromboembolism (PE) screening was performed for all 605 patients 7-10 days after surgery. The binomial logistic regression analysis was used to assess the association of risk factors.

Results: The overall incidence of VTE was 10.6% (64/605 patients). 1.8% (11/605 patients) showed PE, and no DVT was found in 8 of these 11. 63.6% (7/11 patients) of PE was spinal tumor patients. However, only 0.3% of the patients (2/605 patients) had symptomatic PE. The incidence of VTE was 2.8% in group 1, 3.4% in group 2, 10.8% in group 3, 10.0% in group 4, 12.5% in group 5, 15.1% in group 6, 19.6% in group 7. The statistical analysis showed that female ($P=0.007$) and advanced age ($P=0.009$), spinal tumor ($P<0.001$), operative time ($P=0.018$), neurologic deficit ($P=0.001$), duration of postoperative bed rest ($P=0.003$) were risk factors for VTE. On the other hand, cervical spine surgery was the low risk of VTE ($P<0.001$).

Conclusion: The current study demonstrates that lumbar spine surgery carries threefold greater risk of VTE compared to cervical spine surgery. Spinal tumor surgery carries a high risk of critical VTE. No DVT was found in 8 of 11 PE positive patients. This result indicates that screening for PE itself is also needed in the case of high risk patients.

242. Titanium Spine Implants Are Not Associated with Lower Infection Rates

Margaret L. Wright, BS; Hiroko Matsumoto, MA; Regina P. Woon, MPH; John M. Flynn, MD; Michael G. Vitale, MD, MPH; David L. Skaggs, MD, MMM
USA

Summary: Surgical site infection (SSI) is a known complication of pediatric spine surgery, but the role of implant metal composition as a risk factor for SSI is unknown. This study evaluated patients who underwent spine surgery at three large children's hospitals and found no significant differences in SSI rates with varying implant metal types.

Introduction: Surgical site infection (SSI) is a well-described complication following pediatric spine surgery. Many risk factors have been identified in the literature, but controversy remains regarding the effect of metal composition as a risk factor for infection. This study sought to determine the effect of implant metal composition on the rate of SSI following pediatric spine deformity surgery.

Methods: This was a retrospective study of pediatric patients who underwent spinal instrumentation procedures between January 1st, 2006 and December 31st, 2008 at three large children's hospitals. All etiologies of scoliosis and procedure types were included, but patients undergoing insertion of Vertical Expandable Prosthetic Titanium Rib implants were excluded. The CDC definition of SSI was used. A chi-squared test was used to determine the relationship between type of metal implant and development of SSI.

Results: 874 patients underwent 1156 total procedures. 752 (65%) procedures used stainless steel (SS) instrumentation, 238 (21%) procedures used titanium (Ti) instrumentation, and the remaining 166 (14%) procedures used cobalt chrome (CC) and titanium hybrid instrumentation. The overall infection rate was 6.1% (70/1,156) per procedure; 5.9% (44/752) for SS, 6.7% (12/238) for Ti and 6.0% (10/166) for CC. There was no significant differences in the metal type used between patients with and without infection ($p=.886$).

Conclusion: This study was powered to conclude that there is no difference in SSI rates with SS, Ti, or CC instrumentation in our patients. We found a similar overall infection rate (6.1%) to previously reported studies performed in the same time period. This is the largest series of pediatric spine patients with varying etiologies of scoliosis and procedures that evaluates the effect of metal composition of spine implants on infection rates.

243. Posterior Vertebral Column Resection: Complications and Clinical Outcomes with Minimum Five-Year Follow Up

Ra'Kerry K. Rahman, MD; Lawrence G. Lenke, MD; Jeffrey L. Gum, MD; Nisha Raja-Rahman, MD
USA

Summary: 49 pts (33 pediatric and 16 adults) having undergone a posterior VCR procedure for the correction of severe spinal deformity showed minimal complications between the 2yr and min 5yr (range 5 to 11) follow-up with SRS outcome scores remaining significantly improved at this mid-term assessment.

Introduction: Short-term (2yr) follow-up has been reported for posterior vertebral column resection (pVCR) in pediatric and adult cohorts. The durability of this technically demanding procedure is of interest to deformity surgeons. This study seeks to determine the complications and clinical outcomes of pVCR patients with minimum 5-year follow in a combined adult/pediatric cohort.

Methods: Adult and pediatric spinal deformity patients undergoing a pVCR by a single surgeon were retrospectively identified from a single institution, prospectively collected database from 2000 to 2013. Forty-nine pts met the inclusion criteria. 33 were pediatric patients (age ≤ 18) and 16 adults. Patient charts were reviewed for clinical outcome scores and documentation of intraoperative or postoperative complications. Mean levels fused = 16 (range 5 to 20) with a mean of 2 levels resected (range 1 to 3) in this cohort. Perioperative and postoperative complications were defined as any change in neurologic status including neuromonitoring alerts, instrumentation migration/failure, acute infection, late infection, pseudarthrosis, reoperation, and medical complications.

Results: The mean follow-up was 7 yrs (range 5 to 11 yrs). The total observed complication rate was 63.2% (31 in 49 pts). The complications in this cohort were pleural effusion ($n=7$, 3 requiring a chest tube), other medical ($n=6$), infection ($n=5$, 0 acute and 5 late), implant failure/migration ($n=4$), intraoperative neuromonitoring change ($n=3$), pre-to-postop neurologic deficit ($n=3$), reoperation ($n=2$), and pseudarthrosis ($n=1$). Only 2 (6.4%) late complications were seen more than 2yrs postop. Importantly, there were no deaths and no permanent paraplegia/major neurologic deficits remaining at the latest F/U. The mean preop SRS score was 3.26, while the ultimate (min 5yr)

E-POSTER ABSTRACTS

postop SRS score was significantly improved to 3.80 ($p=0.03$).

Conclusion: Although pVCR has an admittedly high early complication rate, patients appear to have minimal complications in the interval between short (2yr) and mid-term (5yr) follow-up. Importantly, the significantly improved clinical outcomes are durable.

244. The Influence of Topical Vancomycin on Surgical Site Infection Rates following Instrumented Thoracolumbar Surgery

Anand Mohapatra, BS; Lukas P. Zebala, MD; Lawrence G. Lenke, MD; Wilson Z. Ray, MD; Michael P. Kelly, MD
USA

Summary: Topical vancomycin powder was effective prophylaxis against postoperative wound infections in thoracolumbar spine fusions (OR: 0.44 [0.29-0.66]). Complications possibly related to vancomycin exposure were not different between NoVanc and YesVanc groups. There were no cases of anaphylaxis in either group. Prospective study of vancomycin powder is needed to further define the effectiveness and safety of this prophylactic measure.

Introduction: Postoperative spine wound infection rates are as high as 20% in some series. These infections are associated with higher costs of care, higher rates of readmission, and higher acute mortality rates. Topical vancomycin powder is one method employed to reduce postoperative deep wound infections. The purpose of this study was to examine the effects of topical vancomycin on infections and other adverse events.

Methods: The Clinical Investigation Data Exploration Repository (CIDER) at Washington University was used to identify patients undergoing a posterior thoracolumbar spinal fusion between 2002 and 2012. Topical vancomycin usage and wound infections were identified and patients were divided into groups based upon their exposure to topical vancomycin (NoVanc/YesVanc). Adverse events and comorbidities were identified using ICD-9-CM codes. Linear multivariate regression was performed to investigate the association between topical vancomycin use and infections, controlling for known and reasonable confounders. Records were reviewed for complications potentially related to vancomycin usage, including acute renal insufficiency (ARI) and anaphylaxis.

Results: 2170 Pts were identified with complete data available for 2074 (NoVanc: 1240, YesVanc: 834). The groups were similar with respect to gender, age, BMI, surgical levels, and Charlson comorbidity index. Acute postoperative wound infections were more common in the NoVanc group (NoVanc 101/1240 [8.1%], YesVanc: 34/834 [4.1%], $p<0.001$). A decreased risk of infection was observed in the YesVanc group (OR: 0.44 [0.29-0.66]), controlling for confounding variables including number of levels fused. Rates of ARI, pseudoarthrosis, and anaphylaxis were similar between groups. (ARI YesVanc 3.2%, NoVanc 4.2%, $p=0.27$, Anaphylaxis 0% both groups).

Conclusion: The application of topical vancomycin powder was associated with a lower risk of postoperative wound infections. There were no complications associated with the application of vancomycin in this series. Prospective randomized-controlled trials are necessary to determine the extent to which topical vancomycin decreases postoperative wound infection and to determine rates of adverse events.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

245. An Increasing Risk of Late Onset Infection in the Years after AIS Surgery

Jahangir Asghar, MD; Michelle C. Marks, PT, MA; Ronald A. Lehman, MD; Peter O. Newton, MD; Maty Petcharapom, BS; Tracey Bastrom, MA; Amer F. Samdani, MD; Harry L. Shufflebarger, MD
USA

Summary: In a prospectively collected multi center database, the incidence of late infection for patients with minimum 2-year follow-up was 2.25%. However, the predicted probability of late infection increased with time to 4.8% at 10 years.

Introduction: Late-onset infection in AIS is a significant complication with unique therapeutic, and societal challenges. This study reviews a prospectively collected multi-center dataset to determine the incidence, bacteriology, and common treatment methods utilized for late onset infection.

Methods: Late infections were defined as a combination of drainage, increased pain, wound fluctuance, fevers, or abnormal inflammatory markers occurring after 90 days following the index operation. Treatment and outcome information was compiled on all confirmed infections. We compared Group I (Infection) to Group II (no infection) in terms of demographic, surgical, complication, and radiographic data preoperatively and at 2 years postop (F/U rate: 75%). Late infection risk over time was calculated with Kaplan-Meier survival analysis.

Results: 1752 patients met inclusion criteria with minimum 2-year follow-up (Mean f/u: 4.0 ± 2.2 years). 40/1752 (2.25%) presented with late infection (>90 days). The primary presenting complaint was spontaneous drainage in 85%, worsening back pain in 32.5% and fluctuance in 12.5%. They presented at 972 ± 625 days following the index procedure. The probability of late infection at 5 yrs was 2.9% and 4.8% at 10 yrs (see Table).

35/40 patients were treated with irrigation and debridement, 16 patients had total explantation (2 having partial removal of implants), 13 patients had retention of implants, and 4 patients had primary exchanges. Two patients with retained implants exhibited recurrence. 20.1% had positive documented cultures, with one patient having a documented pseudoarthrosis. There was little variation in the rates of late infection amongst the participating centers ranging from (1.6-3.1%, $p=0.3$). The initial treatment of 22/40 was oral Antibiotics, with 68% ultimately requiring irrigation and debridement. There were no correlations with variables such as: increased BMI, OR time, surgical approach, operative time, or rod material.

Conclusion: The overall incidence of late infection was 2.25%. However, the predicted probability of late infection increased with time to 4.8% at 10 years. Lastly, treatment of late infections with oral antibiotic therapy alone had a 68% rate of recurrence.

E-POSTER ABSTRACTS

246. Proximal Junctional Kyphosis Associated with Magnetically Controlled Growing Rod Surgery for Early Onset Scoliosis

Kenneth M. Cheung, MBBS(UK), MD, FRCS(England), FHKCOS, FHKAM(ORTH); Kenny Kwan; John Ferguson; Colin Nnadi, FRCS(Orth); Ahmet Alanay; Muharrem Yazici, MD; Gokhan H. Demirkiran; Behrooz A. Akbarnia, MD Hong Kong

Summary: This is a retrospective review of prospectively collected data from a multicentre study of early-onset scoliosis (EOS) treated by magnetically controlled growing rod (MCGR) with a minimum of 2 year follow-up. Proximal junctional kyphosis (PJK) occurred in 21.7% of the patients. This was associated with failure of the distraction mechanism, proximal foundation dislodgement and rod breakage. Risk factors for PJK associated with traditional growing rods (TGR) were not present in this series.

Introduction: Early reports suggested favourable clinical results for MCGR surgery in the treatment of EOS. However, their complication rate has not been widely reported. PJK is one of the causes of postoperative complications associated with TGR surgeries. As MCGR allows more frequent non-invasive distractions and the implant has a long straight portion which cannot be contoured, it is not known whether these may contribute to the incidence of PJK. The purpose of this study was to determine the incidence of PJK and examine possible associations in a series of patients treated by MCGR with a minimum of 2 year follow-up.

Methods: Patients from 5 spine institutes that are part of a multicentre study with prospectively collected data were assessed. Only those that had a minimum of 24 months follow-up were included.

Results: Twenty-three patients met the inclusion criteria. The mean age at the time of surgery was 7.6 years (range, 4 to 14) and the mean follow-up period was 36 months (range, 24 to 50 months). PJK occurred in 5 of 23 patients (21.7%). The clinical and radiographic parameters for these patients were studied. 3 of 5 patients had proximal anchor dislodgement. All constructs were revised, 4 of which were due to problems of rod distraction, while one patient had implant breakage. At the time of revision surgery, 2 cases were found to have autofusion at the apex, and were converted to definitive fusion, and 3 had new MCGR rods and anchors implanted and distraction was continued. Risk factors for PJK in TGR including proximal thoracic scoliosis, thoracic kyphosis, and proximal pedicle screws were not present in these cases. There was no difference in the frequency of distraction (range, 1 to 3 months) between those that developed PJK (n=5) and those that did not (n=17).

Conclusion: This is the largest series with the longest follow-up to date that describes PJK in MCGR patients. The incidence is 21.7%. All experienced failure of rod distractions due to failure of the distraction mechanism, proximal implant failure or rod breakage. While it is not possible to determine causation and risk factors in this relatively small series, surgeons using such techniques should be aware of potential issues related to MCGR.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

247. Causes and Risk Factors for 30-Day Unplanned Readmissions after Lumbar Spine Surgery

Andrew J. Pugely, MD; Christopher T. Martin, MD; Yubo Gao, PhD; Sergio A. Mendoza-Lattes, MD USA

Summary: Thirty-Day unplanned readmission rate was 4.4% and increased with procedure invasiveness. Both medical and surgical characteristics contributed to readmission.

Introduction: The rising costs associated with lumbar spinal surgery have received national attention. Recently, the government has chosen to target 30-day readmissions as a quality measure. Few studies have specifically analyzed the incidence, causes, and risk factors for readmission in a multi-center patient cohort.

Methods: A large, multi-center clinical registry was queried for all patients undergoing lumbar spine surgery in 2012. CPT codes were used to select patients undergoing lumbar discectomy, laminectomy, anterior and posterior fusions, and multi-level deformity surgery. Thirty-day readmissions rates and causes were identified and analyzed. Univariate and multivariate logistic regression analysis was used to identify patient characteristics, comorbidities, and operative variables predictive of readmission.

Results: Overall, 695 of 15,668 patients undergoing lumbar spine had unplanned 30-day hospital readmissions (4.4%). When separated by procedure type, readmissions were lowest after discectomy, 3.3%, and highest after deformity surgery, 9.0% (p < 0.001). The top causes for readmission were wound-related (38.6%), pain-related (22.4%), thromboembolic (9.4%), and systemic infections (8.0%). Predictors of readmission included advanced patient age > 80 years (p=0.03), Black race (p=0.03), recent weight loss (p=0.04), COPD (p < 0.01), history of cancer (p=0.04), creatinine > 1.2 (p < 0.01), elevated ASA Class (p=0.01), operative time > 4 hours (p=0.01), and prolonged hospital length of stay > 4 days (p < 0.01).

Conclusion: Thirty-Day unplanned readmission rates increased with procedure invasiveness. Both medical and surgical reasons contributed to readmission, many unavoidable. Surgeons should explore optimization measures for those at risk of early, unplanned readmission.

Risk Factors for 30-day Readmission determined by multivariate logistic regression

	Adjusted Odds Ratio (95% Confidence Interval)	P Value
Age (years): 50-60 vs <50 (reference)	1.17 (0.89 - 1.53)	0.271
Age (years): 60-70 vs <50 (reference)	1.46 (1.12 - 1.90)	0.005
Age (years): 70-80 vs <50 (reference)	1.08 (0.80 - 1.44)	0.623
Age (years): >80 vs <50 (reference)	1.51 (1.05 - 2.17)	0.026
Black Race	1.38 (1.03 - 1.84)	0.030
Recent Weight Loss	2.61 (1.04 - 6.53)	0.040
History of COPD	1.73 (1.24 - 2.41)	0.001
History of Cancer	2.23 (1.01 - 5.00)	0.049
*Serum Creatinine >1.2	1.61 (1.26 - 2.04)	<0.001
ASA Class 3 vs 1 and 2	1.30 (1.07 - 1.57)	0.008
ASA Class 4 vs 1 and 2	1.78 (1.14 - 2.75)	0.011
Prolonged Operative Time (> 4 hours)	1.30 (1.05 - 1.59)	0.014
Prolonged Length of Stay (>4 days)	1.75 (1.43 - 2.13)	<0.001

*COPD = Chronic Obstructive Pulmonary Disorder, ASA = Association of Anesthesiologists

E-POSTER ABSTRACTS

248. Long-Term Follow Up of Deep SSI after Spinal Fusion in Cerebral Palsy: Recurrence Rare, but Lower HRQOL

Urvij Modhia, MBBS, MD; Amit Jain, MD; Suken A. Shah, MD; Peter O. Newton, MD; Firoz Miyanji, MD, FRCSC; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Paul D. Sponseller, MD

USA

Summary: Deep SSI after PSF (Posterior Spinal Fusion) in CP (Cerebral Palsy) has sustained resolution with prompt operative care, regardless of organism. However, HRQOL scores remain significantly lower in than patients without infection.

Introduction: In children with CP who developed Deep Surgical Site Infection (DSSI) after spinal fusion surgery, to assess: 1) rate of recurrent infection, 2) differences by causative organisms, 3) effect of management strategies and 4) to compare CPCHILD score and overall Quality of life (QoL) of the deep DSSI group and control group.

Methods: A multicenter prospectively collected database of 151 children with CP who underwent spinal fusion surgery included 11 who developed DSSI and had minimum two year follow up after infection. They were compared to patients with no infection (NI). Causative organisms were: E. coli in 2 children, polymicrobial infection in 5, P. mirabilis, S. aureus, E. faecalis, and Peptostreptococcus in 1 each. All 11 required irrigation and debridement (I&D) and received minimum 6 weeks of antibiotics; 6 patients had wound VAC; the others had early primary closure. T tests were used to analyze deformity and repeated measures ANOVA to analyze CPCHILD scores; CPCHILD scores in both groups at pre-operative and 2 year follow up were compared. Significance was set at $P < 0.05$.

Results: At mean 4 year follow up (range, 3-5 y), no patients had recurrence of infection after management of the initial infection. One patient with DSSI 6 months post-op had elective late implant removal. From postoperative to two year follow up, there was no significant loss of major coronal correction (mean pre-operative 100 o, post-operative 42 o and final 41 o, $P=0.77$) or pelvic obliquity correction (mean pre-operative 31 o, post-operative 13 o and final 14 o, $P=0.71$). However, at 2 year follow up overall QOL and CPCHILD scores in the DSSI group were significantly lower compared to the NI group ($P = 0.04$ and 0.03 respectively; Fig 1). At 2 year follow up after SSI, only positioning, transfers and mobility and overall health sub scores were stable compared to preoperative scores.

Conclusion: In children with CP with early DSSI after spinal fusion, there was no recurrence of infection or deformity after infection management, regardless of organism. There was no difference between operative I&D with primary closure versus wound VAC. However, overall QoL and total CPCHILD scores in CP patients with DSSI were significantly lower compared to NI.

249. Unplanned Reoperation within 30 Days of Fusion Surgery for Spinal Deformity

Jianxiang Shen, MD; Zheng Li

China

Summary: No recent studies exist that analyze the rate or reason for unanticipated revision surgery for spinal deformity patients within 30 days of primary surgery. To decipher the incidence, characteristics, reasons and risk factors for unplanned 30-day revision surgery in spinal deformity treated at one institution.

Introduction: No recent studies exist that analyze the rate or reason for unanticipated revision surgery for spinal deformity patients within 30 days of primary surgery. To decipher the incidence, characteristics, reasons and risk factors for unplanned 30-day revision surgery in spinal deformity treated at one institution.

Methods: All patients presenting for primary instrumented spinal fusion with a diagnosis of spinal deformity at a single institution from 1998 to 2012 were reviewed. All unplanned reoperation performed within 30 days after primary surgery were searched. Demographics, surgical data, and complications were analyzed. Statistical analysis was performed to obtain correlations and risk factors for anticipated revision.

Results: Of 2758 patients aged 16.07 years (range, 2-71), with 69.8% women who underwent spinal fusion surgery, 59 (2.1%) required reoperation within 30 days after primary surgery. Follow-up time of each patient was over 30 days. 87.0% of patients had posterior surgery only, 5.7% of patients had anterior surgery, and 7.3% had double anteroposterior approach. Reasons for reoperation included implant failure ($n=20$), wound infection ($n=12$), neurologic deficit ($n=9$), pulmonary complications ($n=17$), and coronal plane imbalance ($n=1$).

Risk factors for reoperation were age, diagnosis, surgery procedure with osteotomy. **Conclusion:** The rate of unplanned reoperation in spinal deformity surgery at a single institution was 2.1%. The most common reasons for revision were implant failure, pulmonary complications, wound infection, and neurologic deficit. The risk factors for reoperation were age, diagnosis, surgery procedure with osteotomy.

250. Unexpected Intraoperative Events that Prompt Discontinuation of Pediatric Spinal Deformity Surgery with Two-Year Follow Up

Sreeharsha V. Nandyala, BA; Richard M. Schwend, MD

USA

Summary: In this retrospective case series, intraoperative complications involving neurological, anaphylactic, or equipment complications prompted discontinuation of PSDS in 2% of the cases

Introduction: In rare situations, the surgeon may discontinue a pediatric spinal deformity surgery (PSDS) due to an unresolved intraoperative complication. No studies have characterized the reasons that may prompt termination of a case prior to completion

Methods: This is an IRB approved retrospective series of 561 PSDS from 2007-2011. Eleven cases (1.9%) (5 idiopathic, 5 neuromuscular, and 1 syndromic scoliosis) were discontinued prior to completion. Medical records were reviewed to identify the hospital course along with a 2-year follow up. Root cause

E-POSTER ABSTRACTS

analysis (RCA) was utilized to assess the intraoperative complications, corrective measures, and potential lessons to mitigate future recurrences

Results: Of the 11 discontinued cases, 7 (64%) demonstrated loss of neuromonitoring potentials and failed standard corrective measures. These disturbances were mainly noted during screw insertion and rod distraction. Of these 7 patients, one was diagnosed with medial pedicle wall breach and another subsequently with Charcot-Marie-Tooth Type 1. Three of 11 (24%) patients developed severe intraoperative anaphylactic reactions of which one demonstrated cardiopulmonary instability from inhaled anesthesia and two developed dyspnea after blood product transfusion of which one patient was diagnosed with IgA deficiency. One case (9%) was terminated following neuromonitoring equipment malfunction. Overall, three patients (27%) required additional interventions to address sequelae from the discontinued procedure including wound dehiscence and reintubation. All discontinued cases were safely completed at a later date when the patient was stable. Three patients (27%) developed deep surgical site infections at 2, 3, and 4 years respectively, and responded to implant removal with debridement. There were no permanent neurological deficits

Conclusion: When an intraoperative neurological, anaphylactic, or equipment complication occurs, termination of the case may be the safest decision if the complication cannot be safely resolved. RCA suggested that complications in 4 cases were preventable due to missed preoperative diagnoses (1), assessment of spinal cord proximity (2), and lack of back-up monitoring equipment (1)

251. Populations at Risk for Reoperation after Spine Fusion for Scoliosis

Justin C. Paul, MD, PhD; Baron S. Lonner, MD; Thomas J. Errico
USA

Summary: Previous studies have analyzed the rate of reoperation after spine fusion surgery have evaluated a small number of patients treated by small groups of surgeons limiting the conclusions that could be drawn particularly for relatively rare conditions. This study follows the inpatient stay administrative data collected for a cohort of more than 50,000 patients who had spine fusion surgery in the state of New York. Neurofibromatosis and arthrogyrosis have the highest relative risk for a reoperation within one year.

Introduction: The incidence of post-operative complications and re-operations is known to vary among patients with varying scoliosis pathologies. As these are heterogeneous conditions often with rare occurrence, it is difficult to compare them in a single study. Large administrative databases provide an opportunity to understand how they interact. We aimed to assess reoperation events after fusion for several etiologies for scoliosis.

Methods: The 2008-2011 New York State Inpatient Database was queried the database using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes for patients with in-hospital stays including a spine arthrodesis for a diagnosis of scoliosis. All approaches, all fusion lengths, and all ages were included. Patient identifiers and linkage variables were used to identify revisits. The relative risk of reoperation was calculated for several rare conditions associated with scoliosis.

Results: A total of 58,624 primary fusion operations for scoliosis were identified. The overall rate of reoperation after spine fusion for all etiologies was 3%. Some

of the reoperation patients (7%) had multiple reoperations. Neuromuscular scoliosis (RR 1.97, $p < 0.001$, see Table) patients showed increased risk of reoperation within one year, while idiopathic scoliosis did not (RR 0.7, $p = 0.003$). Arthrogyrosis (RR 2.46, $p < 0.001$) and neurofibromatosis (RR 3.13, $p = 0.007$) showed the highest risk for reoperation. Having a diagnosis of infection during the initial hospital stay increased risk for any etiology (RR 4.24, $p < 0.001$). Fusions longer than 8 levels also increased risk (RR 1.36, $p = 0.018$). Each reoperation visit was associated with longer length of stay and increased hospital charges.

Conclusion: Using relevant in-hospital patient records from the New York State Inpatient Sample, we found that neurofibromatosis and arthrogyrosis have the highest relative risk for a reoperation within one year. At risk populations should be identified and resources allocated accordingly to prevent these devastating events.

252. Creation of a Consensus-Based Checklist for the Response to Intraoperative Neuromonitoring Changes in Spine Deformity Surgery

Michael G. Vitale, MD, MPH; Gregory I. Pace, BA; Margaret L. Wright, BS; Hiroko Matsumoto, MA; Mark A. Erickson, MD; John M. Flynn, MD; Michael Glotzbecker, MD; Kamal N. Ibrahim, MD, FRCS(C), MA; Stephen J. Lewis, MD; Scott J. Luhmann, MD; B. Stephens Richards, MD; James O. Sanders, MD; Suken A. Shah, MD; David L. Skaggs, MD, MMM; John T. Smith, MD; Kit Song, MD, MHA; Paul D. Sponseller, MD; Daniel J. Sucato, MD, MS; David P. Roye, MD; Lawrence G. Lenke, MD
USA

Summary: This project sought to develop an initial tool to optimize surgical team responses to intraoperative neuromonitoring (IONM) changes during spine deformity surgery of patients with stable spines. A consensus-based process utilizing the literature and the expertise of leading spine surgeons facilitated the creation of the final checklist.

Introduction: Neurologic injury during spine deformity surgery is a rare but devastating complication. Currently, no widely accepted guidelines exist for the response to IONM changes in spine surgery. This project sought to develop a consensus-based checklist to guide surgeon responses to IONM changes for patients with stable spines.

Methods: After a thorough literature review identifying risk factors and current recommendations for responding to IONM changes a series of surveys was administered to 20 experienced spine surgeons assessing areas of equipoise and consensus in surgical team responses to IONM changes. Results were presented to all participants and the nominal group process was used to determine the checklist items to be included. The working group re-evaluated the consensus based work product at three separate face-to-face meetings. Agreement over 80% was considered consensus and items near consensus were re-discussed and followed by repeated nominal group technique.

Results: Consensus was reached for the creation of five headings containing relevant items to consider in response to IONM changes. These headings are: gain control of room, anesthetic and systemic considerations, technical and neurophysiologic considerations, surgical considerations, and ongoing considerations, which are items to be considered throughout the entire response.

E-POSTER ABSTRACTS

Additionally, the checklist includes items to consider if IONM changes improve or persist (see figure).

Conclusion: The result of this project represents the consensus of several leading spine surgeons as to the most important and high yield items to consider when responding to IONM changes for patients with stable spines. The final checklist contains 5 headings with 26 total items to consider in response to IONM changes.

253. Does Antibiotic-Loaded Bone Graft Used in Scoliosis Surgery Lead to Superbugs

Sujal Patel, MD; Sina Pourtaheri, MD; Suken A. Shah, MD; Kirk W. Dabney, MD; Kenneth J. Rogers, PhD; Freeman Miller, MD

USA

Summary: A single institutional experience of using antibiotic-loaded bone graft for pediatric scoliosis surgery reduced infection rates over a 5-year period compared to a control cohort. However, cultured pathogens from SSI cases with antibiotic-loaded bone graft showed an alarming rate of methicillin-resistant *S. aureus*.

Introduction: Antibiotic-loaded bone graft has decreased SSIs in pediatric scoliosis surgery; however, are decreased infection rates obtained at the expense of creating antibiotic resistance in the community? We reviewed cultured pathogens from SSI cases with and without antibiotic-loaded allograft and determined if there were antibiotic resistant pathogens seen in the antibiotic-loaded group.

Methods: 851 consecutive pediatric scoliosis surgeries from 2006-2010 with antibiotics in bone graft (ABX) were compared to 620 cases from 1998-2004 without antibiotics in bone graft (Non-ABX). In 2006, we initiated a protocol of placing antibiotics in bone graft from our published study. All patients received prophylactic IV antibiotics prior to skin incision. Neuromuscular scoliosis patients received gentamicin in the bone graft, and AIS cases received vancomycin. Two different control cohorts were devised as well: non-infected cases in the antibiotic-loaded group (Control ABX) and non-infected cases for the group without antibiotics in bone graft (Control Non-ABX). Chi-squared statistic, Fisher's exact, and single sample t tests were used for analysis.

Results: 24 ABX cases were compared to 30 Non-ABX cases. Patient demographics were similar in both groups: AIS and cerebral palsy. The proportion of gram positive and negative infections was similar between the infected groups. MRSA infections were greater in the ABX group. No resistant gram negative infections were seen in either group.

Conclusion: Antibiotic-loaded bone graft was effective prophylaxis for infection in scoliosis surgery. However, increased occurrence of MRSA was seen with antibiotic-loaded bone graft. The rise of MRSA infections could be attributable to the antibiotics used; or, it could be a result of the rise of MRSA in the community, since the earlier cases predate our protocol for placing antibiotics in the bone graft.

254. Meta-Regression Analysis of the Effect of Tranexamic Acid on Blood Loss in Spine Surgery

Thomas Cheriyan; Carl B. Paulino, MD; Kristina Bianco, BA; Stephen P. Maier, BA; Baron S. Lonner, MD; Thomas J. Errico

USA

Summary: TXA has shown to be effective in reducing surgical blood loss.

However there is no study on optimal dose-response and amount of blood loss in spine surgery. This meta-regression shows a total dose of about 1 gm appears to be effective in reducing surgical blood loss in spine surgery. However, further dose-comparative studies are necessary for robust conclusions on dose-dependent efficacy of TXA.

Introduction: Tranexamic acid (TXA) has been shown to reduce surgical bleeding in spine surgery. However dose-response and amount of reduction has not been fully established. Furthermore, a dose-comparative cost analysis of the commonly utilized and less costly antifibrinolytic, epsilon amino caproic acid (EACA), has not been analyzed in the current spine literature. The purpose of this study is to investigate

1. Dose relation to surgical blood loss reduction.
2. Extent of reduction of bleeding.
3. Cost comparison of TXA vs EACA.

Methods: MEDLINE, Embase, Cochrane controlled trials register, and Google Scholar were used to identify RCTs published before January 2014 that examined the effectiveness of intravenous TXA or EACA on reduction of blood loss and blood transfusions, compared to a placebo/no treatment group in spine surgery. Meta analysis was performed using STATA11.0. A weighted standardized mean difference with 95% confidence interval (CI) was summarized and presented as pooled ratios (PR) for continuous outcomes. Meta-regression was used to assess effect of dosage. Back-transformed pooled estimate with a 95% CI was used to assess extent of absolute reduction in blood loss with TXA.

Results: Nine RCTs (n=644) were included in the study with 325 and 319 patients in the TXA and control group, respectively. The effect of TXA on blood loss did not vary over the range of total dose of 0.8 to 11.6 gram. TXA reduced intraoperative blood loss by 38%. (PR= -0.62 [-0.97, -0.28]) and total blood loss by 8% (PR= -0.92 [-1.42, -0.42]). TXA led to a reduction in the proportion of patients who received a blood transfusion by 34% (OR= 0.66 ([0.54, 0.80], p <0.05) relative to placebo. In the TXA group there was one report of MI and one case of VTE reported in the control group. Cost comparison of TXA versus EACA is shown in the Table.

Conclusion: A total dose of about 1 gm appears to be effective in reducing surgical blood loss in spine surgery. However, further dose-comparative studies are necessary for robust conclusions on dose-dependent efficacy of TXA.

E-POSTER ABSTRACTS

255. Posterior Hemivertebra Resection with an Anterior Titanium Mesh Cage and Short Segmental Fusion for the Treatment of Congenital Scolio-Kyphosis Due to Fully-Segmented Nonincurated Hemivertebra

Zhang Jianguo, MD

China

Summary: There exist lots of reports on posterior hemivertebra resection for the early surgical intervention of congenital scoliosis due to hemivertebra. However, few reports focused on the anterior reconstruction after hemivertebra resection.

Introduction: This is a retrospective study to evaluate the results of posterior hemivertebra resection with a anterior titanium mesh cage and short segmental fusion for the treatment of congenital scolio-kyphosis due to fully-segmented nonincurated hemivertebra.

Methods: 18 children aged 5.9 (2-12) years with scolio-kyphosis due to fully-segmented nonincurated hemivertebra were treated by posterior hemivertebra resection with a anterior titanium mesh cage and short segmental fusion. The location of the hemivertebra was as follows: thoracolumbar region(T10-L2) in 9 cases, lumbar spine(L3-4) in 6 cases, lumbosacral region(L5-S1) in 3 cases. They were retrospectively studied with a mean follow-up of 37.2(24-85) months. Radiographs, operative reports and patient charts were reviewed to evaluate the correction and complications.

Results: The averages fused segments were 1.67(1-3). The segmental scoliosis was 39.8° before surgery, 4.1° post surgery and 6.4° at the latest the follow-up. And the segmental kyphosis(difference to normal segmental alignment) was improved from 26.1° to 3.9°. The correction of the compensatory cranial and caudal curve was 74.7% and 82.4%.The trunk shift improved from 17.7mm to 5.3mm. No complications occurred until the latest follow-up.

Conclusion: Posterior hemivertebra resection with an anterior titanium mesh cage and short segmental fusion is a reliable procedure for patients with scolio-kyphosis due to a fully-segmented nonincurated hemivertebra, especially when the hemivertebra is big and the segmental kyphosis is pronounced. As a fulcrum, anterior reconstruction with a titanium mesh cage could help to improve the correction of the sagittal plane. This advantage is more significant in the spine below thoracic, which show lordosis on sagittal plane. Furthermore, the cage may help to stabilize the level of hemivertebra resection like a structural autograft, decreasing the stress of the pedicle and implants. Thus the risk of pedicle fracture and implants failures could be reduced. This may be helpful to avoid extending fusion level.

257. Outcome of 115 Patients with Congenital Scoliosis: A Five-Year Follow-Up Study

Andrew J. Paterson, MD; Skye King; Azadeh F. Fotouhie; Antony Kallur, MD USA

Summary: Outcome of patients with congenital scoliosis seems to depend on curve magnitude at presentation, presence of more than one anomalous malformation, other organ involvement and early age of operation.

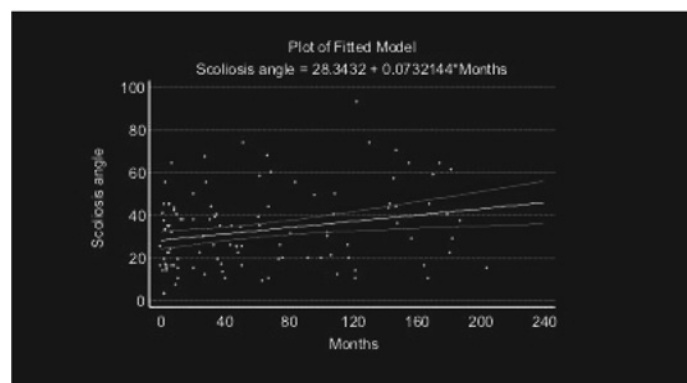
Introduction: The etiology, severity and prognosis of congenital scoliosis depend on multiple factors, with limited data in the literature. Given the progressive

nature of the disease and eventual need for surgical intervention, the study was designed to obtain more data on epidemiology and surgical outcomes in order to elucidate the disease and tailor surgical interventions to specific structural defects, reduce the need for a second surgery, and reduce complications.

Methods: Using a retrospective chart review of 125 patients with congenital scoliosis, seen at the Carrie Tingley Hospital in Albuquerque, NM from the years 2002 to 2011. This includes information on patient age, ethnicity, geographical location in NM, degree of spinal curvature using the Cobb method, type of vertebral anomaly, and surgical intervention and outcomes.

Results: Of the 125 patients recorded, mean age at presentation is 4 years and 9 months and mean length of follow-up is 5 years. There are 69 females and 56 males. The ethnic distribution is 70 Hispanic, 36 Caucasian, 13 Native American, 1 African American, and 5 other. 55% of all patients had one or more co-morbid conditions, 37% of patients required surgery, and 24% of these required revision surgery. Approximately 55% of all patients had one or more co-morbid conditions. There was a wide range of scoliotic curve magnitudes at presentation, ranging from 3 degrees to 93 degrees, with some patients having a single curve and others exhibiting compensatory curves. Using the standard classification method, 83% of patients had mild scoliosis upon presentation, while 13% had moderate scoliosis and 0.04% had severe scoliosis. Regarding the nature of their scoliosis, approximately 49% of patients had one or more hemivertebrae accounting for their abnormality, while approximately 36% of patients had mixed vertebral abnormalities. Interventions performed included anterior fusion, posterior fusion, both, vertebral excision in combination with any of the above, VEPTR, fusion, and Woodward procedure.

Conclusion: Within limitations of study the the overall rate of children with congenital scoliosis requiring surgery is 37% and the rate of revision surgery in these operated children is 24%.



The output shows the results of fitting a linear model to describe the relationship between Scoliosis angle and Months. The equation of the fitted model is $\text{Scoliosis angle} = 28.3432 + 0.0732144 * \text{Months}$

E-POSTER ABSTRACTS

258. Evaluation of Scoliosis Screening using Moiré Topography in School Children

Akiko Misawa, MD; Michio Hongo, MD; Daisuke Kudo; Yoichi Shimada, MD Japan

Summary: The purpose of this study was to evaluate the prevalence rate of scoliosis diagnosed by screening school children using Moiré topography. A total of 835 children (2.47%) were diagnosed using Moiré topography. The overall prevalence rate of patients with Cobb angles $\geq 10^\circ$ was 1.27% using radiographic examination. Recent data show that the prevalence rate in elementary school students increased; therefore, screening should be performed at an appropriate time to ensure early detection of scoliosis.

Introduction: Screening of school children for scoliosis is an orthopedic examination that has a direct effect on the health of these children. Screening can be performed using various methods. Since 1983, in our prefecture, we have used Moiré topography for screening. The purpose of this study was to evaluate the prevalence rate of scoliosis diagnosed by screening school children using Moiré topography.

Methods: Between 2005 and 2012, 33,840 students were screened: 22,897 elementary school boys and girls in the sixth grade and 10,943 junior high school girls in the second grade. Our screening program involved the use of Moiré topography and radiography. This study was performed to determine the prevalence and distribution of scoliosis as well as the Cobb angle. When anomalous findings were observed, a roentgenographic examination of the entire spine was performed. The results were defined as follows: normal findings, a Cobb angle $< 10^\circ$; non-reassuring, $10-14^\circ$; regular examination, $15-24^\circ$; and requires treatment, 25° .

Results: A total of 835 children (2.47%) were diagnosed using Moiré topography. Radiographic examination revealed a Cobb angle of $\geq 10^\circ$ in 429 (61.3%) children. The overall prevalence rate of patients with Cobb angles $\geq 10^\circ$ was 1.27% (elementary school: 0.81%; junior high school: 2.22%). The findings revealed non-reassuring results in 0.46%, regular examination results in 0.61%, and the need for treatment in 0.20%.

Furthermore, the prevalence rate of patients with Cobb angles $\geq 15^\circ$ was 0.81%. The mean prevalence rate of Cobb angles $\geq 10^\circ$ during the last 4 years increased from 0.96% during the first 4 years to 2.51%, especially in elementary school children where the rate increased from 0.49% to 1.15%.

Conclusion: Moiré topography is more suited for screening scoliosis rather than for inspection and palpation due to limited oversight and the ability to screen a large number of school children. Recent data show that the prevalence rate in elementary school students increased; therefore, screening should be performed at an appropriate time to ensure early detection of scoliosis.

259. Restoration of Kyphosis and Thoracic Symmetry: Does it Improve Pulmonary Function in AIS?

Leok-Lim Lau; Kushagra Verma, MD, MS; Petya Yorgova, MS; Geraldine I. Neiss, PhD; Suken A. Shah, MD USA

Summary: Thoracic hypokyphosis and thoracic asymmetry are commonly seen in AIS. We hypothesized that restoration of these parameters may result in pulmonary function improvement. 52 patients with AIS (mean age 13.8) pre/postop PFTs, and minimum 2 year follow-up were included. Mean FEV1, FVC and TLC improved post-operatively. The changes in FEV1/FVC ratio correlated with changes in kyphosis from T5 to T12, T2 to T12, pre- and post-op SSAL but not with changes in SAL and T1 to S1 length.

Introduction: Thoracic hypokyphosis is a common feature in patients with adolescent idiopathic scoliosis (AIS). The thoracic cage deformity may contribute to restrictive pulmonary disease, especially if pulmonary reserve is diminished for other reasons with normal or high FEV1/FVC ratios. We hypothesized that an improvement in thoracic kyphosis and thoracic symmetry may result in better pulmonary function as a result of improved volume and mechanics.

Methods: We reviewed prospective and consecutively enrolled patients from 2006 to 2008 at our institution. Inclusion criteria were all AIS patients managed surgically who had pulmonary function tests (PFTs) performed pre-operatively and at the latest follow-up (min 2 yrs). Exclusion criteria were anterior approach or thoracoplasty. Coronal and sagittal corrections were assessed and additional radiological parameters including coronal space available for lung (SAL), T1 to S1 length, sagittal space for lung (SSAL), and total lung capacity (TLC) were measured. SSAL represents a new measurement of sagittal thoracic symmetry and volume (see Figure).

Results: 52 patients (mean age 13.8 years, range 10-18) were identified. One patient had obstructive lung disease which improved post-operatively. None of the patients had symptomatic restrictive lung disease. Pulmonary function improved from pre-op to post-op: mean FEV1 (2.46 to 2.66, $p < 0.05$), FVC (2.86 to 3.19, $p < 0.01$) and TLC (4.01 to 4.43, $p < 0.01$). However, FEV1/FVC ratios were unchanged (0.85 to 0.84, $p = 0.890$). The changes of the ratios correlated significantly with improvement in kyphosis from T5 to T12 and T2 to T12, pre-op SSAL and post-op SSAL in a multiple regression model ($r = 0.503$, $p < 0.01$). The mean follow-up was 50.4 months (range 24-60 months). Coronal SAL and T1 to S1 length changes did not correlate with pulmonary function.

Conclusion: This study demonstrated that restoration of thoracic kyphosis and sagittal thoracic symmetry/volume (SSAL) after spinal fusion for AIS correlated with improved pulmonary function. Coronal space available for lung (SAL), however, did not correlate with pulmonary function. This is clinically significant in patients with decreased pulmonary reserve.

E-POSTER ABSTRACTS

260. Significant Unexpected Abnormalities Detected on MRI Scan in Scheuermann's Kyphosis: A Consecutive Series of 104 Patients over Six Years

Matthew P. Newton Ede, MB, ChB, MRCS(Eng), FRCS(Tr&Orth); Udara Kularatane, MB, BChir, BE, PGD, FRCR; Hassan Douis, MRCP, FRCR; Adrian Gardner, BM, MRCS, FRCS (T&O); Steven James, MB, ChB, FRCR; David S. Marks, FRCS; Jwalant S. Mehta, FRCS (Orth); Jonathan Spilsbury, FRCS United Kingdom

Summary: A consecutive series of 104 patients over 6 years with Scheuermann's Kyphosis (SK) had whole-spine MRI scans. We detail a 13% prevalence of unexpected findings, including 8% neural axis anomalies.

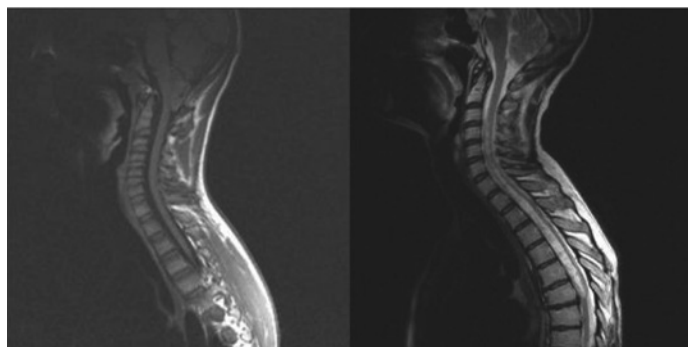
Introduction: Neural axis anomalies in idiopathic scoliosis (AIS) are well documented, with prevalence of 7% in adolescents; 20% in early-onset and up to 40% in congenital, the case for pre-operative MRI of brainstem to sacrum is well made in these groups.

SK is rarer than AIS and the prevalence of anomalies is not defined. The case for routine MRI scan is unclear. A recent report concluded that routine MRI was not indicated, although this was based on only 23 MRI scans in 85 patients. At our institution all patients undergo whole spine MRI following a diagnosis of SK.

Methods: Using a keyword search for "Scheuermann", we reviewed all SK patients' MRI reports over the past 6 years.

Results: 117 MRI scans were identified. 13 patients did not fulfil the radiological criteria for SK and thus 104 (73M: 31F) scans were reviewed. 14 (13%) of 104 scans showed unexpected Significant abnormal findings. There were 8 (8%) with neural axis anomalies: 4 syrinxes; 1 cord anomaly; 2 cerebellar descents and 1 cerebellar tumour. All these patients had normal neurological examination except one with examination consistent with a known diagnosis of Parkinson's disease. A further 6 patients had non-neural anomalies.

Conclusion: The presence of neural axis anomalies may influence the management of a patient with SK. Neurological compromise during correction is higher in patients with neural axis anomalies and this risk can often be partially mitigated by a preceding neurosurgical procedure (such as foramen magnum decompression or shunt). Furthermore it is well described that these anomalies often occur in patients who demonstrate a normal neurological examination. This study confirms this. Given that MRI is widely available and considering the devastating life implications of neurological injury, we advise pre-operative MRI scan in all SK patients.



Left: Cerebellar tumour. Right: Large syrinx.

261. Wide Intra- and Inter-Observer Variability of the Rib-Vertebral Angle Difference (RVAD): Is the RVAD Useful?

Robert G. Tysklind, BS; Karen S. Myung, MD, PhD; Shyam Kishan, MD; George Gantsoudes, MD; Matthew R. Wanner, MD; Chad M. Turner, MD; Stella Lee, MD; Meagan Sabatino, BA; Randall T. Loder, MD USA

Summary: This study shows the intra- and inter-observer measurement variability of the RVAD to be extremely wide, 24° and 23°, respectively. It is important to understand this variability in the course of counseling patients with IIS.

Introduction: The RVAD is used to prognosticate the risk of progression in children with infantile idiopathic scoliosis (IIS). While it is widely used in clinical practice, the measurement variability of the RVAD has not been rigorously studied. The purpose of this study is to determine the intra- and inter-observer variability of the RVAD.

Methods: A retrospective review of 43 patients with IIS at a single center was performed. Radiographs were distributed to 7 readers (orthopedic surgery residents, pediatric fellowship-trained orthopedic surgeons and radiologist) for measurement of 50 distinct RVADs. Each reader measured each RVAD twice, separated by at least 8 weeks between measurements. Intra- and inter-observer variability was determined using three statistical methods (Bland & Altman, Hall & Morrissy, Browne & Carman).

Results: The mean RVAD was 6°±22°. Among a total 350 intra-observer differences, the mean intra-observer difference was 1°±12°. Among a total of 4200 inter-observer differences, the mean inter-observer difference was 2°±13°. Although the mean intra- and inter-observer difference is small, the mean does not reflect the range of variability. Using 3 different statistical methods to determine intra- and inter-observer variability, all methods show similar results and extremely wide variability in RVAD measurements (Table 1).

Conclusion: Children with IIS and an RVAD <20° will often see spontaneous resolution of the scoliosis without treatment, while an RVAD >20° fairs worse. However when the mean intra- and inter-observer variability of the RVAD is 24° and 23°, respectively, the utility of the RVAD in medical decision-making and counseling of patients should be approached with caution.

262. Quality of Life in Patients with Early Onset Idiopathic Scoliosis Mean 24 Years after Maturity

Aina J. Danielsson, MD, PhD; Kerstin Löfdahl-Hällerman, MD, PhD Sweden

Summary: Patients with onset of idiopathic scoliosis (IS) before the age of 10 years (y) and treated before maturity were reexamined mean 24 years after end of bracing (B) and 29 years after surgery (S). Quality of life (QoL) was found to be at normal levels for most of the patients.

Introduction: Knowledge about QoL in middle-aged patients with early onset IS is sparse. The aim was to determine outcome in terms of QoL in patients treated before maturity.

Methods: Consecutive patients with IS, diagnosis before the age of 10 y and treatment before maturity were invited to a clinical follow-up (FU). Treatment was performed between 1970 and 1995 with similar treatment protocol for

E-POSTER ABSTRACTS

bracing and surgery over the whole time period. Quality of life questionnaires incl. SRS-22r and SF-36 were answered. Mean values are presented.

Results: Of patients attending the FU, 67 were braced only (B) and 51 underwent surgery before maturity (S) while 6 were braced before maturity but operated later and 4 observed only. 106 were female. Initial values did not differ between those who attended (68% of the original group) and not.

The age at follow-up for the whole group was 41.6 y, for B 40.6 y and for S 42.6 y. Major curve sizes were similar at present FU, 35° (B) and 37° (S).

One-fourth of the patients had curve sizes >45°. Bracing time was 4.7 y, starting between 3-17 y and surgery was performed at 13.5 y.

The total score of SRS-22r for the whole group was 4.05, for B 4.01 and 4.05 for S. Satisfaction with management differed between B (3.44) and S (3.66, $p=0.0010$). No other differences were seen between the B and S groups.

For SF-36, brace treated and surgically treated patients did not differ in any of the subscales. No differences of clinical importance were noted when compared to a previously studied group of patients with adolescent idiopathic scoliosis of the same age with >20 y FU after treatment. When compared to age-matched national norm scales, no differences were found.

Conclusion: Middle-aged patients treated before maturity due to IS with onset before the age of ten seem to have a quality of life at the same level as the normal population and also at the level of previously treated patients with adolescent idiopathic scoliosis.

263. How do Supine and Standing Radiographs Differ in Early Onset Scoliosis?

Caleb Behrend, MD; Suzanne J. Hilt, PNP; John R. Faust, MD; James O. Sanders, MD
USA

Summary: In patients with early onset scoliosis, the transition from supine films to standing makes measurement changes uncertain and is important in decisions about non-operative treatment and prognosis. This study evaluates that change in early onset scoliosis transitioning from supine to standing and having concurrent radiographs. The Cobb angle increases nearly 10 degrees with standing and the RVAD has a nearly 5-degree increase. Rib phase was not as sensitive to the change in position.

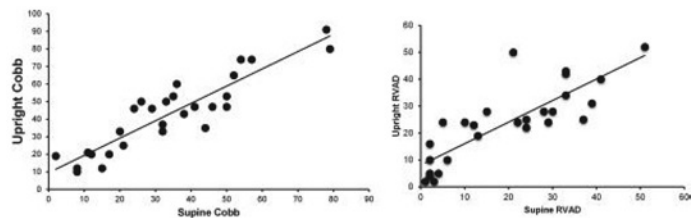
Introduction: Standing scoliosis radiographs are the standard for measurement but cannot be obtained in infants. The differences between the two are important when transitioning from infancy to childhood both for prognosis and treatment decisions. This study quantifies the measurement changes from supine to upright positioning during radiographic evaluation of early onset scoliosis.

Methods: Records of 26 patients from a prospectively maintained database of patients with early onset scoliosis were examined with regard to age, curve etiology, and curve type during derotational casting treatment. During the time when patients were beginning to stand, supine and standing radiographs were obtained at the same visit out of the cast. Comparison of RVAD, phase, and Cobb were made for upright and supine films when the patient was able cooperate with standing radiographs using SPSS 20, IBM.

Results: The mean age at first standing film was 2.7 yrs (95% CI 3.1-2.2) of age. The mean Cobb for supine radiographs was 32 degrees compared to 43

for standing films for a mean change of 9 degrees, $p<.001$. The mean RVAD for supine radiographs was 19 degrees compared to 23 degrees for a mean change of 4 degrees, $p=.01$. Phase did not change significantly between groups with 61% of patients in phase 2 on supine films and 65% on upright films. Only one patient went from phase 1 to phase 2 with standing.

Conclusion: In the present study population when patients with early onset scoliosis at a mean age of 2.7 years were transitioning from supine to upright radiographs having nearly a 10 degree change in Cobb angle. The RVAD had a nearly 5-degree increase while the rib phase was not as sensitive to the change in position. This study documents the increases that occur when children are learning to stand. An increase in curve magnitude of 10 degrees and the RVAD of 5 degrees is a reasonable expectation if concurrent films are not obtained.



264. Surgeon Experience Does Not Reduce Complications Associated with VEPTR Surgery in Early Onset Scoliosis

John T. Smith, MD; Man Hung, PhD; Jessica V. Morgan, BS; Heather A. Fillerup, BS
USA

Summary: The use of growth friendly techniques to manage Early Onset Scoliosis is associated with frequent complications. This study examines whether surgeon experience results in fewer complications over time. 95 patients underwent 915 surgeries over a 10 year period by a single surgeon. The overall complication rate was 20% per year and did not change despite increasing surgeon experience, suggesting that the significant co-morbidities in this population are responsible for the high rate of complications.

Introduction: Children with Early Onset Scoliosis (EOS) are diverse and complex, and frequently have multiple associated co-morbidities. The use of growth friendly techniques to manage EOS is associated with frequent complications. The purpose of this study is to determine if surgeon experience over time results in a decreased frequency of complications related to repetitive surgeries.

Methods: This is a retrospective review of an IRB approved prospective database 915 consecutive VEPTR surgeries including initial implants, expansion and exchanges by a single surgeon between 2003 and 2012. Population demographics and complications were collected. Statistical analysis including Pearson correlation was conducted to examine the association between the rate of complication and the number of surgeries performed.

Results: 95 patients underwent 915 surgeries during the study period. The average age was 7.7 years (0-17). There was an average of 11.5 surgeries per patient (2-25). 173 complications were reported with a mean of 2.35 per patient. Sixteen patients had no complications, while the majority of patients had 1-2 complications, with one patient having 15. The rate of complications did not increase with increasing numbers of surgeries ($r=0.028$; $p=.831$). 96

E-POSTER ABSTRACTS

complications were classified as disease related and 77 were device related. The overall rate of total complications remained steady at approximately 20% per year. Device related complications alone remained steady at 8.6% per year despite increasing experience of the surgeon.

Conclusion: Complications are a relatively common and expected event in managing EOS using growth-friendly instrumentation. Despite increasing surgeon experience with VEPTR expansion and exchange surgeries, the rate of complications remained consistent over a 9 year period. This may be a reflection more of the complexity of this patient population rather than the experience of the surgeon.

265. Predictive Validity of the Classification for Early Onset Scoliosis (C-EOS): Examining the Timing, Rate, and Severity of Postoperative Complications

Michael G. Vitale, MD, MPH; Hiroko Matsumoto, MA; Children's Spine Study Group; Growing Spine Study Group; Howard Y. Park, BA; Evan P. Trupia, BS; Daren J. McCalla, MD; Hasani W. Swindell, BS; David P. Roye, MD; John M. Flynn, MD
USA

Summary: This study examines the ability of the now finalized C-EOS to predict the timing, rate, and severity of post-operative complications. Survival analysis and descriptive statistics support the predictive validity of the C-EOS by identifying groups with low, medium, and high risk of rapid VEPTR proximal anchor failure, as well subsets of patients which suffer a disproportionate share of complications.

Introduction: Gaps in the evidence-base and variability in management of EOS have driven improvements in the research infrastructure, including development of the C-EOS. The purpose of this study is to examine the ability of the C-EOS to predict timing of VEPTR proximal anchor failure and identify patients at higher risk for complications following growing instrumentation surgery.

Methods: 105 patients treated with VEPTR and 254 patients with a minimum of 5 years post-op follow-up from growing instrumentation surgery were identified from 2 multi-center EOS databases. All patients were classified using the C-EOS; by etiology (C: Congenital, M: Neuromuscular, S: Syndromic, I: Idiopathic), major curve angle (1: <20°, 2: 20-50°, 3: 51-90°, and 4: >90°) and kyphosis (-: <20°; N: 20-50°; +: >50°). Outcomes included rate of anchor failure and other device and disease related complications.

Results: Survival analysis identified groups with low (C3-), medium (C3N, C3+, M3+), and high (M4N, M4+) risk of rapid VEPTR proximal anchor failure. Of patients with 5 post-op years of follow-up, 75% experienced a complication but only 13% experienced a complication affecting outcome. The greatest frequency of complications with the highest severity occurred among non-idiopathic, hyperkyphotic classes with large Cobb angles.

Conclusion: The ability of the C-EOS to discriminate among patients with varying times to anchor failure and identify subsets of patients which suffer a disproportionate share of complications support its predictive validity and demonstrate its potential use in guiding decision making. Further experience with the C-EOS may allow more tailored treatment, and perhaps better outcomes for patients with EOS.

Etiology	Major Curve Angle	Maximum Total Kyphosis	Progression Modifier (optional)
Congenital/Structural	1: <20°	(-) <20°	P0: <10°/yr
neuromuscular	2: 20-50°	N: 20-50°	P1: 10-20°/yr
Syndromic	3: 51-90°		
Idiopathic	4: >90°	(+) >50°	P2: >20°/yr

266. Effective in Adolescent Idiopathic Scoliosis Surgery: Reptilase, Tranexamic Acid or Acombination: A Prospective, Randomized, Double-Blind, Placebo-Controlled Study

En Xie, PhD, MD
China

Summary: Effective in adolescent idiopathic scoliosis surgery: Reptilase, tranexamic acid or acombination-A Prospective, Randomized, Double-Blind, Placebo-Controlled Study.

Introduction: Adolescent idiopathic scoliosis surgery is often associated with significant blood loss and blood transfusion. In this clinical trial, the authors investigated the efficacy of reducing blood loss and allogeneic blood transfusion by using Reptilase, tranexamic acid (TA) and the combination of the two agents.

Methods: 80 adolescent patients undergoing scheduled idiopathic scoliosis surgery were randomly divided into four groups to receive 0.9% saline (group A), Reptilase (group B), TA (group C), and both two agents in the same manner (group D). The amounts of blood loss, transfusion requirements, frozen fresh plasma (FFP) and overall drainage were assessed. The hemoglobin concentration (Hb), hematocrit and platelet counts were recorded preoperative y, postoperatively and on the first operative day. The coagulation parameters were measured meanwhile. Deep vein thrombosis (DVT) was diagnosed by ultrasound.

Results: Blood loss of group B and group C decreased similarly by 36.7 and 47.7% (p = 0.162) compared with group A, while group D was reduced by 67.7, 47.3 and 37.7% compared to group A, B and C, respectively. The amount of allogeneic blood transfusion of group B and group C was comparably reduced by 57.8 and 77.1% compared to group A (p = 0.065), while group D decreased by 92.1, 87.7 and 81.7% compared to group A, B and C. Overall drainage of group B, C and D decreased by 22.8, 47.0 and 77.9% compared with group A, respectively, while group C was reduced by 27.7% compared with group B (p < 0.01). The FFP of group B, C and D was reduced by 61.7, 78.1 and 97.1% as compared with group A, while group C decreased by 42.7% as compared to group B (p = 0.027). There were no urgent coagulation disorders or DVT reported.

Conclusion: In our study, Reptilase and TA can markedly reduce the blood loss and the transfusion requirements equivalently. However, TA performs better in

E-POSTER ABSTRACTS

minimizing FFP and the overall drainage than Reptilase. The combination seems to achieve best results and was more effective than either of the two drugs alone. No apparent adverse events were detected in these groups.

267. Performing a Definitive Fusion in Juvenile CP Patients is a Good Surgical Option

Burt Yaszay, MD; Paul D. Sponseller, MD; Suken A. Shah, MD; Jahangir Asghar, MD; Firoz Miyanji, MD, FRCSC; Amer F. Samdani, MD; Carrie E. Bartley, MA; Peter O. Newton, MD
USA

Summary: Surgical options for juvenile CP patients with progressive scoliosis generally include growing treatment or definitive fusions. Performing a definitive fusion to halt and correct scoliosis progression in these skeletally immature patients resulted in good correction with improved HRQOL and without the need for anterior fusion.

Introduction: Management of juvenile CP patients with large scoliosis is a challenge. When observation with or without a brace is no longer a viable option, surgeons frequently choose growing rod treatment or early definitive fusion. The purpose of the study is to present a series of juvenile CP scoliosis patients that underwent early definitive fusion.

Methods: A retrospective review of a multi-center database identified patients 10 years and younger who had a definitive fusion for their scoliosis. Preoperative and postoperative demographic and radiographic changes were evaluated with descriptive statistics. Repeated measures ANOVA were utilized to compare outcome scores.

Results: Fifteen patients with an average age of 9.7 years (8.2-10.7 yrs) and a minimum of 2 years follow-up were identified. The average preop curve magnitude and pelvic obliquity was 87° and 28°, respectively. All patients were skeletally immature with open triradiate cartilage. 14 patients underwent posterior only surgery and 1 patient had an anterior/posterior fusion. 3 patients had unit rods with wires while the rest incorporated pedicle screws. Immediately postop, the average major Cobb was 22° ($p \leq 0.001$, 75% correction rate). At 2yrs post-op, the average major Cobb increased to 29° ($p \leq 0.001$) for a 67% correction rate. Pelvic obliquity improved to 6° (79% correction; $p \leq 0.001$) immediately postop and to 8° ($p \leq 0.001$) at 2yrs postop for a 71% correction rate. None of the patients required revision surgery for progression. From pre to 2yrs post-op, the CPchild Health outcome scores improved from 45 to 58 ($p = 0.004$). One patient had a deep infection requiring a return trip to the operating room, and one patient had a broken rod that did not require further treatment.

Conclusion: Progressive scoliosis refractory to conservative measures in juvenile CP patients can be a challenge which requires the surgeon to balance the need for further growth with the risks of progression or repeated surgical procedures. Our study demonstrates that definitive fusion results in stable fusions in these skeletally immature patients. Further follow-up is needed to determine whether those results are stable to skeletal maturity.

268. Natural Sagittal Spino-Pelvic Alignment in Boys and Girls Before, at and after Adolescent Peak Height Velocity

Tom P. Schlösser, MD; Suken A. Shah, MD; Kenneth J. Rogers, PhD; Koen L. Vincken, PhD; Rene M. Castelein, MD, PhD
Netherlands

Summary: In order to understand the role of sagittal alignment in the etiology of adolescent idiopathic scoliosis (AIS), sagittal spino-pelvic alignment was evaluated in 156 normal adolescents. It was found that the population at risk for initiation and progression of idiopathic scoliosis, girls before and at the peak of the growth spurt, had relative lower pelvic incidence and pelvic tilt, lower thoracic kyphosis and their spines were more posteriorly inclined compared to girls after the growth spurt and compared to boys.

Introduction: One of the unexplained, but well known, characteristics of AIS is that girls are far more often affected than boys and the initiation and progression of the deformity normally occurs around the adolescent growth spurt. From previous studies it can be inferred that, due to biomechanical forces that act on posteriorly inclined spinal segments, certain sagittal spinal profiles are more prone to develop a spinal deformity than others. The aim of this natural history study was to quantify sagittal spino-pelvic alignment and orientation in space of each individual vertebra in normal boys and girls in the beginning, the peak and at the end of pubertal growth.

Methods: Standardized lateral radiographs of the spine of boys ($n=57$) and girls ($n=99$) from 7-18 years old who underwent scoliosis screening and had a normal spine were enrolled. Children with spino-pelvic pathology at initial screening or during follow-up were excluded. According to Dimeglio, subjects were classified into before, at and after the peak growth spurt based on skeletal maturity parameters. Seven regional sagittal spino-pelvic parameters and exact inclination of each individual vertebra between C7 and L5 were measured semi-automatically.

Results: Thoracic kyphosis, pelvic incidence and pelvic tilt were lower, the posteriorly inclined segment was longer and T1-T8 were more posteriorly inclined before and at the peak of the growth spurt compared to after the growth spurt ($P \leq 0.023$) in all subjects. In girls, thoracic kyphosis was smaller ($P = 0.023$), the posteriorly inclined segment was longer ($P < 0.001$) and T1 and T3-T11 were more posteriorly inclined ($P < 0.05$) compared to boys. At the peak of the growth spurt, girls still had a relatively lower thoracic kyphosis with more posterior inclination whereas boys already developed a greater thoracic kyphosis with less posterior inclination ($P = 0.005$).

Conclusion: These results imply that the spine of girls during the growth spurt is more posteriorly inclined, affected by greater posteriorly directed shear loads and rotationally less stable compared to boys and compared to girls after the growth spurt. This may explain why initiation and progression of AIS frequently occurs in girls around puberty.

E-POSTER ABSTRACTS

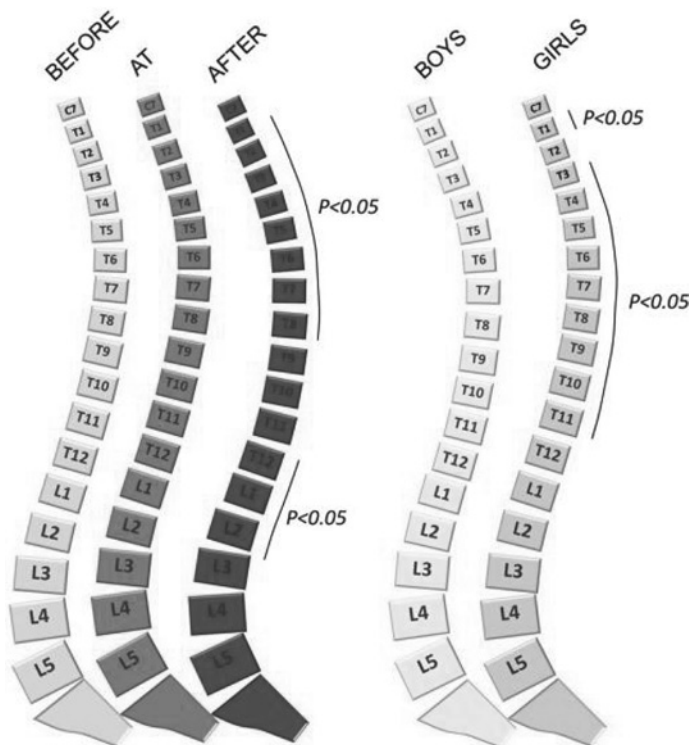


Figure 1. Differences in vertebral inclination between the cohorts and genders.

269. Posterolateral Diskectomies as Alternative to Anterior Posterior Spinal Fusion in Children with Severe Spinal Deformities

Hamid Hassanzadeh, MD; Amit Jain, MD; Emmanuel N. Menga, MD; Paul D. Sponseller, MD
USA

Summary: Our aim was to compare posterolateral diskectomies (PLD) at the apex of the deformity as an alternative to anterior releases and posterior spinal fusion (APSF). We retrospectively compared 18 children with severe spinal deformities ($94 \pm 21^\circ$ coronal, $63 \pm 30^\circ$ sagittal) who underwent PLD, to 19 children ($106 \pm 20^\circ$ coronal curve, $70 \pm 36^\circ$ sagittal curve) who underwent APSF. PLD offers a single-approach alternative to APSF, and can achieve better coronal and equivalent sagittal correction with shorter operative time and a reduced risk of monitoring changes.

Introduction: Removal of the convex-side PLL, annulus and discs at the deformity apex facilitates spinal shortening and posterior-only deformity correction. The aim of this study was to compare the results of posterolateral diskectomies (PLD) at the apex of the deformity as an alternative to anterior releases and posterior spinal fusion (APSF) for significant thoracolumbar deformity.

Methods: We retrospectively compared 18 children (mean age: 15.9 ± 3 years, 8F, 10M, $94 \pm 21^\circ$ coronal Cobb, $63 \pm 30^\circ$ sagittal Cobb) who underwent PLD to 19 children (mean age: 14.5 ± 2.4 years, 14F, 5M, $106 \pm 20^\circ$ coronal Cobb, $70 \pm 36^\circ$ sagittal Cobb) who underwent APSF. There was no significant difference in the mean age ($P=0.11$), preoperative coronal ($P=0.09$) and sagittal ($P=0.53$) Cobb, and number of posterior levels fused ($P=0.60$). There was a significant difference by diagnosis ($P<0.01$): idiopathic scoliosis (3 vs 15),

neuromuscular or syndromic scoliosis (15 vs 4). In the PLD group, diskectomies were performed at apical levels on the convexity, removing the convex annulus, convex half of the posterior endplate, with rib head resection if it limited convex shortening. Radiographic results and clinical results, and complications were compared. Significance was set at $P<0.05$.

Results: PLD group had on average 2.6 ± 0.7 diskectomies, and APSF had on average 7.7 ± 2 anterior levels released ($P<0.01$). PLD group had a lower final coronal Cobb (28° vs 47° , $P<0.01$); there was no significant difference in final sagittal Cobb (34° vs 41° , $P=0.30$). There was no significant difference in blood loss (1.65 vs $1.60L$, $P=0.87$). The PLD group had significantly shorter operative time (305 mins vs. 403 mins, $P=0.02$). There were no intraoperative neuromonitoring changes or neurologic complications in the PLD group. In the APSF group, 2 patients had intraoperative loss of signals requiring removal of implant. The PLD group had significantly shorter overall length of hospital stay (12 vs 25 days, $P=0.03$).

Conclusion: PLD offers a single-approach alternative to APSF for dealing with moderately large spinal deformities. It can achieve better coronal and equivalent sagittal correction with shorter operative time and a reduced risk of monitoring changes.

270. Long-Term 6 to 11 Year Clinical Outcomes after Dynamic Correction by External Fixator for Severe Spinal Deformity

Tepei Suzuki; Koki Uno, MD, PhD; Yoshihiro Inui
Japan

Summary: The external fixator devices allows the dynamic correction safely without anterior approach for severe spinal deformity. Long term 6 to 11 year clinical outcomes evaluate in this study. Though complications, such as deep infection and implant failure, are high, most of the complications can be managed non-operatively.

Introduction: The surgical treatment of severe and rigid spinal deformities poses difficulties and dangers. The patients whose pulmonary status places them at the risk of anterior approach may be considered for spinal external fixation. In this study we have aimed to evaluate the efficacy of the dynamic correction by external fixator for these deformities.

Methods: Since 2002, a total of 21 consecutive patients who had external fixator procedure were analyzed. There were 11 males and 10 females. Average age was 18 ± 8 years at initial surgery. Patients were observed with an average follow up of 8.3 ± 1.7 years. Radiographic evaluation included changes in Cobb angle, sagittal parameter over treatment. Analysis included early and late complications. The surgical procedure consisted of minimum 2 stages, posterior osteotomies and the placement of external devices at both ends of the corrected vertebra. Correction is then performed at the bed side.

Results: Cobb angle improved from 113 ± 27 degree to 59 ± 19 degree at post-initial and 64 ± 20 degree at final follow up. The average number of correction period was 39 ± 17 days. All patients maintained correction of their deformity and were noted to have solid arthrodesis on plain radiographs. Complications during distraction were pin site infection, implant loosening and back out, transient palaplesia and necrosis of soft tissue. Though almost complications after posterior

E-POSTER ABSTRACTS

fusion were infection, they resolved. Late complications were intermittent discharge from wound, allergic dermatitis.

Conclusion: The external fixator devices allows the dynamic correction safely without anterior approach. Though complications, such as deep infection and implant failure, are high, most of the complications can be managed non-operatively.

271. The Deformity Angular Ratio Accurately Predicts Risk of Intraoperative Spinal Cord Monitoring Alerts during Surgery for Severe Pediatric Spinal Deformity

Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Daniel J. Sucato, MD, MS; Peter O. Newton, MD; Harry L. Shufflebarger, MD; Paul D. Sponseller, MD; John B. Emans, MD; Suken A. Shah, MD; Baron S. Lonner, MD; Amer F. Samdani, MD; Michael P. Kelly, MD; Brenda A. Sides, MA
USA

Summary: The Deformity Angular Ratio (DAR, defined as the maximum Cobb/# segments from end-end vertebrae) was significantly greater in both the coronal and sagittal planes for those pts having Spinal Cord Monitoring (SCM) alerts during surgical treatment of 289 severe pediatric spinal deformity pts.

Introduction: Although somewhat intuitive, the amount of angular deformity encountered in s pediatric pts with severe curvatures would seem to increase the neurologic risk during spinal deformity surgery, but has never been documented or quantified in a large group of pts to our knowledge. We developed the Deformity Angular Ratio (DAR), defined as the maximum Cobb measurement divided by the # of spinal segments within the coronal or sagittal curve from end-end vertebrae, as a surrogate for the angular nature of the deformity. Our purpose was to evaluate whether a larger DAR would lead to a higher incidence of SCM alerts during surgical correction of severe pediatric spinal deformity.

Methods: 289 pediatric deformity pts were accrued from both an initial retrospective study of 147 consecutive VCRs long with an additional 142 pts from a prospective study of pts either undergoing a VCR (n=63) or having at least 100° of maximum Cobb angle treated with another method besides a VCR (n=79). Thus a total of 210 pts out of 289 (72%) underwent a VCR procedure highlighting the severity of the patient's deformity. For all pts, the DAR was calculated using their preop upright xrays for all Maximum Cobb angles in both the coronal and sagittal planes and then correlated to the presence of SCM alerts occurring intraoperatively.

Results: The Coronal DAR for those pts with a SCM alert was 13.48°/level (± 6.78) vs 10.95°/level (± 5.71) without a SCM alert ($p=0.0018$). Similarly, the Sagittal DAR for those pts with a SCM alert was 16.27°/level (SD 8.81) vs 11.70°/level (± 6.73) without a SCM alert ($p<0.001$). For every 5°/level increase in the Coronal DAR, there was a 39.6% increase in the SCM alert rate during surgery (Odds ratio 1.396); similarly, for every 5°/level increase in the Sagittal DAR, there was a 46.8% increase in the SCM alert rate (Odds ratio 1.468).

Conclusion: The Deformity Angular Ratio (DAR) is a novel means of assessing pediatric pts with severe spinal deformity regarding neurologic risks during surgery. Both a larger Coronal and especially Sagittal DAR significantly correlated with the rate of SCM alerts occurring intraoperatively thus helping preoperatively predict patients at high neurologic risk during corrective surgery.

273. Mesenchymal Stem Cells in Bone Marrow Concentrate with Allograft in Posterolateral Lumbar Fusion

Radek Hart, MD, PhD, FRCS

Czech Republic

Summary: PLF is still the most common technique performed to obtain fusion in the lumbar spine. Harvesting autologous bone from the iliac crest is associated with increased operation time, blood loss, and chronic donor site pain. Autograft substitution with autologous MSCs in form of the BMC in combination with allograft is an effective option how to enhance the PLF healing. Allograft by itself is not an effective material as a posterior onlay graft for the PLF in adult surgery.

Introduction: Posterolateral fusion (PLF) is a commonly accepted surgical procedure. Allograft material has an insufficient osteogenic and osteoinductive potential. Bone marrow concentrate (BMC) could be an option how to promote allograft PLF healing. The aim of the study was to investigate the validity of BMC addition to allografts in instrumented lumbar PLF surgery.

Methods: The study was prospective, randomized, controlled and blinded. Eighty patients with degenerative disease of the lumbar spine underwent instrumented (S4, Aesculap, Tuttlingen, Germany) lumbar or lumbosacral PLF. In forty cases, the PLF was done with spongius allograft chips alone (Group I). In another forty cases, spongius allograft chips were mixed with BMC (Group II), where the mesenchymal stem cell (MSCs) concentration was 1.74 x104/L at average (range, 1.06-1.98 x104/L). Patients were scheduled for anteroposterior and lateral radiographs at 12 and 24 months after the surgery and for CT scanning at 24 months after the surgery. Fusion status and the degree of mineralization of the fusion mass were evaluated separately by two radiologists blinded to patient group affiliation.

Results: In Group I at 12 months, the bone graft mass was assessed in X-rays as fused in no case (0 %) and at 24 months in 4 cases (10 %). In Group II, 6 cases (15 %) achieved fusion at 12 months and 14 cases (35 %) at 24 months. The statistically significant difference between both groups was proven for complete fusion at 12 months ($p = 0.041$) and at 24 months ($p = 0.011$), too. CT scans showed that 16 cases (40 %) in Group I and 32 cases (80 %) in Group II had evidence of at least unilateral continuous bridging bone between neighboring vertebrae at 24 months ($p < 0.05$). We have confirmed the hypothesis that the autologous BMC together with the allograft is a better alternative for the PLF than the allograft alone.

Conclusion: The use of autologous MSCs in form of the BMC in combination with allograft is an effective option how to enhance the PLF healing. Allograft by itself is not an effective material as a posterior onlay graft for the PLF in adult surgery.

E-POSTER ABSTRACTS

274. Development of a Complex Spine Registry and Tracking of Postoperative Narcotic Usage: The Effect of Multidisciplinary Team Approaches including a Preoperative Clearance Conference and Pain Service Consultation

Rajiv K. Sethi, MD; Wyndam M. Stradtbeck, MD; Eric Baldwin, MS; Melissa L. Anderson, MS; Karen J. Wernli, PhD
USA

Summary: Recent initiatives now stress overtreatment with opioids and poor long term outcomes. This study looks at opioid usage after corrective adult spinal deformity surgery via a complex spine registry. Corrective adult spinal deformity surgery leads to a significant decline in postoperative narcotic usage compared to preoperative doses. The institution of a multidisciplinary preoperative screening conference for complex spine patients and formal pain service consultation during hospitalization leads to further decline in narcotic dosage at 1 year postop. This study highlights the importance of a longitudinal electronic complex spine registry in tracking such measures.

Introduction: During the 1990s, the undertreatment of pain in the United States was highlighted by a number of organizations. As a result, the prescriptions for opioids increased steadily from 2000 to 2010 with the total number of prescriptions increasing 104%. Recent initiatives now stress overtreatment with opioids and poor long term outcomes. This study looks at opioid usage after corrective adult spinal deformity surgery via a complex spine registry.

Methods: 407 surgical adult spinal deformity patients aged 21-85 who had 6 levels or greater fused between 2004-2013 enrolled in an electronic complex spine registry were tracked via an electronic medical record and postoperative narcotic usage was calculated in terms of morphine equivalents at 3, 6, 9 and 1 year postop. In addition, a multidisciplinary clearance conference and formal pain service consultation was initiated on all patients from 2009-2013.

Results: A significant decline in postoperative narcotic usage was noted in the study period. Postoperative opioid utilization 12 months postop peaked in 2006 and by 2012, the p50 was 5 mg/day of morphine or less compared to 15 mg/day preoperatively (see Figure 1). At 12 months postop, the mean morphine equivalent usage decreased from 42.5 in 2004-2008 time period to 12.5 in the 2009-2013 time frame after the institution of a multidisciplinary preoperative screening conference and formal pain service consultation during the hospitalization (P=.006).

Conclusion: Corrective adult spinal deformity surgery leads to a significant decline in postoperative narcotic usage compared to preoperative doses. The institution of a multidisciplinary preoperative screening conference for complex spine patients and formal pain service consultation during hospitalization leads to further decline in narcotic dosage at 1 year postop. This study highlights the importance of a longitudinal electronic complex spine registry in tracking such measures.

275. Switching to a Pediatric Dose O-Arm Protocol in Spine Surgery Significantly Reduced Patient Radiation Exposure

T. David Luo; Amy L. McIntosh, MD; Beth A. Schueler, PhD; Jennifer A. Winkler, BS; Anthony A. Stans, MD; A. Noelle Larson, MD
USA

Summary: We successfully changed to a pediatric dose O-arm protocol in clinical practice, reducing the dose per scan from 2.37 to 0.65 mSv, or less than 1/4 of the mean annual natural background radiation. This is an acceptable level of radiation to ensure accurate screw placement.

Introduction: The use of the O-arm imaging system during spine surgery improves the accuracy of screw placement. Radiation exposure to the patient, however, remains a primary drawback. Abul-Kasim et al.* described accurate pedicle measurements on cadaveric pig spines using a low radiation dose O-arm technique. We recently adopted these settings in clinical use for all pediatric O-arm imaging. We sought to compare the estimated O-arm radiation doses for the manufacturer default acquisition technique, our current reduced dose protocol, and our new pediatric dosing technique.

Methods: This is a cohort study of consecutive patients under the age of 18 years who underwent an intraoperative O-arm scan. Techniques (kV and mAs) for manufacturer and reduced dose settings were manually adjusted based on spinal level and weight (Table). Pediatric dose techniques (per Abul-Kasim et al.) were 80kV/80mAs with no adjustment for level or weight. Adequacy of image quality was assessed by the treating surgeon. The mean estimated effective dose between the three protocols was compared.

Results: Sixty-eight scans (Table) were performed in 37 consecutive patients with mean age 14.4 years (range 5-18) and mean weight 55.0 kg (range 19-108). Diagnoses included spondylolisthesis, kyphosis, scoliosis, and congenital deformity. For reference, the mean annual natural background radiation from all sources for the US is approximately 3 mSv (chest x-ray examination approximately 0.1 mSv). Use of the manufacturer default technique resulted in a mean dose per scan of 4.65 mSv, while reduced dose settings resulted in 2.37 mSv. The pediatric dose protocol reduced the mean dose to 0.65 mSv per scan (p<0.0001). Accounting for multiple scans per patient, the mean dose per surgery was: pediatric dose - 1.17 mSv, reduced dose - 3.83 mSv, and manufacturer - 12.79 mSv. All scans were found to have satisfactory image quality. There were no neurologic complications or screw-related complications.

Conclusion: The estimated radiation dose received by the pediatric patient during an O-arm scan was reduced by nearly 75% by using our pediatric dosing protocol without compromising surgeon satisfaction. Avoid using the manufacturer default O-arm technique in pediatric spine imaging.

276. New Emerging Technology for the Treatment of Early Onset Scoliosis: A Preliminary Study and Cost Analysis

David E. Lebel, MD, PhD; Shlomo Wientroub, MD; Dror Ovadia, MD
Israel

Summary: The treatment of early onset scoliosis with magnetic assisted growing rods is safe, might have less long term complications and therefore might be inexpensive when compared to traditional growing rods.

E-POSTER ABSTRACTS

Introduction: Early onset scoliosis imposes challenges for the patient and surgeon.

Recently, new technology evolved and might reduce the need for repetitive surgeries. The MAGEC® (magnetic expansion control) system holds the promise for physiological growth without the need for distraction surgeries.

The purpose of this study was to describe the short-term experience with the device and to determine the expected cost of the novel treatment compared to traditional growing rods technique.

Methods: Retrospective review of patient's charts operated with the MAGEC®. The device was inserted through a posterior approach. A brace was used for the first four months after index surgery. Distractions were started two months after index surgery and every two months ever since. Cost analysis and simulation was preformed.

Results: 19 patients were treated with the system. All were diagnosed with early onset scoliosis. Five were with idiopathic scoliosis, 13 with neuromuscular or syndromic scoliosis and one with congenital scoliosis. The average age at index surgery was 7.95 years (4.8-9.8). The mean Cobb angle measured 65 ° (56-90) and the average Cobb angle on first postoperative x-rays was 30.6 ° (12-45) with an average correction of 55%. We followed the patients 3-24 months with minimum of one distraction and maximum 12 distractions. The average spine growth velocity is 0.7mm/month.

Two patients were revised due to proximal screw dislodgment that was attributed to misplacement at the index surgery. No complications occurred due to failure of the device.

The predicted cost per patient over 4 years of treatment is 39245\$ for MAGEC® versus 36470\$ for traditional growing rods. Complications treatment was excluded while performing cost analysis.

Conclusion: Magnetic growing rods for early onset scoliosis are safe and save the patients from repeated distractions under general anesthesia. Comparison between MAGEC® and traditional growing rods found that the overall cost per patient is comparable.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

277. Operative Efficiency in Adolescent Idiopathic Scoliosis Surgery

Baron S. Lonner, MD; Suken A. Shah, MD; Peter O. Newton, MD; Burt Yaszay, MD; Yuan Ren, PhD
USA

Summary: Operative time in AIS surgery impacts blood loss, infection rates and cost. Opportunities for improved efficiency and procedural innovation exist for exposure, screw insertion, rod maneuvers and wound closure which account for 73% of total operative time.

Introduction: Operative time associated with adolescent idiopathic scoliosis (AIS) surgery impacts blood loss, infection rates, and cost. The purpose of this study was to identify the relative portion of time spent in performing various segments of the operation for AIS in order to identify opportunities for improvements in operative efficiency.

Methods: A multicenter (3 sites) prospective study of operative time in posterior fusion (PSF) for AIS for 14 distinct steps of the procedure was performed. Impact of major curve magnitude, Lenke type, number of levels fused, osteotomy number and implant type on operative time was evaluated using regression models. Association between total operative time and EBL was also determined. Variability between surgeons in each operative step was compared using ANOVA. **Results:** 50 consecutive PSF cases were studied (site 1 n=15; site 2 n=19 and site 3 n=16). Exposure (20.4%), screw insertion (22.4%), closure (15.7%) and rod maneuvers (14.5%) are the four major segments of the surgical procedure (see figure) accounting for 73% of the operative time. Surgeon variability was noted in EBL after adjusting for levels fused (p=0.0006) and in total operative time (p=0.010), exposure (p=0.001), facetectomy (p<0.0001), screw imaging (p<0.0001), rod maneuvers (p=0.002), wound cleansing (p=0.002), decortication/grafting (p=0.001), and wound closure (p<0.0001). Total operative times were 230.5, 259.5 and 196.3 minutes (p=0.010) with average levels fused of 8.6, 10.1 and 9.1 (p=0.257), respectively, for the 3 sites. Number of levels fused was the sole predictor of EBL (p=0.041, controlled for total operative time & surgeon) and total operative time (p<0.0001, controlled for Cobb magnitude, number of osteotomies & surgeon).

Conclusion: Opportunities for improved efficiency and procedural innovation exist for exposure, screw insertion, rod maneuver and wound closure. Between surgeons variability was present in exposure, rod maneuvers, and closure. Number of levels fused was a sole predictor for EBL and total operative time.

278. Cervical Spine Alignment after Thoracic and Thoracolumbar Adolescent Idiopathic Scoliosis Surgery

Shiro Imagama, MD; Zenya Ito; Kei Ando, PhD; Kazuyoshi Kobayashi, MD; Junichi Ukai; Akio Muramoto, MD; Ryuichi Shinjo, MD; Tomohiro Matsumoto, MD, PhD; Hiroaki Nakashima, MD; Kenyu Ito; Yukihiko Matsuyama, MD; Naoki Ishiguro
Japan

Summary: Pre- and postoperative differences in spinal sagittal alignment, including the cervical spine and pelvis, were evaluated in 60 consecutive surgical cases with AIS. Thoracic kyphosis (TK) improved after surgery, even in hypo-TK cases, but this did not always directly lead to good cervical lordosis. PI did not change the cervical sagittal balance. Pre- and postoperative T1 slopes and preoperative TIA may be predictors of postoperative CL and should be considered in planning a surgical strategy for AIS.

Introduction: Relationships among the thoracic, lumbar spine, and pelvis are important in spinal surgery, but sagittal alignment of the cervical spine is poorly documented in surgery for adolescent idiopathic scoliosis (AIS). The study objective was to evaluate pre- and postoperative spinal sagittal alignment, including the cervical spine and pelvis, in a retrospective analysis of a prospective database.

Methods: Sixty consecutive surgical cases of AIS were followed prospectively for a minimum of two years. Pre- and postoperative cervical lordosis (CL), CO-2 angle, C1-2 angle, T1 slope, thoracic inlet angle (TIA), neck tilt, pelvic incidence (PI), pelvic tilt (PT), lumbar lordosis (LL), thoracic kyphosis (TK), C1-C7 sagittal

E-POSTER ABSTRACTS

vertical axis (SVA), C1-C7 SVA, C2-C7 SVA, C2 SVA, and C7 SVA were measured using coronal Cobb angles and corrections on plain radiographs. Cases with TK $<10^\circ$ and CL $<10^\circ$ were defined as the hypo-TK and low-CL groups, respectively. Correlations were analyzed using Pearson's correlation coefficient and differences between groups were evaluated by unpaired t test.

Results: The mean preoperative curve of 56° (range 40° - 96°) was corrected to 11.6° postoperatively, giving a correction rate of 79.1%. In hypo-TK cases, the preoperative mean of 8.4° improved to 21.8° at final follow-up. Pre- and postoperative sagittal balance, as defined by SVA parameters, were well balanced. PI was not correlated with cervical parameters. Hypo-TK cases had a significantly lower preoperative CL ($p<0.05$). There were significant correlations of pre- and postoperative T1 slopes and preoperative TIA with postoperative CL ($p<0.05$) and of the postoperative T1 slope with postoperative C2-C7 SVA ($p<0.05$). Postoperative low-CL cases had a significantly lower preoperative T1 slope (10.5° vs. 20.2° ; $p<0.001$).

Conclusion: Thoracic kyphosis improved after surgery, even in hypo-TK cases, but did not always directly lead to good cervical lordosis. PI did not change the cervical sagittal balance. Pre- and postoperative T1 slopes and preoperative TIA may be predictors of postoperative CL and should be considered in the surgical strategy for AIS.

279. The Choice of the Distal Fusion Level for Correction of Scheuermann's Kyphosis

Mikhail Mikhailovsky, MD; Artem Sorokin, PhD; Vyacheslav Novikov, PhD; Alexandr Vasyura
Russian Federation

Summary: In previous researches it was recommended to selection of the first lordotic vertebra for the distal level of fusion in the treatment of Scheuermann's kyphosis. In 2009, Cho et al introduced the concept of the sagittal stable vertebra (SSV) after recognizing the development of distal junctional kyphosis (DJK) despite the lower instrumented vertebra (LIV) were located proximally.

Introduction: To analyze the efficacy of the method for selecting the distal level of fusion in treatment of thoracic hyperkyphosis in patients with Scheuermann's disease.

Methods: Over the period of 2007-2010 years 36 patients were operated in the Department of Children and Adolescent Spine Pathology. Patients were divided into two groups: in Group I ($n = 29$) a LIV corresponded to the sagittal stable one and in Group II ($n = 7$) this vertebra located proximally. The mean follow-up period was 2.7 years.

Results: The mean preoperative magnitude of kyphosis was $79.3^\circ \pm 11.6^\circ$, postoperative $-40.6^\circ \pm 11.9^\circ$ (correction 49.9%), loss of correction was $4.9^\circ \pm 7.0^\circ$. Sagittal balance changed from -0.3 ± 3.2 cm before surgery to -1.7 ± 2.1 cm. DJK developed in 1 case (4%) in Group I, and in 5 cases (71%) in Group II.

Conclusion: Distal level of instrumentation ending at the first lordotic vertebra is not justified and causes violation of sagittal balance and development of DJK. The inclusion of a SSV in fusion prevents the development of DJK.

280. Platelet Rich Fibrin Matrix in Posterolateral Lumbar Fusion

Joshua E. Schroeder, MD; Antonio T. Brecevic; Celeste Abjornson, PhD; Frank P. Cammisa, MD
USA

Summary: Platelet rich fibrin matrix is a fibrin matrix composed of platelet rich plasma that has been recalcified in the absence of thrombin this matrix is a stable membrane that can be placed in a specific location and will secrete growth factors for up to 14 days. In a retrospective analysis of 52 patients in which a posterior lateral fusion was performed in 76 levels resulting in fusion rates of 94.7% at one year.

Introduction: Despite $>300\%$ increase in lumbar fusion operations over the past decade, pseudarthrosis remains a challenge, occurring in up to 15% of case. The use of platelet rich plasma as an osteoinductive enhancement in spine fusion has resulted in mixed outcomes. Platelet rich fibrin matrix (PRFM) is a fibrin matrix composed of platelet rich plasma that has been recalcified in the absence of thrombin this matrix is a stable membrane that can be placed in a specific location and will secrete growth factors for up to 14 days. This study reports the outcome of the use of PRFM in posterolateral lumbar spine fusion (PLLF).

Methods: The PLLF was performed by standard procedure. Autologous bone graft, PRFM and bone marrow aspirate were mixed together, implanted in the facets and across the traverse process at fusion sites. Charts were reviewed for demographics, medical co-morbidities, pain assessment, radiographic findings, and physical exam preoperatively and post-operatively at 3 months, 6 months, and at 12 months of all cases undergoing PLLF with PRFM.

Results: 52 consecutive patients (76 fused levels) underwent PLLF with PRFM. Mean follow-up was 12.25 months (range 9-32 months). Average age was 52 (range = 34-85 years); 28 were male and 24 females. 10 patients suffered from osteoporosis, 8 were diabetics and three were smokers. Fusion was achieved in 94.2% of patients ($n = 49$) and 72 levels (94.7%). There was one non union, and two delayed unions at latest follow up. Mean pre and latest post-operative VAS scores were 7.17 and 1.12, respectively. No complications were associated with the PRFM in this series.

Conclusion: the use of PRFM with local bone graft and bone marrow aspirate results with high rate of fusion in a posterior spine fusion. These properties are especially important in elderly or comorbid populations where there is limited supply of high quality bone graft.

282. Comparative Mechanical Properties of Commonly Used Spinal Rods

Carolin Melcher, MD; Christian Schröder, Dipl.-Ing.; Bernd Wegener, MD; Volkmar Jansson; Christof Birkenmaier, MD
Germany

Summary: This biomechanical study independently tests a large number of spinal rods from various manufacturers with regards to bending stiffness, yield point and ultimate point in order to enable spinal surgeons to objectively compare rods and if desired chose a specific rod for a specific application.

Introduction: Pedicle screw-rod-constructs are used for a wide range of applications with strongly varying demands on construct stiffness. Rod stiffness is an important factor determining construct performance. A wide range of rod

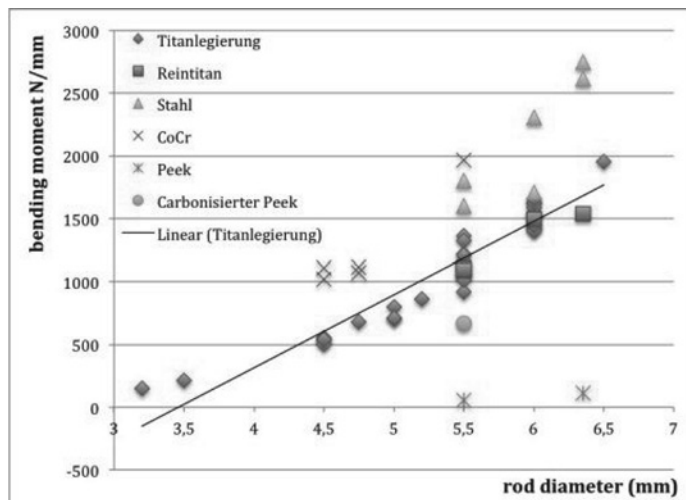
E-POSTER ABSTRACTS

diameters and materials is available from manufacturers. No catalogue has so far been published that would permit surgeons to objectively compare rods based on their specific properties. The goal of our study was to independently and objectively compare the biomechanical properties of spinal rods.

Methods: Testing was according to ASTM norm F2193. We measured bending stiffness, the bending ultimate moment, the bending yield moment and elastic recoil. Over 200 tests were performed on 63 rods.

Results: We found decreasing material stiffness from cobalt-chrome (CoCr) and stainless steel (SS) via titanium (Ti) to PEEK. Surprising differences of up to 10% were found between Ti rods from different manufacturers. Differences between materials were most pronounced with small diameters: A 4.5 mm CoCr rod has about twice the stiffness of a 4.5 mm Ti rod, but the difference is only 15% with 6.0 mm rods. CoCr rods provided the highest elastic modulus with 4.5 mm diameter CoCr rods being as stiff as 5.5 mm diameter titanium rods and 5.5 mm CoCr rods being stiffer than 6.35 mm Ti rods. The stiffness of PEEK rods was only 4% that of Ti rods of the same diameter with the exception of carbon fiber-reinforced PEEK, which was close to titanium. A simplified overview is displayed in image 1.

Conclusion: Our results show surprising variability between the popular 5.5 mm Ti rods from different manufacturers. With smaller diameters, the choice of material is increasingly important and may sometimes allow for using smaller implants while maintaining construct stiffness. Ultimate moment and yield moment determine at which load a construct can be expected to plastically deform in vivo and what amount of force is required to contour the rod prior to implantation. The elastic recoil after plastic deformation makes exact contouring more difficult which makes certain rods less comfortable to use in certain applications. We found considerable differences between the diameters / materials tested for all these parameters.



283. How Does State Income and the Number of Uninsured Patients Relate to Hospital Charges for Spine Care?

Kushagra Verma, MD, MS; Eric Padegimas, MD; Todd J. Albert, MD; Alexander R. Vaccaro, MD, PhD; Alan S. Hilibrand, MD; Suken A. Shah, MD; Jeffrey A. Rihn, MD; Satyendra Verma, PhD; Kris E. Radcliff, MD

USA

Summary: Using medicare data from 2011, hospital charges and charge to reimbursement ratio were associated with the percent uninsured within each state. Hospital charges for spine care may reflect an effort to recoup financial losses from treating uninsured patients. Paradoxically, reimbursements tend to favor states with higher mean income. Patients and policy makers are increasingly scrutinizing healthcare costs. To this end, spine surgeons are encouraged to take a leading role in understanding and mitigating hospital charges and reimbursements for spine care.

Introduction: Charge and reimbursement data from the Centers for Medicare Services demonstrated significant variation in the hospital charge and charge to reimbursement ratio (CRR) of spine care across the country. The purpose of this study is to determine if the state-to-state variation is correlated with state income and the percent of uninsured patients using data from the United States Census Bureau.

Methods: Four "diagnosis related groups" were analyzed: 460 (Thoracic/lumbar fusion), 473 (Cervical spine fusion), 491 (Nonfusion back/neck), 552 (Medical back). For each group, the correlation between medicare charge, reimbursement, and CRR to state income were analyzed. In addition, the correlation between charge, reimbursement, and CRR to % uninsured was investigated. Associations were determined with a Pearson's correlation.

Results: Thoracic/lumbar fusion: Charge correlated with % uninsured (0.519/<0.0001), while reimbursement with income (0.612/<0.0001). CRR was inversely correlated with income (-0.311/0.043) and associated with % uninsured (0.623/<0.001).

Cervical fusion: Charge correlated with the % uninsured (0.288/0.040).

Reimbursement correlated with income (0.675/<0.0001), and was inversely related to % uninsured (-0.264/0.080). CRR was associated with % uninsured (0.623/0.001).

Nonfusion Surgery: Charge correlated with the % uninsured (0.415/0.002), while reimbursement correlated with income (0.675/<0.0001). CRR was associated with % uninsured (0.524/<0.0001).

Medical Back: Charge correlated with the % uninsured (0.377/0.006). Reimbursement correlated with income (0.605/<0.0001) and inversely with % insured (-0.299/0.05). CRR was associated with % uninsured (0.530/<0.0001).

Conclusion: Overall, hospital charges and charge to reimbursement ratio for spine care increase with the number of uninsured patients within each state. These increased charges may reflect an effort to recoup financial losses from treating uninsured patients. Paradoxically, reimbursements tend to favor states with higher mean income.

284. Variation in Scoliosis Operative Resources: Pediatric Orthopaedic Scoliosis Team Composition

Charles T. Mehlman, DO, MPH; Albert D'heurle, MD

USA

Summary: The purpose of our study was to assess variation in surgical team composition for scoliosis surgery. High frequency team members were defined

E-POSTER ABSTRACTS

as those who started > 10 idiopathic scoliosis fusion cases per year. A team composed of entirely high frequency team members occurred in only 34% of scoliosis surgical cases.

Introduction: The operating room is considered a complex critical care work environment involving multiple team members who have very specific roles and duties. There is a well-established relationship between volume and outcome with multiple surgical disciplines indicating that about 10 cases per year is an important threshold. The purpose of our study was to assess variation in surgical team composition for scoliosis surgery. The same pool of nurses, scrubs, and nurse anesthetists (CRNAs) supported five different pediatric spine surgeons' cases included in this study.

Methods: This was an IRB-approved retrospective review of patients with idiopathic scoliosis who underwent posterior spinal fusion between 01/01/10 and 12/31/12. Patient charts were systematically reviewed with emphasis on team composition regarding care in the operating room. Team members included in the analysis were circulators, scrub persons, and anesthesia professionals. High frequency team members were defined as those who started > 10 adolescent idiopathic scoliosis (AIS) fusion cases during the study period.

Results: Average estimated blood loss was 853 ± 531 cc. Average operative time was 5.5 ± 1.2 hours, and average number of fused vertebral levels was 12 ± 1.5 levels. Four circulating nurses, 4 scrub nurses/scrub technicians, and 2 CRNAs met our definition of high frequency team members (> 10 cases). The circulators logged an average of 23 cases (range: 11 to 40), scrubs logged an average of 23 cases (range: 14 to 29), and CRNAs logged an average of 18 cases (range: 13 to 23). A team composed of entirely high frequency team members occurred in only 34% of scoliosis surgical cases.

Conclusion: This study indicates that only one-third of posterior spinal fusions for AIS at our hospital had high volume circulators, scrubs, and anesthesia all present at the beginning of the case. The potential additional effect of staff turnover following the start of the case must also be considered. Further investigation into the relationship between operating room team volume and potentially important volume thresholds is warranted.

285. Review of Questionnaires Used for Pediatric Spinal Deformity Surgery (AIS & EOS)

Nanjundappa S. Harshavardhana, MD, MS(Orth), Dip. SICOT; John P. Dormans, MD
USA

Summary: Patient reported outcome measures (PROM) have revolutionized clinical research and increasingly used by social scientists to perform cost-utility analysis. All existing / available questionnaires for Adolescent idiopathic (AIS) and Early-onset scoliosis (EOS) were comprehensively analyzed against clinimetric domains reporting their strengths and individual merits. Of all the PROMs, the SRS-22 has enjoyed immense popularity with maximum number of scientifically validated translations into other languages(9). This has enabled easy comparison across cultures and better understanding of role of surgery for scoliosis.

Introduction: Surgical interventions are under increasing scrutiny regarding cost-

effectiveness. Patient reported outcome measures (PROM) facilitate objective interpretation & comparison of therapeutic efficacy. All available outcome questionnaires designed for paediatric spinal deformity were retrieved and evaluated them against clinimetric domains / properties.

Methods: A comprehensive search for all available PROM and published review articles for spinal deformity surgeries was undertaken on PubMed up to December 2013. Eleven disease specific spinal deformity questionnaires were identified for AIS(10) & EOS(1). Each of these 11 questionnaires was evaluated for clinimetric domains:-

- 1) Validity (Content, Construct & Criterion validity)
 - 2) Reliability (Internal consistency & Reproducibility)
 - 3) Responsiveness to change
- and scored on a scale of 0-6 points.

All published full-text articles reporting evaluation, validation; surgical outcomes of these PROM were retrieved and independently analyzed by the author.

Results: Only 3/11 PROM had satisfied all six clinimetric domains in methodological evaluation (score 6/6) :- 1) Paediatric Outcomes Data Collection Instrument (PODCI)

2) Scoliosis research society-22 (SRS- 22)

3) Spinal appearance questionnaire (SAQ)

4/11 was not evaluated for at least 50% of the six clinimetric domains (score $\leq 3/6$) either by designers or other investigators. The uploaded table summarizes evaluation / score of each PROM. SAQ though less popular than SRS-22 demonstrated excellent psychometric behavior and better responsiveness to change in comparison to SRS-22. The sole questionnaire for EOS was developed recently in 2011.

Conclusion: SRS-22 is the most popular and widely used questionnaire. Clinicians should be cautious when choosing appropriate PROM and universal use of SRS-22 & EOS questionnaires when reporting surgical results should be encouraged. Incorporation of SAQ elements into SRS-22 to make the existing tool more robust constitutes ground for further research. Validation studies of other clinimetric domains are needed for EOS questionnaire. TAASQ (Truncal anterior asymmetry scoliosis questionnaire) is the newest PROM first presented / reported at SRS 2013 and its first peer-reviewed publication is awaited.

Table 1: Summary of all Questionnaires for Paediatric Spinal Deformity (as on Dec 2013)

Sl.No	Questionnaire / Outcome measure	Content Validity	Construct Validity	Criterion Validity	Internal Consistency	Reproducibility	Responsive to change	Total Score
1	Quality of Life Instrument for Adolescent idiopathic scoliosis - Clement JM et al. Spine 1995; 20(18): 2006-11.	✓	✓	---	✓	✓	---	4/6
2	PODCI - AAOs & POSSA. Daltroy LH et al. JPO 1998; 18(5): 561-71 and Lerman JA et al Spine 2002; 27(18): 2052-57.	✓	✓	✓	✓	✓	✓	6/6
3	SRS - 24. Haler TR et al. Spine 1999; 24(14): 1433-40.	✓	✓	---	---	---	---	3/6
4	Spina British questionnaire - Wu EK et al. JPO 2000; 20(6): 765-70.	✓	✓	---	---	✓	---	3/6
5	Modified SRS - 24 & SRS-23. Acher MA et al. Spine 2000 - 02; 25(18): 2381-86.	✓	✓	---	✓	✓*	---	4/6
6	SRS - 22 & SRS-22r. Acher MA et al. Spine 2003; 28(1): 61-69.	✓	✓	✓	✓	✓	✓	6/6
7	Walter Reed Visual Assessment Scale (WRVAS) - Sanders JO et al. Spine 2003; 28: 2158-63.	---	✓	✓	✓	✓	---	4/6
8	Scoliosis Quality of Life Index Questionnaire - Fosse RJ et al. Spine 2005; 30(11): 1310-15.	---	✓	---	✓	✓	---	3/6
9	Spinal Appearance Questionnaire (SAQ) - Sanders JO et al. Spine 2007; 32(24): 2719-22.	✓	✓	✓	✓	✓	✓	6/6
10	EOS Questionnaire - Vitale M et al. JPO 2011; 31(2): 180-85.	---	✓	---	✓	---	---	2/6
11	TAAS Questionnaire* - Lומר BS et al (SRS annual meeting 2013)	✓	✓	✓	✓	---	---	4/6

* Not clear from the original paper if it was evaluated & we have given authors the benefit of doubt

*Full-text article yet to be published)

E-POSTER ABSTRACTS

286. Evaluation of Mobile Application Software to Calculate Height Velocity in Patients with Idiopathic Scoliosis

Masaaki Chazono, MD, PhD; Takaaki Tanaka, MD

Japan

Summary: Much attention has been paid to height velocity (HV) as possible predictors of curve progression in patients with idiopathic scoliosis (IS). Time requirements for the measurement of HV values using mobile application software we developed were compared within and between observers. The result from this study indicates that digital measurement of HV values using this application software without using a complex formula such as Bjure's method saves time and enables the user to minimize the measurement error.

Introduction: Much attention has been paid to both peak height velocity (PHV) and height velocity (HV) as possible predictors of curve progression in patients with idiopathic scoliosis (IS). Recently, we developed mobile application software, downloadable through Android/iPhone, which we named "HV Scoliosis," as a tool to easily calculate HV in patients with IS. The aim of this study was to examine the efficacy of this software in female patients with IS.

Methods: The date of clinical visits, body heights, curve patterns, and Cobb angles of 50 skeletally immature female IS patients were randomly extracted from the office charts and X-ray files. Three independent reviewers, an orthopaedic resident (OR), an orthopaedic fellow (OF), and a spine specialist (SS), each calculated HV using three instruments: calculator (C-set), smartphone (S-set) and tablet computer (T-set) installed with the software. Time requirements for the measurement of HV values were compared within and between observers. In addition, the percentage of correct answers was also calculated based on the number of actual HV values each reviewer measured divided by 50 of correct HV values.

Results: Mean measurement times for C-set, S-set, and T-set combined were 81.3 for OR, 78.9 for OF, and 75.7 seconds for SS. Mean Measurement times for all reviewers combined were 80.8 for C-set, 76.4 for S-set, and 78.6 seconds for T-set. In the group with Cobb angles greater than 30 degrees, mean measurement times for all reviewers combined were 104.2 for C-set, 81.3 for S-set, and 83.3 for T-set: the time for S-set and T-set measurements was significantly shorter than for C-set measurements for the OR and SS group. Percentages of correct answers for C-set, S-set, and T-set combined were 83.3%, 100%, and 96.7%, respectively.

Conclusion: The result from this study indicates that digital measurement of HV values using this application software without using a complex formula saves time and enables the user to minimize the measurement error. The English version of the software was launched in January 2014. The curve-progression risk assessment in patients with IS should include PHV/HV, along with measures of skeletal and non-skeletal maturities.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

287. The Patient Experience of Pre-Operative Halo Gravity Traction in

Severe Paediatric Spinal Deformity: A Retrospective Qualitative Analysis

Sanka B. Bambarawana Liyanage, MBChB; Crista Yarrell; John A. Ferguson, FRACS; Antony Field

New Zealand

Summary: We explored the patient experience of pre-operative halo gravity traction in our institution over the last 10 years. Through a structured qualitative interview of 13 patients, we demonstrated that pre-operative halo gravity traction is well tolerated by paediatric patients.

Introduction: The safety and efficacy of this procedure in the management of paediatric spinal deformity is well documented. However, the psychological impact for the paediatric patient is less well described and will be investigated in this study.

Methods: A qualitative assessment questionnaire was developed based on a pre-existing validated questionnaire used by Niemi et al and in consultation with a senior paediatric clinical psychologist. The questionnaire was divided into 4 sections to assess the pre, during and post traction experience as well as the child's opinion of the overall process. This was administered during a 30-minute structured interview in person when able, or over the phone. Analysis was moderated by a third party.

Results: A total of 17 patients were eligible from 2003 to 2013, 14 (9 female, 5 male) between the ages of 8 to 18 were interviewed. 1 was excluded due to poor recall. Pain, especially during pin tightening, was noted by 8 out of 13 patients to be severe (62%) and the worst part of the experience by 5 patients (38%). However, 12 of the 13 patients had no pain at one week. Daily activities were well tolerated although 5 reported difficulty with sleeping. 4 patients were left with no visible forehead scars. 9 had residual scars with none concerned about them. All patients would recommend halo gravity traction to others who need it as part of treatment. 12 out of the 13 patients found the post-operative course following corrective surgery to be worse than their experience with halo traction.

Conclusion: Pre-operative halo gravity traction is well tolerated in the paediatric population prior to spinal deformity correction. We aim to corroborate these findings with a prospective study.

288. Variability of Reviewers' Comments in Spine Research

Stephanie Iantorno; Lindsay Andras, MD; David L. Skaggs, MD, MMM

USA

Summary: There was a high degree of variability amongst reviewers' comments. Between reviewers at the same journal an average of 12.4% of comments were repeated. Only 20.4% of comments were repeated by reviewers at a second journal.

Introduction: The consistency of the peer review process in spine research has not been objectively examined. Our goal was to assess the likelihood that comments provided by reviewers of one orthopaedic journal would be similar to the comments of reviewers from another journal. To our knowledge this is the first study to quantify and analyze the comments provided by reviewers of major medical journals.

E-POSTER ABSTRACTS

Methods: We performed a retrospective study of reviewers' comments for spine papers submitted for publication in major orthopaedic journals (JBJS, Spine, Spine Deformity, European Spine Journal, and JPO) that were rejected. All papers were returned with comments from 2-3 reviewers. Each paper was re-submitted to a different journal at which it was accepted in the exact same form. Authors made no changes to the manuscript between the submissions. The papers were returned from the second journal with comments from 2-3 reviewers. All reviews were examined and comments were treated as separate data points. Comments were compared both between reviewers of the same journal (intra-journal) and between journals (inter-journal).

Results: Four papers met the inclusion criteria. When comparing comments from reviewers of the same journal, an average of 12.4% of comments were repeated (range 0%(0/11) to 21.7%(5/23)). Comments of reviewers from the first journals, which the papers were rejected from, were then compared to the comments from the second journal, at which the papers were accepted. On average 20.4% of comments from the first journal were repeated by a reviewer at the second journal (range 10.0% (1/10) to 33.3% (6/18)).

Conclusion: There was a low likelihood that any comment would be repeated by another reviewer, either at the same or a different journal. Our study raises concern for the reliability of the current peer review process. It also suggests there may exist little incentive for authors to spend time revising manuscripts when comments are unlikely to be repeated.

289. Toei Study: Relationship between Sagittal Spinopelvic Parameters and Oswestry Disability Index Scoring in High Age Volunteers

Daisuke Togawa, MD, PhD; Tatsuya Yasuda; Yu Yamato; Sho Kobayashi, PhD; Hideyuki Arima; Tomohiko Hasegawa; Yukihiko Matsuyama, MD Japan

Summary: Six-hundred-ninety-four volunteers (274 males, 420 females, average age 73) with age of more than 50 were participated in musculoskeletal examination. Lateral whole spine and pelvic X-rays were digitally taken in standing position and Oswestry disability index (ODI) was evaluated. In the group of ODI less than 20%, PT, SVA, and PI minus LL, used as 3 sagittal modifiers in SRS Schwab Classification, were almost in normal range. Higher ODI categories clearly showed larger PT, SVA, and PI minus LL values.

Introduction: The purpose of this study was to investigate the relationship between sagittal spinopelvic parameters and the Oswestry Disability Index (ODI) scoring in high age volunteers.

Methods: 746 volunteers with age of more than 50 were participated in this IRB approved study in Toei town of Aichi prefecture in Japan. There were 295 males and 451 females with average age of 73. Lateral whole spine and pelvic X-rays were digitally taken in standing position. Radiographic parameters included Sacral Slope (SS), Pelvic Tilt (PT), Pelvic Incidence (PI), Lumbar Lordosis (LL), Thoracic Kyphosis (TK), Sagittal Vertical Axis (SVA) were measured by computer software. PI minus LL was also calculated. Health related QOL was evaluated by Oswestry disability index (ODI), and categorized into Zero (0), Minimal (1-20), Moderate (21-40), Severe (41-60), and Crippled (61-80). Relationship between these

radiographic parameters and ODI scoring was statistically analyzed.

Results: Digitized radiographs were successfully evaluated in 694 volunteers (274 male, 420 female, average age 73). Average radiographic parameters according to each category of ODI scoring were showed in Table 1. In ODI scoring, there were 109 volunteers in Zero, 531 in Minimal, 137 in Moderate, 21 in Severe, 3 in Crippled categories. In ODI Zero, average PT, SVA, and PI minus LL were 16.32, 30.22, 5.08, respectively. In ODI Minimal categories (minimal disability and no treatment required), PT, SVA, and PI minus LL were 18.00, 46.00, and 2.46, respectively. These results suggested these parameters (PT, SVA, PI minus LL) used as 3 sagittal modifiers in SRS Schwab Classification in ODI Zero and Minimal categories were almost in normal range. However, the higher ODI categories (Moderate, Severe, and Crippled) clearly showed significantly larger PT, SVA, and PI minus LL values ($p < 0.0001$).

Conclusion: This study analyzed average sagittal spinopelvic parameters in the different range of ODI scoring in high age volunteers with average age of 73. This data clearly showed that sagittal spinopelvic malalignment impaired health related QOL.

290. A Normative Baseline for the SRS-22 from Over 1000 Healthy Adolescents in South East Asia: Which Demographic Factors Affect Outcome?

Kushagra Verma, MD, MS; Senthilnathan Thirugnanasambandam, MD; Yuan Ren, PhD; Baron S. Lonner, MD; Suken A. Shah, MD USA

Summary: This is the first normative baseline for the SRS-22 in SE Asia. Younger age correlated with better image, while female gender was associated with improved pain, mental health, and overall SRS-22 score. Patients with higher BMI had less pain, however income and household status (single/dual parent income) had no effect on the SRS-22. These findings are in contrast to data gathered in the United States. This study stresses the importance of normative data for cross-cultural comparisons.

Introduction: Previous studies have established a baseline for the SRS-22 in the US. While the SRS-22 is used internationally, limited normative data is available. This study aims to: 1) establish a baseline for the SRS-22 in SE Asia and 2) evaluate the influence of patient demographics on the SRS-22.

Methods: This is a prospective observational study utilizing the SRS-22 in SE Asia. After hospital/school approval, 1200 adolescents (age 10-18) were asked to anonymously complete the SRS-22. Demographic factors: height, weight, age, gender, household income (range <\$30K to >\$200K) and household status (single/dual parent income). Participants with a prior spine history or active medical problems were excluded. Statistical analysis: Pearson's correlation, ANOVA.

Results: 1019 unaffected adolescents completed the SRS-22 (mean age 14.4 \pm 1.6). Demographics as follows: gender (42%F, 58%M), household status (640 single/379 dual), height (157 \pm 12cm), weight (46 \pm 11.2 kg), BMI (18.5 \pm 3.6). SRS-22 score for all patients and by gender: Male gender was associated with worse pain (-0.15), mental health (-0.11), and overall SRS-22 score (-0.11). Age was correlated with a worse image ($r = -0.17$, $p = <0.000$),

E-POSTER ABSTRACTS

while higher BMI was associated with less pain (0.07/0.02).

Conclusion: Younger age, female gender, and higher BMI correlated with a better SRS-22 score. Income and household status did not affect the SRS-22. These findings are in contrast to data gathered in the US. This study establishes the first SRS-22 normative baseline in SE Asia and analyzed the effect of demographics on the outcome score.



292. Natural Progression of Scoliosis in Spastic Cerebral Palsy

Kyu-Jung Cho, MD; Seung Yeol Lee, MD; Young-Tae Kim; Jung-Hee Lee, MD; JinHyok Kim
Republic of Korea

Summary: The purpose of this study is to analyze annual changes in radiographic indices of the spine and influencing factors of its progression in CP patients. A total of 184 patients with spastic CP were included. The mean follow-up was 2.1 years (range 1.0-9.1 years). Annual increase of the scoliosis Cobb angle was 3.4° in the GMFCS level IV-V group. The thoracic kyphosis angle increased by 2.2° and apical vertebral translation increased by 5.4 mm annually in the GMFCS level IV-V group.

Introduction: Few studies have investigated progression rates of the scoliosis curve in cerebral palsy (CP) patients and the multiple factors affecting it. The purpose of this study is to analyze annual changes in radiographic indices of the spine and influencing factors of its progression in CP patients.

Methods: A total of 184 patients (774 radiographs) with spastic CP who had taken whole spine radiographs more than twice were included. The mean follow-up was 2.1 years (range 1.0-9.1 years). Scoliosis Cobb angle, coronal balance, apical vertebral translation, apical rotation, and pelvic obliquity were measured on anteroposterior (AP) radiographs; thoracic kyphosis and lumbar lordosis angles and sagittal balance on lateral radiographs; and migration percentage on AP hip radiographs to determine hip instability. For each Gross Motor Function Classification System (GMFCS) level, the Cobb angles, apical vertebral translation, coronal and sagittal balance, and pelvic obliquity were adjusted by multiple factors with a linear mixed model.

Results: Annual increase of the scoliosis Cobb angle was 3.4° in the GMFCS level IV-V group ($p = 0.020$). Whereas, there was no significant annual change

in scoliosis Cobb, thoracic kyphosis, and lumbar lordosis angles in the GMFCS level I-II and III group. The thoracic kyphosis angle increased by 2.2° ($p = 0.018$) annually in the GMFCS level IV-V group. Apical vertebral translation increased by 5.4 mm ($p = 0.029$) annually in the GMFCS level IV-V group. Progression of coronal and sagittal balance and pelvic obliquity with aging were not statistically significant. Sex, hip instability, hip surgery, and triradiate cartilage did not affect the progression of scoliosis and the balance of the spine and pelvis. **Conclusion:** The scoliosis Cobb angle, thoracic kyphosis angle, and apical vertebral translation in the GMFCS level IV-V of CP patients progressed with age. These finding is helpful to predict radiographic progression of scoliosis in CP patients.

293. Goals and Indications for Surgery in Severe Pediatric Scoliosis Related to Cerebral Palsy

Patrick J. Cahill, MD; Charlotte Carroll; Joshua M. Pahys, MD; Kimberly M. Hayes; Randal R. Betz, MD; Amer F. Samdani, MD
USA

Summary: A review of 126 patients who underwent a spinal fusion for scoliosis related to cerebral palsy (CP) assessed the indications and goals reported by surgeons and compared them to the reported goals and indications from the patient caregivers. Surgeons and caregivers both reported the potential for improved sitting ability most often as an indication for surgery.

Introduction: Surgery is a frequent recommendation for treating scoliosis in patients with CP. The decision to perform a fusion on these patients weighs both the costs and benefits of the surgery and must involve a conversation between the surgeon and caregiver on their goals for treatment. However, few data exist on explicitly reported reasons by the patient caregivers and treating surgeons themselves for deciding on surgery.

Methods: A prospective study of surgeon and caregiver reported indications for patients undergoing spinal fusion was performed as part of a multicenter CP spinal fusion study. Surgeons and caregivers selected from an identical list of indications or could include their own free response. Surgeons and caregivers also ranked their indications in order of importance. Correlations in the frequency of all responses selected and in the primary indications for each case were evaluated. The primary indications were identified by virtue of their ranking as one of the three most important indications for the surgery by the surgeon/care giver respondent.

Results: Responses were available for 126 cases. Surgeons listed an average of 3.55 goals, while caregivers listed an average of 6.82 goals. The most common responses for surgeon goals were to improve sitting (94%), to prevent sitting problems (48%), and to prevent pulmonary compromise (43%). Caregivers' most common reported goals were to improve sitting (91%), to prevent pulmonary compromise (74%), and to improve head control or position (67%). Surgeons ranked improve sitting as their primary goal most often (74%), while caregivers ranked helping to relieve back pain as their primary goal most often (25%). Improvement in pain and self-image were indications listed by caregivers more than twice as often as surgeons.

E-POSTER ABSTRACTS

Conclusion: Surgeons and caregivers varied on their goals for surgery, although both ranked “improved sitting” in >90% of cases. Caregivers list twice as many goals for surgery as the surgeons. Surgeons should understand the nature and extent of the families’ goals and educate families in an attempt to manage the expectations of surgery.

294. Effect of Back Strengthening Exercise on Spinal Alignment and Range of Motion: A Randomized, Controlled Trial

Michio Hongo, MD; Naohisa Miyakoshi, MD; Yuji Kasukawa; Yoshinori Ishikawa; Daisuke Kudo; Akiko Misawa, MD; Yoichi Shimada, MD
Japan

Summary: Randomized controlled study in eighty postmenopausal women with osteoporosis was conducted to investigate the effect of a home-based, back strengthening exercise. The results demonstrated that back exercise could alter the spinal posture especially for lumbar lordosis. Besides, lumbar mobility in flexion and quality of life was enhanced with this exercise. Therefore, back exercise is an effective method for improving back strength, quality of life, and possibly spinal curvature in patients with kyphotic spinal deformity.

Introduction: Back extensor strength is an important factor for developing spinal kyphosis. We have demonstrated that low intensity back strengthening exercise was effective in improving the quality of life. However, there were very few literatures describing whether the exercise could alter the spinal curvatures. The purpose of this study was to assess the influence of back strengthening exercise on spinal sagittal curvature and range of motion.

Methods: Eighty women with average ages of 67 years were randomly assigned to a control group (n=38) or an exercise group (n=42). Subjects were instructed to lift their upper trunk from prone position antigravity and maintain the neutral position for 5 second with 10 times repetition a day. Each session was performed five days a week at home. Spinal curvatures and range of motion were evaluated with SpinalMouse®. Also Isometric back extensor strength, and scores for quality of life were evaluated at baseline and 4 months.

Results: Lumbar lordosis of neutral standing position significantly increased in the exercise group. Also an increase in lumbar lordosis was significantly larger compared with control group (p=0.018). Whereas, there was no significant change in thoracic kyphosis and spinal inclination angle. Range of motion in lumbar flexion significantly increased compared with control group. Back extensor strength significantly increased both in the exercise group (26%) and in control group (11%). Scores for quality of life increased in the exercise group (7%).

Conclusion: This study demonstrated that back strengthening exercise could alter the spinal posture especially for lumbar lordosis. Besides, lumbar mobility in flexion and quality of life was enhanced with this exercise. Therefore, back exercise is an effective method for improving back strength, quality of life, and possibly spinal curvature in patients with kyphotic spinal deformity.

295. Effects of Manual Correction and Strength Training in Adolescents with Idiopathic Scoliosis: A Prospective, Queue, Partly-Randomized Study

En Xie, PhD, MD; Dingjun Hao

China

Summary: Our researcher studied that in adolescent patients with idiopathic scoliosis, manual correction and strength training decreased the progression of curves to the point where surgery would be needed,

Introduction: The effect of Manual correction and Strength training on curve progression and rate of surgery has remained unclear, To help fill the gap, we designed a randomized trial, but slow enrollment led us to add a preference cohort in which patients and families could choose our therapy.

Methods: We conducted a metacenter study that included patients with typical indications for manual correction and strength training due to their age, skeletal immaturity, and degree of scoliosis. All told, 2,087 patients met the inclusion criteria and 417 agreed to part, but 40 were not analyzed because they had not reached the endpoint when the study was stopped. Both a randomized cohort and a preference cohort were enrolled. Of 377 patients included in the analysis, 217 were randomly assigned to manual correction and strength training or observation, and 160 choose between manual correction and strength training and observation. Patients in the manual correction and strength training group were instructed to professional treat at least 2 times per week. The primary outcomes were curve progression to 45 degrees or more (treatment failure) and skeletal maturity without this degree of curve progression (treatment success).

Results: The trial was stopped early owing to the efficacy of manual correction and strength training. In an analysis that included both the randomized and preference cohorts, the rate of treatment success was 77% after Manual correction and Strength training, as compared with 37% after observation (propensity-score-adjusted odds ratio for treatment success, 1.91; 95% confidence interval [CI], 1.17 to 3.77). In the intention-to-treat analysis, the rate of treatment success was 75% among patients randomly assigned to Manual correction and Strength training, as compared with 42% among those randomly assigned to observation (odds ratio, 4.07; 95% CI, 1.77 to 7.17). There was a major positive association between hours of brace wear and rate of treatment success (P<0.01).

Conclusion: Manual correction and strength training significantly decreased the progression of high-risk curves to the threshold for surgery in patients with adolescent idiopathic scoliosis. The benefit increased with longer hours of manual correction and strength training.

296. Predictive Factors for the Outcome of Surgical Treatment of Lumbar Spondylolysis in Young Sporting Individuals

Ujjwal K. Debnath, MS(Orth), FRCS, FRCS (Trooth), DM (Orth)

India

Summary: Most athletes or young active professional sportsmen or women would like to return to their previous level of sports. 55 patients treated operatively for lumbar spondylolysis were followed up with background data (both subjective and objective) and outcome questionnaires. Multiple regression analysis was carried out with post-operative ODI as the dependent variable to

E-POSTER ABSTRACTS

identify the predictor variables and develop a regression equation to predict the outcome.

Introduction: Only few sporting individuals with symptomatic lumbar pars injuries require surgical repair and it is often difficult to predict the outcome following surgery. This study analyses the predictive factors of outcome after direct repair of pars defect.

Methods: 52 consecutive young sporting individuals with a mean age of 19 years (range 8-35 years) were treated surgically for lumbar pars defect confirmed on imaging studies (i.e. SPECT, CT and MRIs). 50 patients completed the VAS (visual analogue scores), ODI (Oswestry Disability Index) and SF-36 (Short Form) questionnaires as a part of their assessment. Preoperative background variables were used in a multiple regression model to find the strongest predictor of post-operative outcome as measured by ODI.

Results: Buck's screw repair of the pars defect was carried out in 44 patients (33M: 11 F). Unilateral in 8 patients (7M: 1F) and bilateral in 36 patients (26M: 10F). Age at surgery showed linear co-linearity ($p=0.32$, $p<0.05$), it was not significant in the model. The most consistent association with the preoperative VAS score were the pre and post operative ODI scores i.e. $p=0.51$ ($p<0.01$) and $p=0.33$ ($p<0.05$) respectively. In the bilateral group, with Buck's repair at a single level i.e. 33/36 (93%) patients had returned to sports at a mean time of 7.5 months (range 6-12 months). Overall, 44/52 (84%) individuals had returned to their sports with post-treatment ODI score of <10 . The stepwise regression modeling suggested six independent factors (pre-operative ODI, pre-operative SF36 pcs, Buck's repair, multiple operations, professionalism and pars defect at L3), as the determinants of the outcome (i.e. post-operative ODI.) in 80.9% patients ($R^2=0.809$).

Conclusion: The outcome after direct repair of pars defect below 25 years of age runs a predictable course. Preoperative ODI and SF-36 pcs scores are significant predictors of good functional outcome. The regression equation can predict the outcome in 80.9% sporting individuals undergoing Buck's repair.

298. Role of Autologous Bone Marrow Derived Mononuclear Cells as a Synergetic Aid in Neurological Recovery in Spinal Cord Injury

Rajeshwar N. Srivastava, MD; Ashok K. Agrahari, MSc, MPhil (THS), PhD; Saloni Raj
India

Summary: The neurological recovery following spinal cord injury remains obscure. It has long been believed that intrinsic repair is restricted after SCI because neurogenesis rarely occurs in the central nervous system. As a result of unpredictable results following available methods of SCI treatment, the stem cell transplantation is becoming a promising therapeutic option. Due to the ethical, logistics and the economy involved in embryonic stem cell, the use of autologous bone marrow derived mononuclear cells (BMCs) in SCI patients has been investigated

Introduction: We designed this study to improve the conventional treatment modalities by augmenting with autologous bone marrow derived mononuclear cells (MNCs). MNCs have property to bear stem and progenitor cells of various fate with a goal to repair a damaged tissue that has lost the property to heal itself.

Methods: The aim of the study was correlation of infused mononuclear cell

concentration to neurological recovery scales of SCI. Eligible patients for this phase 2, open label trial were acute complete injuries between T3 - L1 spine. The three arms of the study group comprised of Gp1- Decompression and posterior instrumentation, Gp2- Decompression, posterior instrumentation and MNC infusion, Gp3 non surgical treatment as control.. Follow up was done at 6 monthly intervals for 2 years. In respect to go through the safest way for the bone marrow aspiration, centrifugation and infusion, we used non touch close system by transfusion blood bags. The MNCs were counted by automated cell counter and the counts were correlated with recovery of SCI patients using ASIA (American Spinal Injury Association) Impairment Scales.

Results: A total of 92 patients were included in the study and 80 patients followed up to 2 years.

The recovery was higher in group 2 at 6 monthly followups. The motor score increased to 5.14 at 1 year, to 4.95 at 2 year from admission (3.90 ± 8.84) in group-1. However, in group-2, this was in increasing order and there was no change in group-3 ($p>0.05$). The sensory score increased to 163.43, 166.29 and 169.33 from 159.43 at admission in group-1. Similar observations were found in group-2 and 3 ($p>0.05$). The purity and yield of MNC's were almost same to some other studies showing the best result of MNCs count in purified BM. But our result became more significant than other studies in which they used different procedures of MNCs isolation that required MNCs retrieval at least washing by saline or even more while our procedure consists an aseptic closed system of purification that also not require any retrieval process.

Conclusion: This study promises the efficacy of autologous mononuclear bone marrow cells in the regeneration of neurons and a sound ground to continue this study with a large sample size

299. One-Stage Posterior Vertebral Column Resection (PVCR) and Vertebral Column Shortening Produced Tension Reduction for Treatment of Thoracolumbar Vertebral Fracture with Spinal Cord Injury (SCI)

Yingsong Wang, MD; Jingming Xie; Zhiyue Shi; Ying Zhang; Tao Li; Ni Bi; Leijie Chen; Zhi Zhao; Zhou Liu
China

Summary: We report an effective surgical strategy to treat thoracolumbar fracture with SCI.

Introduction: There have not been described PVCR and vertebral column shortening for treatment of thoracolumbar fracture with SCI. The aim of this study was to analyze the outcome of patients with thoracolumbar fractures with SCI.

Methods: A total of 25 patients undergoing PVCR for thoracolumbar fracture with SCI in 2009-2011 were reviewed. All of patients were not spinal cord cutting off and suffered one segmental fracture in MRI. Neurologic status was classified using the American Spinal Injury Association (ASIA) impairment scale. The kyphotic angles were measured in the lateral radiographic images.

Results: There were 16 males and 9 females, with age of 25.8(16-45) years. The follow-up was 32(28-45) months. The operative time was 414.29 \pm 76.78 minutes. The blood loss was 1650.24 \pm 64.64 mL. The range of shortening of the spinal column was 0.9cm-1.4cm. Preoperative canal encroachment was on average 75.7%, while surgery got completely 360° spinal

E-POSTER ABSTRACTS

cord decompression. At preoperation, 12 case was classified as ASIA grade A, 8 as grade B, 5 as grade C. At discharge time, 7 case was classified as ASIA grade A, 6 as grade B, 9 as grade C, 3 as grade D, neurologic status at discharge was improved when compared with preoperative one ($P < 0.05$). At last follow-up, 3 case was classified as ASIA grade A, 4 as grade B, 7 as grade C, 7 as grade D, 4 as grade E, neurologic status was improved when compared with discharge one ($P < 0.05$). The segmental kyphotic angle was $27.57^\circ \pm 8.48^\circ$ pre-operatively and $6.64^\circ \pm 2.62^\circ$ at last follow-up, last follow-up Cobb angle was improved when compared with preoperative one ($P < 0.05$).

Conclusion: The PVCR maybe is a meaningful strategy to treat thoracolumbar fracture with SCI because of completely 360° spinal cord decompression, vertebral column shortening and reconstruction, and greatly facilitating of neurological recovery. It is safe to shorten the spinal cord within 1.4 cm in thoracolumbar spine.

300. Modified Posterior Vertebral Column Resection for the Treatment of Osteoporotic Fractures with Neurological Deficits in Elderly Patients

Meric Enercan; Erden Erturer; Mesut Kilic, MD; Neron Popovski, MD; Mustafa F. Seckin; Cagatay Ozturk, MD; Ufuk Talu, MD; Ahmet Alanay; Azmi Hamzaoglu, MD

Turkey

Summary: Modified PVCR technique described in this study provides spinal canal decompression, restoration of anterior column support with posterior stabilization and eliminates the disadvantages of anterior or combined A+P approaches in elderly patients.

Introduction: The purpose of this retrospective study was to evaluate the results of spinal canal decompression and anterior column support via modified PVCR (Unilateral hemilaminectomy, pediclectomy, subtotal vertebrectomy) performed for eliminating the disadvantages of the anterior or combined A+P approaches, in the management of osteoporotic vertebral fractures with neurological deficits in elderly patients.

Methods: 55 patients (40F/15M) with more than 2 years of f/up were included in this study. The fractures were in the thoracic spine in 16 patients, and thoracolumbar spine in 39 patients. 11 patients had ASIA C and 41 patients had ASIA D neurological deficits. Clinical and radiological outcome and complications were also evaluated. Surgical technique included placement of fenestrated titanium pedicle screws, followed by hemilaminectomy, unilateral pediclectomy, and decompression of the spinal canal by subtotal vertebrectomy, and support of anterior column by titanium cage. Contralateral facet joint fusion and grafting was made. Prophylactic vertebroplasties were made in one level above and one level below in all patients.

Results: Mean age was 74.2 (66-92), and mean f/up was 43.5 m (28-102). Mean operation time was 252 m (160-340), and blood loss was 580 ml (420-800). Mean preoperative LKA of 18.5° , 4.2° after the operation and 4.8° at the final f/up. VAS was 8 before the operation, 2 at final f/up. Full neurologic recovery was achieved in all patients. There were no pseudoarthroses. The major complication was adjacent segment fracture was made 3 patients (5.4%). The minor complications were superficial wound infections in 5, dural tear in 4 patients (16.3%).

Conclusion: Treatment of osteoporotic vertebral fracture with neurologic deficit is a challenging procedure in elderly patients. Modified PVCR provides effective decompression of neural structures. Contralateral intact lamina, pedicle and cortex of the vertebra increase primary stability and provides more bony surface for fusion.

301. Enneking Appropriate Enbloc Surgery for Osteogenic Sarcoma of the Spine Results in Reduced Local Recurrence and Enhanced Survival over Enneking Inappropriate Intralesional Surgery

Mark B. Dekutoski, MD; Stefano Boriani, MD; Peter S. Rose, MD; Michelle J. Clarke, MD; Peter P. Varga; Laurence D. Rhines, MD; Charles G. Fisher, MD, MHS, FRCSC; Dean Chou, MD; Nasir A. Quraishi, FRC; Michael G. Fehlings, MD, PhD; Ziya L. Gokaslan, MD

USA

Summary: Multicenter retrospective review of 57 patients treated surgically for primary osteogenic sarcoma of the spine were analyzed for character of surgical resection adjuvant therapy versus time to recurrence and mortality. There are trends toward improved survival with en bloc resection when compared with intralesional resection and with the use of adjuvant therapy.

The best results can be obtained by the combination of full course of chemotherapy and en bloc w/m resection. The role of radiotherapy as further adjuvant in case of feasibility of such procedure should be better investigated

Introduction: Osteogenic sarcoma rarely occurs in the spine, but when it does, the prognosis is poor. Enneking Appropriate, En bloc resection (wide/marginal margin) is recommended for osteogenic sarcoma of the extremities. This procedure is technically demanding in the spine, resulting in significant morbidity and possible functional sacrifice.

Methods: A multicenter ambispective database of surgically treated patients with osteogenic sarcoma of the spine was developed by the AOSpine Knowledge Forum Tumor. Data about patient demographics, diagnosis, treatment, perioperative morbidity, local recurrence, and cross-sectional survival were collected. Tumors were classified according to Enneking and Weinstein-Boriani-Biagini. Descriptive statistics were summarized and time to first local recurrence and survival were displayed by Kaplan-Meier curves. Prognostic variables for local recurrence and survival were identified with Fisher's exact and log-rank tests. Significance was decided when $P \leq 0.05$.

Results: Between 1987 and 2012, 57 patients (36 years (SD = 16)) underwent surgical treatment for a high grade spinal osteogenic sarcoma. Patients were followed for a mean period of 3.4 years (SD = 3.5). Thirty-four patients (60%) underwent Enneking Appropriate (EA) en bloc (marginal/wide) resection while 18 patients (32%) were treated by Enneking Inappropriate (EI) intralesional resection, and five resections (9%) were unknown.

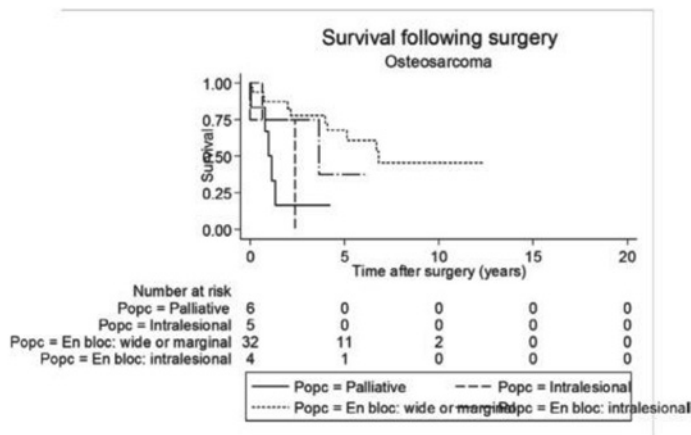
Recurrence and survival was significantly enhanced by EA surgery versus EI resection. Recurrence EA 3/33 vs 11/19 EI and Survival EA 24/33 vs 7/19 EI. KM Survival Curves Table 1

Median survival for patients who received intralesional resection was 1.3 years postoperative (SE = 0.21; 95% CI = 0.75-3.65) ($P = 0.001$). Median survival for the entire cohort was six years postoperative (SE = 0.08; 95% CI = 0.34-

E-POSTER ABSTRACTS

0.65). Twenty-four patients (42%) died and 17 patients (30%) experienced a local recurrence, ten (59%) of which died.

Conclusion: Osteogenic sarcoma of the spine presents a significant challenge, and most patients die from their disease in spite of aggressive surgery and chemotherapy. There is a trend toward improved survival with en bloc resection when compared with intralesional resection.



The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

302. Evaluation of Scoring Systems and Prognostic Factors in Patients with Spinal Metastases from Nasopharyngeal Carcinoma

Naresh S. Kumar, MBBS, FRCS (Orth&Tr), DM; Jonathan Tan, MBBS, MRCS; Aye Sandar Zaw, MBBS, MPH; Khin L. Wai, MBBS, MSc Singapore

Summary: We aimed to investigate the robustness of four scoring systems namely: Tokuhashi, Tomita, Bauer and Oswestry in prediction of survival for patients with Nasopharyngeal Carcinoma (NPC) from spinal metastases to assist in establishing treatment for them. The results show that patients with spinal metastases from NPC have good survival prognosis. All four scoring systems could be used to prognosticate NPC with significant association with actual survival. The modified Tokuhashi score was the best.

Introduction: The decision for operative treatment of patients with spinal metastases from various primary tumors is largely dependent on the predicted survival. Although Tokuhashi, Tomita, Bauer and Oswestry are popularly used for survival prognosis predictions, none of these systems have been evaluated in Nasopharyngeal Carcinoma (NPC). We aim to investigate the robustness of these scoring systems in prediction of survival for patients with NPC.

Methods: We retrospectively analyzed the NPC patients who presented to our institution between 2007 and 2011. Of a total of 814 histologically proven NPC patients, 87 with spinal metastases were studied. The predicted survival according to the four scoring systems was calculated and labeled as (A) scores. These scores were then re-scored by assigning NPC as a good prognostic tumour and labeled as (B) scores. The predicted survival of scores (A) and (B) were compared to actual survival. Univariate and multivariate Cox regression analyses were performed. The predictive values of each scoring system (A) and (B) were

calculated using post estimation after Cox regression analyses.

Results: The median overall survival for the whole cohort was 13 months (range: 1-120 months). In multivariate analysis, general condition ($p < 0.01$), visceral metastases ($p < 0.01$) and vertebral metastases ($p < 0.01$) showed significant association with survival. The absolute score of all scoring systems were significantly associated with actual survival, which extended to the different prognostic subgroups of each scoring systems. Log rank test revealed that there were statistically significant differences in survival between the different prognostic groups of all scoring systems ($p < 0.01$). Predictive value of survival by modified Tokuhashi score was the highest among all four scoring systems.

Conclusion: Patients with spinal metastases from NPC have good survival prognosis. All four scoring systems could be used to prognosticate these patients with a statistically significant association with actual survival. The modified Tokuhashi score is the best in doing so.

303. O-Arm 3D Navigation for Surgical Resection of Osteoid Osteoma and Osteoblastoma of the Spine

Muayad Kadhim, MD; Odion Binitie; Camila B. R. De Mattos; John P. Dormans, MD; Patrick O'Toole, MD USA

Summary: O arm is helpful for intraoperative tumor localization and resection.

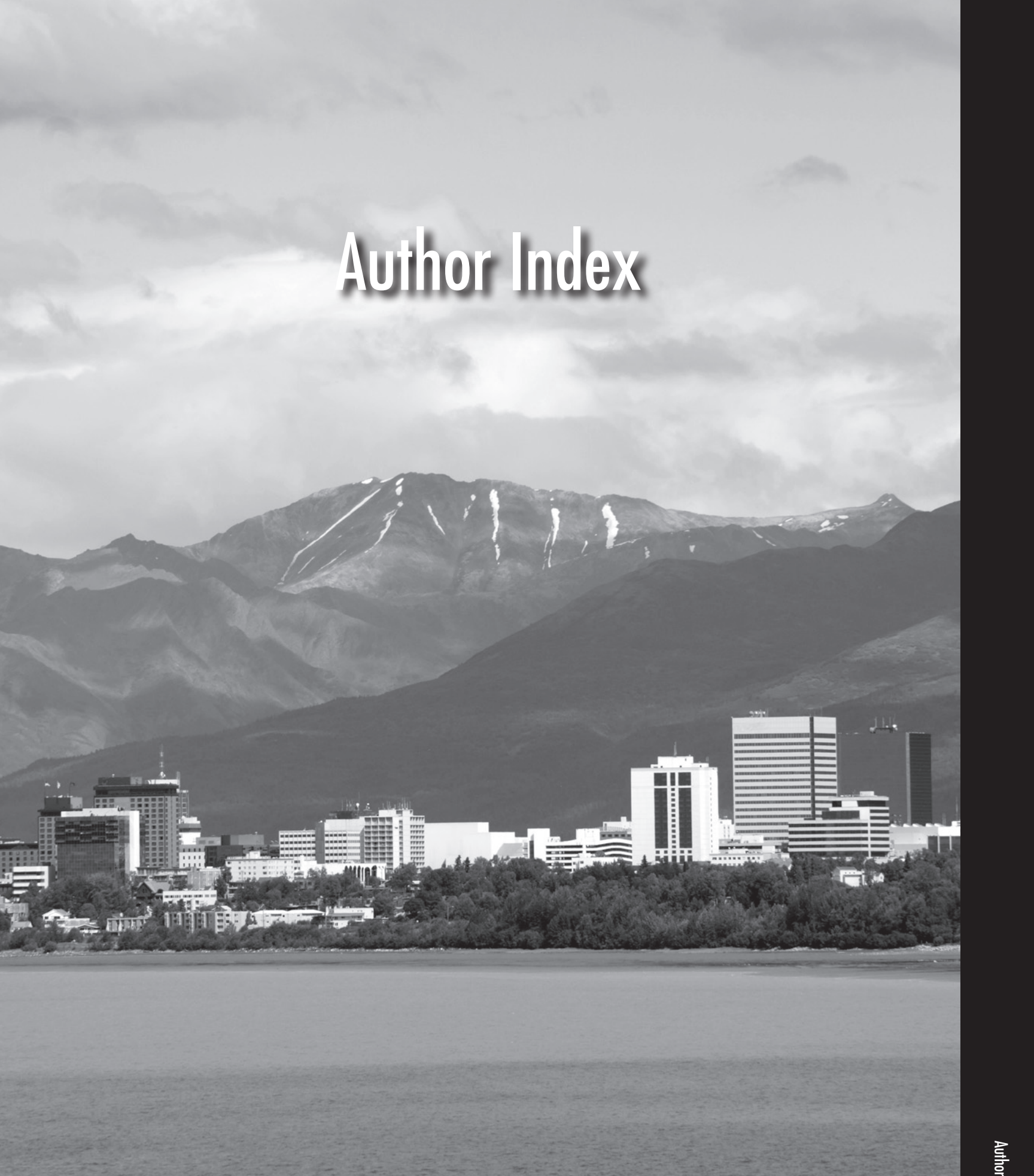
Introduction: Osteoid osteoma (OO) and osteoblastoma (OB) are rare bone tumors in the spine and they tend to occur in the posterior elements. The conventional treatment is open surgical resection and curettage with fluoroscopy guidance. Interventional radiology remains unamenable in certain cases like spinal OO and OB which are close to the spinal cord or peripheral nerves. The aim of this study was to describe the outcome of surgical treatment of spinal OO and OB with the utilization of O-arm compared to the conventional C-arm guidance.

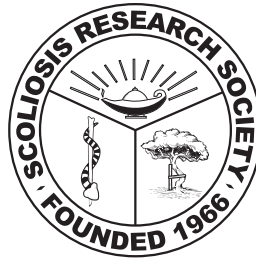
Methods: This retrospective cohort study was conducted to examine all patients with spinal OO or OB who were treated at our institution between 2002 and 2011.

Results: Eighteen patients were examined in this study including 8 with spinal OB (4 boys and 4 girls) and 10 with spinal OO (6 boys and 4 girls). Mean age at surgery was 11.6 ± 3.8 years. All patients presented with back or neck pain, 5 with back or neck stiffness and limited ROM, and 2 had radicular pain. Four patients developed scoliosis with curve magnitude ranged from 21 to 51 degrees and all had spinal OB. Surgical resection was done in 11 patients (4 OB and 7 OO) with C-arm guidance, and 7 patients (4 OB and 3 OO) with O arm guidance. Tumor resection was done via posterior surgical approach and the decision to perform vertebral instrumentation was made based on stability and degree of bone loss after tumor resection. All patients in O-arm group underwent complete tumor resection and complete curettage was confirmed by intraoperative imaging. Surgery time and blood loss were related to surgery extension with no difference between study groups. Two patients developed recurrence of tumor and underwent a second surgery (one in O-arm group who had C2 OO, and one in C arm group who had L3 OO). None of the patients had pain at last follow up. The radiographic evaluation at last follow up did not show any sign of tumor recurrence or vertebral instability following to tumor resection.

Conclusion: O arm is a 3D fluoroscopy technology that allows safe and effective localization of tumor and confirmation of tumor removal during surgery.

Author Index





The Scoliosis Research Society gratefully acknowledges
SpineCraft for support of the Half-Day Courses,
Welcome Reception and Farewell Reception.



AUTHOR INDEX

Abel, Mark F.	122	Attabib, Najmedden	42
Abelin-Genevois, Kariman	1, 103	Ayamga, Jennifer	49, 65, 116
Abjornson, Celeste	280	Ayan, Saankritya	117, CASE 3A, CASE 4C, CASE 4E
Acaroglu, Emre	69, 105	B. R. De Mattos, Camila	303
Agrahari, Ashok K.	298	Bago, Juan	69, 105
Ahituv, Nadav.	72	Bailey, Chris S.	42
Ahmad, Azeem.	84, 221, 224	Bains, Ravi S.	38
Ahn, Henry	42	Balasubramanian, Sriram	LTS
Akazawa, Tsutomu	44, 126	Baldus, Christine R.	84
Akbarnia, Behrooz A.	48, 52, 82, 89, 246	Baldwin, Eric	274
Akoto, Harry	49	Bambarawana Liyanage, Sanka B.	287
Al Maaieh, Motasem	17, 216	Barrios, Carlos	113
Alanay, Ahmet	4, 52, 69, 77, 90, 105, 246, 300, LTS, PMC	Bartley, Carrie E.	100, 128, 267, CASE 1C
Albanese, Stephen	6	Bastrom, Tracey	8, 9, 100, 121, 124, 128, 245, 248
Alberich-Bayarri, Angel	204	Bayley, Edward.	54
Albert, Todd J.	283, HDC	Behrend, Caleb.	263
Alobaidan, Raed M.	233	Bell, Kevin	15
Alvarez, Julie L.	38	Beltran, Andy A.	6
Amaral, Rodrigo A.	219	Benlong, Shi	2, 208
Amaral, Terry D.	117, 213, CASE 2C, CASE 3A, CASE 3B CASE 4C, CASE 4D, CASE 4E	Bennett, James T.	118
Ames, Christopher P.	22, 28, 29, 37, 79, 82, 85, 86, 89, 102, 218, 219, 220, 222, 227, 232, HDC	Bersusky, Ernesto	47
Ames, Robert J.	9, 57, 118	Berven, Sigurd H.	79, HDC, PMC
An, KiChan.	119	Bess, Shay	22, 37, 82, 85, 86, 89, 102, 110, 220, 222, 227, 232, LTS
Anand, Neel	219	Betz, Randal R.	5, 9, 57, 211, 293, CASE 2A, CASE 3D
Andersen, Mikkel	76	Bi, Ni	61, 62, 63, 64, 299
Anderson, Melissa L.	274	Bianco, Kristina	254
Ando, Kei.	278	Binitie, Odion	303
Andras, Lindsay	203, 288	Birkenmaier, Christof	282
Annis, Prokopis.	93, 231	Bjerke-Kroll, Benjamin T.	49, 116
Antón-Rodríguez, Luis Miguel	113	Blakemore, Laurel C.	PMC
Archer, Kristin R.	58	Blanke, Kathy	5, 16
Arima, Hideyuki	127, 225, 289	Blasier, R. D.	LTS
Asazuma, Takashi	229	Boachie-Adjei, Oheneba	23, 37, 49, 60, 65, 79, 82, 89, 107, 116, 271, PMC
Asghar, Jahangir	8, 121, 122, 245, 267, CASE 2A, CASE 3C, CASE 3D, HDC	Bollini, Gérard	14, 111
		Bonete, Daniel	204

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Boniello, Anthony J.	28, 29, 207	Chen, Yongsheng	32
Boriani, Stefano	301	Chen, Yuexin	38
Bosch, Patrick	15	Cheng, Jack C.	11, 56
Brecevich, Antonio T.	280	Cheriyana, Thomas	21, 254
Bridwell, Keith H.	17, 50, 58, 84, 221, 224, 230	Cheung, Kenneth M.	52, 79, 246, HDC, PMC
Brink, Rob C.	56	Chiba, Kazuhiro	70
Briot, Jerome	103	Cho, Kyu-Jung	292
Brochmann, Elsa J.	233	Cho, Robert H.	16
Brodke, Darrel S.	34, 93, 231	Cho, Samuel K.	17, 216
Brooks, Jaysson T.	94, 226	Chou, Dean	301
Bruce, Robert W.	203, 212	Choudhry, Dinesh K.	24
Buchowski, Jacob M.	30, 59, 110, PMC	Choufani, Elie.	14
Bumpass, David B.	50, 221, 224, 230	Christensen, Steen B.	76
Bunger, Cody E.	83	Christie, Sean	42
Burgos, Jesús F.	113	Chu, Winnie C.	11, 56
Burton, Douglas C.	16, 37, 82, 89, 110	Clarke, Michelle J.	301
Burton, Rob	54	Clements, David H.	5, 211
Cahill, Patrick J.	8, 9, 60, 124, 293, CASE 2A, CASE 3C, CASE 3D	Clovis, Nina	81
Caird, Michelle S.	LTS, PMC	Coe, Jeffrey D.	219
Callaghan, John	68	Connolly, James	216
Cammisa, Frank P.	280	Cook, P Christopher	234
Campbell, Robert M.	HDC	Cooperman, Daniel	234
Cao, Jessica	203	Courtois, Isabelle	1
Caprio, Brendan	206	Cowan, Joseph	40
Caridi, John	17	Crawford, Charles H.	110
Carl, Allen L.	6	Cree, Andrew K.	219
Carlson, Brandon B.	16	Cunningham, Matthew E.	23, 107
Carreon, Leah Y.	10, 19, 59, 79, 84, 221, 230	Curtis, Mary R.	40
Carroll, Charlotte.	293	Cutler, Holt	216
Carter, Emma V.	40	Dabney, Kirk W.	253
Cassidy, Jeff.	240	Daffner, Scott D.	81
Castelein, Rene M.	11, 56, 268	Dahl, Benny.	79
Challier, Vincent	95, 239	Daley, Erika	112
Chang, Michael S.	CASE 2E	Dang, Debbie Y.	234
Chazono, Masaaki	286	Danielsson, Aina J.	53, 262, PMC
Chen, Leijie	61, 62, 63, 64, 299	Dankowski, Aygul.	10

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Das, Gurudip	297
Daubs, Michael D.	.93, 219, 231, 233
Davidson, Darin J.	.71
de Kleuver, Marinus	.106
de la Iglesia-Vaya, Maria	.204
Dear, Taylor E.	CASE 1B, CASE 1D
Debnath, Ujjwal K.	296, LTS
Dede, Ozgur	.15
Dekutoski, Mark B.	.79, 301
Demirkiran, Gokhan H.	.52, 218, 246
Demura, Satoru	.7, 31, 241
Desai, Mihir J.	.212
Deviren, Vedat	.82, 89, 218, 220, HDC
DeWald, Christopher	LTS
D'heurle, Albert	.284
Diebo, Bassel G.	.95, 239
Dimar, John R.	.19, HDC, PMC
Doan, Josh	.101
Dolan, Lori A.	3, 75, LTS
Dolotin, Denis	.217
Doménech, Julio	.204
Domenech, Pedro	.113
Domingo-Sàbat, Montse	.69, 105
Dooley, Zachary A.	.96
Dormans, John P.	115, 129, 285, 303, PMC
Douis, Hassan	.260
Doyle, John S.	.25
Dreimann, Marc	.98, 125
Drevelle, Xavier	.1
Drew, Brian M.	.42
Dubousset, Jean	.1
Duggal, Neil	.42
Durbin-Johnson, Blythe	.36
Dvorak, Marcel F.	.42
Dworkin, Aviva G.	.213, CASE 3B
Ebermeyer, Eric	.1
Eckalbar, Walter	.72
Ellison, Matthew	.81
Elsayed, Sherief	.54
Emans, John B.	48, 206, 271, PMC
Emerson, Ronald G.	.116
Emery, Sanford E.	.81
Enercan, Meric	.4, 77, 90, 300
England, Kristin	.99
Erickson, Mark A.	13, 60, 115, 206, 252, PMC
Errico, Thomas J.	.5, 21, 39, 89, 95, 228, 239, 251, 254
Erturer, Erden	.77, 90, 300
Estivalezes, Erik	.103
Eule, James M.	PMC
European Spine Study Group, Essg	.69, 105
Fabris-Monterumici, Daniele	.219
Falcone, Kelly S.	.214
Fallah, Nader	.42
Farley, Frances A.	PMC
Faust, John R.	.263
Fehlings, Michael G.	.42, 79, 301
Ferguson, John A.	.52, 246, 287
Fernandes, Pedro M.	CASE 2B
Ferraris, Luis	.98, CASE 1A
Ferrero, Emmanuelle	.95, 239
Field, Antony	.287
Fillerup, Heather A.	.264
Finkelstein, Joel	.42
Fisher, Charles G.	.42, 301
Fletcher, Nicholas D.	.203, 212
Flynn, John M.	67, 115, 201, 242, 252, 265, 272, LTS
Fotouhie, Azadeh F.	.257
Fourney, Daryl R.	.42
France, John C.	.81, HDC
Francheri, Ida Alejandra	.47
Fu, Kai-Ming	.16
Fujimori, Takahito	.101

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Fuller, Jonathan E.	16	Gupta, Sachin	36
Funao, Haruki	85, 94, 222, 226	Guzman, Javier	216
Futatsugi, Toshimasa	114	Gyurdzhyan, Samvel	215
Gaines, Robert W.	HDC	Ha, Joong Won	119
Galaretto, Eduardo	47	Halanski, Matthew A.	240
Ganju, Aruna	16	Halm, Henry F.	HDC
Gantsoudes, George	261	Hamilton, D. K.	86, 102
Gao, Xiaochong	72	Hamzaoglu, Azmi	4, 77, 90, 300
Gao, Yubo	20, 68, 88, 247	Hans, Sarah D.	234
Garcia, Gracian	204	Hao, Dingjun	295
García, Vicente	113	Hardesty, Christina	48
Gardner, Adrian	260, PMC	Harris, Jessica	38
Garg, Sumeet	13, 60, 206	Harshavardhana, Nanjundappa S.	129, 201, 285
Gates, Marilyn L.	102	Hart, Radek	273
Gavaret, Martine	14	Hart, Robert A.	22, 37, 82, 85, 86, 89, 102, 219, 220, 222, 232
Geddes, Benjamin	203	Hasan, Saqib	207
Gerling, Michael C.	207	Hasegawa, Tomohiko	127, 225, 289
Gilbert, Shawn R.	25	Hashizume, Hiroshi	41
Glaser, Diana A.	101, LTS	Hassan, Nabil	240
Glassman, Steven D.	10, 19, 59, PMC	Hassanzadeh, Hamid	269, PMC
Glotzbecker, Michael	236, 252	Hayashi, Hiroyuki	7, 31, 241
Gokaslan, Ziya L.	301	Hayashi, Tetsuo	233
Gokcen, Bahadir H.	77, 90	Hayes, Kimberly M.	293
Goldstein, Jeffrey A.	21	Heary, Robert F.	16
Gordon, Derek	72	Hedden, Douglas	27
Goto, Takahiro	33	Hedequist, Daniel	PMC
Graat, Harm C.	106	Helenius, Ilkka	291
Grewal, Harsh	57	Hempfling, Axel	98, CASE 1A
Grose, Brian W.	81	Hensinger, Robert N.	PMC
Grossman, Seth A.	213	Hepler, Matthew D.	LTS
Guigui, Pierre	111	Herrera-Soto, Jose A.	16
Gum, Jeffrey L.	50, 59, 84, 221, 224, 230, 243	Herring, John A.	72
Guppy, Kern H.	38	Hesham, Khalid	6
Gupta, Kavita	36	Hess, W. F.	49
Gupta, Munish C.	22, 28, 29, 36, 37, 49, 82, 85, 86, 102, 227, 232, PMC	Hey, Lloyd A.	219, HDC
		Hilibrand, Alan S.	283

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Hill, Douglas L.	27	Iwasaki, Hiroshi	41
Hilt, Suzanne J.	263	Jackson, Roger P.	104
Hirano, Toru	43, 55	Jain, Amit	124, 248, 269
Hiratzka, Jayme R.	102	James, Steven	260
Hollenbeck, Steven M.	122	Jansson, Volkmar	282
Hong-da, Bao	91	Jennings, Jonathan K.	25
Hongo, Michio	258, 294	Jeszszsky, Dezsoe J.	CASE 2B
Hoogendoorn, Roel J.	106	Jianguo, Zhang.	255
Hosman, Allard J.	106	Johnson, Michael G.	42
Hosogane, Naobumi	229	Johnston, Charles E.	45, 51, HDC, PMC
Hostin, Richard	22, 37, 82, 89, 102, 220, 222, 227	Jouve, Jean-Luc	14
Hozumi, Takahiro	33	Jun, Qiao.	91
Hsu, Wellington	112	Kadhim, Muayad	303
Hu, Serena	110, PMC	Kahraman, Sinan	4, 77, 90
Hung, Man	264	Kallur, Antony.	257
Hurlbert, R. John	42	Karikari, Isaac	50, 221, 224, 230
Hwang, Steven W.	118	Karol, Lori A.	LTS, PMC
Iantorno, Stephanie	288	Kasten, Michael D.	219
Ibrahim, Kamal N.	252, PMC	Kasukawa, Yuji.	294
Ikegami, Shota.	114	Kato, Hiroyuki	114
Ikegawa, Shiro.	70, 72, 237	Kato, Satoshi	7, 31, 241
Ilgenfritz, Ryan M.	20, 68	Kato, So	33
Ilharreborde, Brice.	209	Katyal, Chhavi	213
Imagama, Shiro	55, 278	Kawakami, Kazuki	73, 256
Inami, Satoshi	92	Kawakami, Noriaki	43, 44, 55, 70, 73, 237, 256
Inui, Yoshihiro	270	Kebaish, Khaled	22, 79, 85, 94, 222, 226, 227, 232, CASE 4A, CASE 4B, HDC, PMC
Isaacs, Robert E.	96	Kelly, Michael P.	5, 50, 60, 85, 102, 220, 244, 271, PMC
Ishibashi, Yasuyuki	12	Kemppainen, John W.	235
Ishiguro, Naoki	278	Keshen, Sam	CASE 1B, CASE 1D
Ishii, Takayoshi.	31	Keskinen, Heli	291
Ishikawa, Yoshinori	294	Kessler, Jeffrey.	215
Issa, Daniela	69	Khoury, Joseph.	25
Itabashi, Taito	12	Kilic, Mesut	4, 300
Ito, Kenyu	278	Kim, Hak-Sun.	119
Ito, Manabu.	43, 55, 70, 123, 237	Kim, Han Jo.	23, 28, 29, 49, 58, 85, 86, 107, 232
Ito, Zenya	278		

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Kim, JinHyok	292	Lai, Sue Min	71
Kim, Sang D.	221, 230	Lam, Tsz-ping	11, 56
Kim, Yongjung J.	17	Lao, Lifeng	233
Kim, Young-Tae	292	Laouissat, Féthi	111
Kimball, Jeff S.	57, 118	Larson, A. Noelle	16, 74, 99, 275
King, Andrew G.	LTS	Lau, Darryl	219
King, Skye	257	Lau, Leok-Lim	259
Kishan, Shyam	261	Lavelle, William	6, 16
Klineberg, Eric	28, 29, 37, 82, 85, 86, 102, 220, 227, 232	Lawrence, Brandon	34, 93, 231
Kobayashi, Kazuyoshi	278	Lazarus, David E.	203, 212
Kobayashi, Sho	127, 225, 289	Lebel, David E.	276
Kobayashi, Tetsuya	223	Lebwohl, Nathan H.	PMC
Kohler, Remi	1	Ledonio, Charles Gerald T.	99, 110
Koller, Heiko	98, 123, 125, 210, 238, CASE 1A	Lee, Byung Ho	119
Kono, Katsuki	70, 237	Lee, Jung-Hee	219, 292
Kopjar, Branko	79	Lee, Seung Yeol	292
Korhonen, Katariina	291	Lee, Stella	261
Koski, Tyler	86, 232, PMC	Lehman, Ronald A.	5, 67, 245, 272
Kostuik, John	PMC	Lehovskiy, Jan	40
Kotani, Toshiaki	43, 44, 70, 126, 237	Lenke, Lawrence G.	5, 10, 17, 26, 50, 58, 59, 60, 79, 107, 221, 224, 230, 243, 244, 252, 271, HDC, LTS, PMC
Kou, Ikuyo	72, 237	Leong, Julian J.	40
KSRG, Keio Spine Research Group	229	Lewis, Noah D.	CASE 1B, CASE 1D
Kudo, Daisuke	258, 294	Lewis, Stephen J.	79, 252, CASE 1B, CASE 1D
Kularatane, Udara	260	Li, Chenshuang	233
Kulkarni, Preethi M.	CASE 2C, CASE 3B, CASE 4C, CASE 4D	Li, Tao	61, 62, 63, 64, 299
Kumagai, Gentaro	12	Li, Yawei	233
Kumar, Naresh S.	32, 302	Li, Zheng	249
Kuraishi, Shugo	114	Liabaud, Barthelemy	95, 239
Kwan, Kenny	52, 246	Lieberman, Isador	LTS
Kwon, Brian K.	42	Line, Breton	37
LaBella, Cynthia	112	Liu, Hongbo	LTS
Labelle, Hubert	211	Liu, Shian	95, 239
Lafage, Renaud	95, 227, 239	Liu, Zhen	2, 91, 208
Lafage, Virginie	21, 22, 28, 29, 37, 82, 85, 86, 89, 95, 220, 222, 227, 232, 239	Liu, Zhou	61, 62, 63, 64, 299
LaGrone, Michael O.	219	Loder, Randall T.	261

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Löfdahl-Hällerman, Kerstin	53, 262	Mehdian, Hossein	54, 79, LTS
Londono, Douglas	72	Mehlman, Charles T.	214, 284
Lonner, Baron S.	8, 9, 39, 78, 87, 110, 211, 251, 254, 271, 277, 290	Mehrkens, Arne	CASE 1B
Lonstein, John	HDC	Mehta, Jwalant S.	260, HDC
Lou, Edmond H.	27	Meier, Oliver	98, 123, 125, 210, 238, CASE 1A
Luhmann, Scott J.	50, 252	Melcher, Carolin	282
Lukkarinen, Heikki	291	Mendoza, Marco	112
Luo, T. David	275	Mendoza-Lattes, Sergio A.	68, 88, 247
Machida, Masafumi.	229	Menendez, Mariano E.	234
Mac-Thiong, Jean-Marc	42, 211	Menga, Emmanuel N.	269
Maeda, Shugo	12	Mesfin, Addisu	84
Mahmud, Rufai M.	49	Mikhailovsky, Mikhail	217, 279
Maier, Stephen P.	254	Miller, Freeman	253
Maitra, Sukanta	36	Miller, Nancy H.	115
Majid, Kamran	38	Miller, Ryan	120
Mao, Saihu	2, 208	Mina, Curtis A.	23
Marascalchi, Bryan J.	228	Minami, Shohei	43, 44, 55, 70, 126, 237
Mardjetko, Steven M.	108	Minamide, Akihito.	41
Marks, David S.	48, 260, PMC	Misaghi, Amirhossein.	101
Marks, Michelle C.	9, 67, 124, 128, 245, 248, 272, LTS	Misawa, Akiko	258, 294
Marti-Bonmati, Luis	204	Mitsunaga, Lance K.	38
Martin, Christopher T.	20, 68, 88, 247	Miyake, Atsushi	70
Matsumoto, Hiroko	242, 252, 265	Miyakoshi, Naohisa.	294
Matsumoto, Morio	55, 70, 72, 229, 237	Miyajiri, Firoz	8, 9, 122, 248, 267
Matsumoto, Tomohiro	278	Modhia, Urvij	248
Matsuyama, Yukihiko.	79, 127, 225, 278, 289	Mogulevitch , Marina	CASE 2C
Mayer, Michael.	98, 210, 238, CASE 1A	Mohapatra, Anand	244
Mazda, Keyvan	95, 111, 209, 239	Montgomery, Scott R.	233
McAtee, Donna R.	214	Moon, Seong-Hwan	119
McCalla, Daren J.	265	Moreau, Marc J.	27
McCarthy, Ian.	22, 222	Morgan, Jessica V.	264
McCarthy, Richard E.	48, LTS	Moridaira, Hiroshi	92
McClung, Anna M.	45, 51, 97	Muchow, Ryan D.	45
McIntosh, Amy L.	275	Mukaiyama, Keiji	114
McLeod, Lisa	115	Mummaneni, Praveen V.	HDC
McManus, Anne	104	Mundis, Gregory M.	22, 28, 29, 37, 85, 86, 96, 222, 232

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Murakami, Hideki	7, 31, 241
Muramoto, Akio	278
Murray, Samuel S.	233
Mutlu, Ayhan	90
Myung, Karen S.	261
Naef, Floreana A.	85, 94, 222, 226, CASE 4A, CASE 4B
Nakagawa, Yukihiko	41
Nakashima, Hiroaki	278
Nandyala, Sreeharsha V.	250
Negrini, Stefano	124
Neiss, Geraldine I.	259
Nelson, Ian W.	16
Nemani, Venu M.	23, 49, 107, 116
Nene, Abhay	281
Neuman, Brian J.	58, 107
Newton Ede, Matthew P.	260
Newton, Peter O.	5, 8, 9, 67, 100, 101, 122, 124, 128, 211, 245, 248, 267, 271, 277, CASE 1C, HDC, LTS, PMC
Ng, Bobby K.	11
Niazi, Ahtsham U.	CASE 1B
Nishi, Hideto	41
Nishnianidze, Tristan	78
Niswander, Cameron	13, 206
Nnadi, Colin	52, 246
Noel, Mariano A.	47
Nohara, Ayato	73
Nohara, Yutaka	92
Noonan, Vanessa	42
Noordeen, Hilali H.	HDC
Norheim, Elizabeth P.	10
Novikov, Vyacheslav	279
Núñez Pereira, Susana	123
Obeid, Ibrahim	105
O'Brien, Michael F.	22
Odent, Thierry	111
O'Donnell, Courtney M.	71
Oetgen, Matthew E.	PMC
Ogura, Yoji	70, 237
Ohara, Tetsuya	73
Ohe, Makoto	92
Okada, Eijiro	229, 237
Olson, John C.	236
O'Neill, Kevin R.	58, 107, 221, 230
Ono, Atsushi	12
Oswald, Timothy S.	203
Ota, Kyotaro	73
O'Toole, Patrick	303
Ovadia, Dror	276
Owen, Robert J.	203
Ozturk, Cagatay	4, 77, 90, 300
Pace, Gregory I.	252
Padegimas, Eric	283
Pahys, Joshua M.	9, 57, 293, CASE 2A, CASE 3C, CASE 3D
Pan, Zhaoxing	13, 206
Paonessa, Kenneth J.	219
Papadopoulos, Elias C.	49, CASE 2D
Paquet, Jerome	42
Parent, Stefan	8, 42, 100, 211, PMC
Park, Howard Y.	265
Pascual Leone, Alvaro	204
Passias, Peter G.	28, 29, 207, 228
Patel, Alpesh A.	112
Patel, Nick	212
Patel, Sujal	253
Paterson, Andrew J.	257
Paul, Justin C.	39, 87, 251
Paulino, Carl B.	21, 254
Pawełek, Jeff	48
Paxton, Liz W.	38
Pekmezci, Murat	218
Pelletier, Glenn J.	57
Pellise, Ferran	49, 69, 79, 105

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Pereira, Maria das Gracas C.	36
Perez-Caballero, Cesar.	113
Perra, Joseph H.	PMC
Pesenti, Sebastien.	14
Petcharaporn, Maty.	245
Phan, Kevin H.	233
Phillips, Lee.	8
Piantoni, Lucas.	47
Pilkahn, Christian.	123
Piza Vallespir, Gabriel.	113
Place, Howard M.	16
Poe-Kochert, Connie.	48
Polly, David W.	18, 74, 99, 110, PMC
Popovski, Neron.	77, 300
Pourtaheri, Sina.	253
Protopsaltis, Themistocles S.	28, 29, 86, 95, 220, 232, 239
Pruszczynski, Blazej A.	78
Pugely, Andrew J.	20, 68, 88, 247
Qian, Bangping.	2, 208
Qiu, Xing.	234
Qiu, Yong.	2, 79, 91, 208, HDC
Quraishi, Nasir A.	301
Radcliff, Kris E.	283
Rahm, Mark D.	102
Rahman, Ra'Kerry K.	243
Raj, Saloni.	298
Raja-Rahman, Nisha.	243
Rajasekaran, S.	109, 297, HDC, PMC
Ramo, Brandon A.	PMC
Rampy, Patricia L.	120
Raso, James V.	27
Rathjen, Karl E.	16
Rawlins, Bernard A.	23
Ray, Wilson Z.	244
Reaserch Associates, FOCOS.	116
Redding, Gregory.	HDC, PMC
Reighard, Fredrick G.	101
Remondino, Rodrigo G.	47
Ren, Yuan.	277, 290
Rhines, Laurence D.	301
Richards, B. Stephens.	252, PMC
Rihn, Jeffrey A.	283
Ritzman, Todd F.	235
Rivers, Carly S.	42
Roach, James W.	15, LTS
Robinson, Chessie.	22
Rogers, Kenneth J.	24, 78, 253, 268
Rose, Peter S.	301
Ross, Thomas.	23
Rothenfluh, Dominique A.	54
Roussouly, Pierre.	111
Roye, David P.	252, 265
Ruangchainikom, Monchai.	233
Ruf, Michael.	PMC
Russo, Scott S.	LTS, PMC
S. Pérez-Grueso, Francisco J.	49, 69, 105, CASE 2D
Sabatino, Meagan.	261
Sacks, Karen.	24
Sacramento-Dominguez, Cristina.	49, 65
Saito, Toshiki.	43, 73
Sakuma, Tsuyoshi.	44, 126
Sales de Gauzy, Jerome.	103, 111
Samdani, Amer F.	5, 8, 9, 57, 60, 118, 211, 245, 267, 271, 293, CASE 2C, CASE 3C, CASE 3D
Sanders, James O.	110, 234, 252, 263, HDC, PMC
Sanli, Tunay.	4, 77
Sanpera, Ignacio.	113
Sarkissian, Eric J.	201
Sarwahi, Vishal.	117, 213, CASE 2C, CASE 3A, CASE 3B, CASE 4C, CASE 4D, CASE 4E
Savage, Jason W.	112
Scheer, Justin K.	28, 29, 86, 220, 227, 232

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Schimmel, Janneke J.	106	Silvestre, Clément.	111
Schlösser, Tom P.	11, 56, 268	Simony, Ane.	76
Schmücker, Jens A.	98	Sinclair, Sarina.	34
Schoenleber, Scott.	121	Singer, Lewis P.	213
Schröder, Christian.	282	Singla, Anuj.	118
Schroeder, Gregory D.	112	Skaggs, David L.	203, 242, 252, 288, HDC
Schroeder, Joshua E.	280	Skalli, Wafa.	1
Schueler, Beth A.	275	Skolasky, Richard L.	94, 226
Schulte, Tobias L.	98	Skovrlj, Branko.	17, 216
Schwab, Frank J.	21, 22, 28, 29, 37, 79, 82, 85, 89, 95, 102, 220, 222, 227, 232, 239, LTS, PMC	Smith, John T.	252, 264, HDC
Schwend, Richard M.	250, PMC	Smith, Justin S.	22, 28, 29, 37, 82, 86, 89, 102, 110, 220, 222, 227, 232, PMC
Sciubba, Daniel M.	86, 220, 232	Snyder, Brian D.	236
Scott, Trevor P.	233	Song, Kit.	252, HDC
Seckin, Mustafa F.	4, 300	Soroceanu, Alex.	28, 29, 89
Sengupta, Dilip K.	LTS	Sorokin, Artem.	279
Seo, Jeong Ho.	119	Sparagana, Steven.	120
Sethi, Rajiv K.	274	Spiker, William R.	34, 93, 231
Shaffrey, Christopher I.	22, 28, 29, 37, 79, 82, 86, 89, 102, 220, 227, 232, HDC, PMC	Spilsbury, Jonathan.	260
Shah, Suken A.	8, 24, 78, 122, 211, 248, 252, 253, 259, 267, 268, 271, 277, 283, 290, HDC	Sponseller, Paul D.	122, 124, 248, 252, 267, 269, 271, HDC, PMC
Shannon, Claire.	48	Srivastava, Rajeshwar N.	298
Sharma, Shalu.	83	Stans, Anthony A.	275
Sharma, Swarkar.	72	Stokes, Oliver M.	54
Shaughnessy, William J.	74	Strodtbeck, Wyndam M.	274
Shen, Jianxiong.	46, 249	Study Group, Children's Spine.	265
Shetty, Ajoy P.	297	Study Group, Growing Spine.	48, 265
Shi, Zhiyue.	61, 62, 63, 64, 299	Study Group, Harms.	121, 124, 128
Shiba, Yo.	92	Study Group, International Spine.	22, 28, 29, 37, 82, 85, 86, 89, 102, 220, 227, 232
Shimada, Yoichi.	258, 294	Sucato, Daniel J.	10, 26, 51, 60, 97, 120, 252, 271, PMC
Shimizu, Masayuki.	114	Sudo, Hideki.	70, 123, 237
Shin, Dong-Eun.	119	Sugarman, Etan P.	CASE 4E
Shinjo, Ryuichi.	278	Sugawara, Ryo.	73
Shufflebarger, Harry L.	9, 60, 67, 121, 211, 245, 271, CASE 3C	Sugrue, Patrick A.	50, 221, 224, 230
Sides, Brenda A.	50, 60, 271	Sun, Xu.	2, 91, 208
Siemionow, Kris.	108	Sun, Yong.	62

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Suprano, Isabelle	.14	Trupia, Evan P.	.265
Suzuki, Teppei	.43, 44, 55, 70, 237, 270	Tsai, Eve C.	.42
Suzuki, Yoshitaka	.73	Tsuchiya, Hiroyuki	.7, 31, 241
Sweet, Fred A.	.35	Tsuji, Taichi	.43, 44, 55, 70, 73, 237
Swider, Pascal	.103	Tsutsui, Shunji	.41
Swindell, Hasani W.	.265	Turner, Alexander W.	.96
Takahashi, Atsushi	.72	Turner, Chad M.	.261
Takahashi, Jun	.114	Tyrakowski, Marcin	.108
Takahashi, Shinji	.233	Tysklind, Robert G.	.261
Takahashi, Yohei	.70, 237	Ukai, Junichi	.278
Takeshita, Katsushi	.55	Ulusoy, Onur Levent	.4
Takeuchi, Daisaku	.92	Uno, Koki	.43, 44, 55, 70, 237, 270
Takimura, Kosuke	.73	Upasani, Vidyadhar V.	PMC
Talu, Ufuk	.300	Vaccaro, Alexander R.	.283
Tamkus, Arvydas A.	.18	Van Hessem, Lotte	.106
Tan, Jonathan	.302	van Stralen, Marijn	.11, 56
Tanaka, Takaaki	.286	Vanushkina, Maria A.	.71
Tanaka, Toshihiro	.12	Varga, Peter P.	.301
Taneichi, Hiroshi	.55, 70, 92, 237	Vasyura, Alexandr	.279
Tao, Huiren	CASE 2E	Vergari, Claudio	.1
Tauchi, Ryoji	.73	Verma, Kushagra	.259, 283, 290
Tello, Carlos A.	.47	Verma, Satyendra	.283
Theologis, Alexander A.	.218	Verma, Vivek	.30
Thirugnanasambandam, Senthilnathan	.290	Vernengo-Lezica, Alejo	.16
Thompson, Alistair G.	PMC	Verska, Joseph M.	.16
Thompson, George H.	.48	Vila-Casademunt, Alba	.69, 105
Thornhill, Beverly	.117	Vincken, Koen L.	.11, 56, 268
Tian, Haijun	.233	Vital, Jean-marc	.95, 239
Togawa, Daisuke	.127, 225, 289	Vitale, Michael G.	.242, 252, 265, HDC, PMC
Tohmeh, Antoine G.	.96	Wada, Kanichiro	.12
Tolo, Vernon T.	PMC	Wagner, Theodore A.	.71
Toombs, Courtney	.87	Wai, Khin L.	.302
Tormos, Jose M.	.204	Wang, Cheng	.15
Toyama, Yoshiaki	.70, 237	Wang, Jeffrey C.	.233
Tran, Dong-Phuong	.26, 51	Wang, Yan	.66
Trobisch, Per D.	.219	Wang, Yingsong	.61, 62, 63, 64, 299

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

AUTHOR INDEX

Wanner, Matthew R.	261	Yazici, Muharrem	52, 246
Watanabe, Kota	55, 70, 229, 237	Yokogawa, Noriaki	7, 31, 241
Wegener, Bernd	282	Yoneoka, Daisuke.	205
Weidenbaum, Mark.	71, HDC, PMC	Yonezawa, Ikuho	55, 70, 237
Weinstein, Stuart L.	3, 20, 68, 75, 88	Yorgova, Petya	78, 259
Wernli, Karen J.	274	Yoshida, Munehito	41
Wetpitiyakul, Pumibal	36	Yoshihara, Hiroyuki	205
Wientroub, Shlomo.	276	Yoshioka, Katsuhito.	7, 31, 241
Winkler, Jennifer A.	275	Zaw, Aye Sandar	32, 302
Wise, Carol	72	Zebala, Lukas P.	85, 244
Wolff, Sarah	214	Zeller, Reinhard D.	PMC
Wollowick, Adam L.	117, 213, CASE 2C, CASE 3A, CASE 3B, CASE 4C, CASE 4D, CASE 4E	Zenner, Juliane.	98, 125, 210, 238
Wong, Hee-Kit	32	Ze-zhang, Zhu	2, 91, 208
Woon, Regina P.	242	Zhang, Wei	233
Wright, Bettye	49	Zhang, Ying	61, 62, 63, 64, 299
Wright, Margaret L.	242, 252	Zhang, Yonggang	66
Wulff, Irene	49	Zhao, Ke-Wei	233
Wyatt, Zane.	HDC	Zhao, Zhi.	61, 62, 63, 64, 299
Xie, En	80, 266, 295	Zheng, GuoQuan.	66
Xie, Jingming.	61, 62, 63, 64, 299	Zhu, Feng	91, 208
Xue, Xuhong	46	Zuchelli, Daniel.	116
Yagi, Mitsuru	49, 65, 229		
Yamada, Hiroshi	41		
Yamaguchi, Toru	43		
Yamakawa, Kiyofumi	33		
Yamamoto, Takuya.	55		
Yamato, Yu	127, 225, 289		
Yamazaki, Ken	55		
Yanagida, Haruhisa.	43, 55, 70, 237		
Yang, Justin S.	30		
Yang, Sun	207		
Yarrell, Crista	287		
Yasuda, Tatsuya	127, 225, 289		
Yaszay, Burt.	8, 100, 122, 128, 267, 277, CASE 1C		
Yaszemski, Michael J.	74, 99		

PRESENTATION KEY: 1-129=Paper/Podium Presentations 200-306=E-Posters PMC=Pre-Meeting Course CASE=Case Discussion LTS=Lunchtime Symposium HDC=Half-Day Course

ABOUT SRS

Founded in 1966, the Scoliosis Research Society is an organization of medical professionals and researchers dedicated to improving care for patients with spinal deformities. Over the years, it has grown from a group of 35 orthopaedic surgeons to an international organization of more than 1,200 health care professionals.

MISSION STATEMENT

The purpose of Scoliosis Research Society is to foster the optimal care of all patients with spinal deformities.

MEMBERSHIP

SRS is open to orthopaedic surgeons, neurosurgeons, researchers and allied health professionals who have a practice that focuses on spinal deformity.

Candidate Fellowship (membership) is open to all orthopaedic surgeons, neurosurgeons and to researchers in all geographic locations who are willing to commit to a clinical practice which includes at least 20% spinal deformity. Candidate Fellows stay in this category for five years, during which time they must meet all of the requirements and demonstrate their interest in spinal deformity and in the goals of the Society. After five years, those who complete all requirements are eligible to apply for Active Fellowship in the Society. Candidate Fellowship does not include the right to vote or hold office. Candidate Fellows may serve on SRS committees.

Active Fellowship (membership) requires the applicant to have fulfilled a five-year Candidate Fellowship and have a practice that is 20% or more in spinal deformity. Only Active Fellows may vote and hold elected offices within the Society.

Associate Fellowship (membership) is for distinguished members of the medical profession including nurses, physician assistants, as well as orthopaedic surgeons, neurosurgeons, scientists, engineers and specialists who have made a significant contribution to scoliosis or related spinal deformities who do not wish to assume the full responsibilities of Active Fellowship. Associate Fellows may not vote or hold office, but may serve on committees.

See website for membership requirement details and application:
www.srs.org/professional/membership

SRS MEMBERSHIP INFORMATION SESSION

Join us and learn more about the Scoliosis Research Society, including:

- How to Apply
- Benefits of Membership
- Leadership Opportunities
- Scholarships
- Networking
- Education

The information session will take place during the networking lunch on Thursday, September 11 from 12:30 – 1:30 PM in Tikanmu CF.

PROGRAMS AND ACTIVITIES

SRS is focused primarily on education and research; Programs include the Annual Meeting, the International Meeting on Advanced Spine Techniques (IMAST), Hands-On Courses, Worldwide Conferences, a Global Outreach Program, the Research Education Outreach (REO) Fund (which provides grants for spine deformity research) and development of patient education materials.

WEBSITE INFORMATION

For the latest information on SRS meetings, programs, activities and membership, please visit www.srs.org. The SRS Website Committee works to ensure that the website information is accurate, accessible and tailored for target audiences. Site content is varied and frequently uses graphics to stimulate ideas and interest. Content categories include information for medical professionals, patients/public and SRS members.

For more information, please visit the SRS website at www.srs.org.

SOCIETY OFFICE STAFF

Tressa Goulding, CAE, CMP – Executive Director (tgoulding@srs.org)
Katie Agard – Meetings Manager (kagard@srs.org)
Shahree Douglas, MS – Communications & Program Manager (sdouglas@srs.org)
Courtney Kissinger – Executive Assistant (ckissinger@srs.org)
Ashtin Kitzerow – Program Manager (akitzerow@srs.org)
Cydni Schaeffler – Meetings Manager (cschaeffler@srs.org)
Stephanie Tesch – Education Manager (stesch@srs.org)
Nilda Toro – Membership Manager (ntoro@srs.org)

SCOLIOSIS RESEARCH SOCIETY

555 East Wells Street, Suite 1100
Milwaukee, WI 53202
Phone: +1-414-289-9107
Fax: +1-414-276-3349
www.srs.org

BOARD OF DIRECTORS, COUNCILS, COMMITTEES & TASKFORCES

BOARD OF DIRECTORS

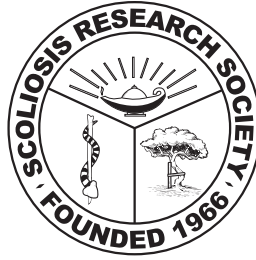
Steven D. Glassman, MD – President
John P. Dormans, MD – President-Elect
David W. Polly, Jr., MD – Vice President
Hubert Labelle, MD – Secretary
Mark Weidenbaum, MD – Secretary-Elect
Paul D. Sponseller, MD – Treasurer
Kamal N. Ibrahim, MD, FRCS(C), MA – Past President I
B. Stephens Richards, III, MD – Past President II
Todd J. Albert, MD – Director
David H. Clements, III, MD – Director
Muharrem Yazici, MD – Director
Laurel C. Blakemore, MD – Director
Munish C. Gupta, MD – Director
Stefan Parent, MD, PhD – Director
Kenneth M.C. Cheung, MD – Research Council Chair
Frank J. Schwab, MD – Research Council Chair-Elect
Daniel J. Sucato, MD, MS – Education Council Chair

COUNCIL CHAIRS

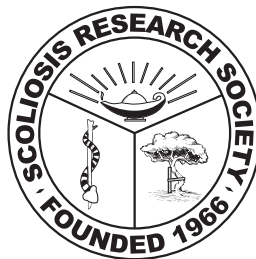
Education Council Daniel J. Sucato, MD, MS
Finance Council Paul D. Sponseller, MD
Governance Council Hubert Labelle, MD
Research Council Kenneth M.C. Cheung, MD

COMMITTEE & TASKFORCE (TF) CHAIRS

Adult Deformity Lloyd A. Hey, MD, MS
Advocacy and Public Policy Baron S. Lonner, MD
Awards and Scholarship J. Michael Wattenbarger, MD
BrAIST Response TF Michael T. Hresko, MD
Bylaws and Policies Jeffrey D. Coe, MD
CME Frank J. Schwab, MD
Coding Christopher J. DeWald, MD
Corporate Relations Kamal N. Ibrahim, MD, FRCS(C), MA
Development John R. Dimar, II, MD
Education Lori A. Karol, MD
E-Text Praveen Mummaneni, MD
Ethics & Professionalism Richard E. McCarthy, MD
Evidence Based Medicine TF (2) Douglas C. Burton, MD
Evidence Based Medicine TF (1) James O. Sanders, MD
50th Anniversary TF Behrooz A. Akbarnia, MD
Fellowship Hilali M. Noordeen, FRCS
Finance Paul D. Sponseller, MD
Global Outreach Hossein Mehdian, MD, FRCS(Ed)
Globalization Lawrence G. Lenke, MD
Growing Spine David L. Skaggs, MD
Historical Behrooz A. Akbarnia, MD
IMAST Christopher I. Shaffrey, MD
Long Range Planning Kamal N. Ibrahim, MD, FRCS(C), MA
Morbidity & Mortality Howard M. Place, MD
Newsletter John P. Lubicky, MD, FAAOS, FAAP
Nominating Kamal N. Ibrahim, MD, FRCS(C), MA
Non-Operative Management Michael T. Hresko, MD
Patient Education Robert P. Huang, MD
Pediatric Device TF Michael G. Vitale, MD
Program James O. Sanders, MD
Public Relations Allen L. Carl, MD
Research Grant Andrew G. King, MD
Scoliosis Screening TF Hubert Labelle, MD
3D Scoliosis Carl-Eric Aubin, PhD
Surgical Safety TF Kit M. Song, MD
Translation Munish C. Gupta, MD
Website Anthony S. Rinella, MD
Worldwide Conference Marinus DeKleuver, MD, PhD



The Scoliosis Research Society gratefully acknowledges
Mazor Robotics for support of the Annual Meeting Breakfasts.



The Scoliosis Research Society gratefully acknowledges Stryker Spine for
their overall support of the 49th Annual Meeting & Course.

stryker[®]

Spine

Meeting Agenda

Tuesday, September 9, 2014

7:00 AM – 5:00 PM	SRS Committee Meetings
1:00 – 5:00 PM	Hibbs Society Meeting
2:00 – 6:00 PM	Registration Open
7:00 – 10:00 PM	SRS Leadership Dinner (by invitation only)

Wednesday, September 10, 2014

6:30 AM – 6:00 PM	Registration Open/ Internet Kiosks, E-Posters Open
7:45 – 11:55 AM	Pre-Meeting Course – Morning Sessions
12:10 – 1:10 PM	Lunchtime Symposia
1:20 – 4:30 PM	Pre-Meeting Course – Afternoon Sessions
4:45 – 5:45 PM	Case Discussions
6:00 – 7:15 PM	Opening Ceremonies
7:15 – 9:00 PM	Welcome Reception

Thursday, September 11, 2014

6:30 AM – 4:30 PM	Registration Open/ Internet Kiosks, E-Posters Open
6:30 – 7:45 AM	Members Business Meeting/ Non-Members Continental Breakfast
7:30 – 10:00 AM	Spouse Hospitality Suite (at Captian Cook)
7:55 AM – 12:30 PM	Scientific Program
12:30 – 1:30 PM	Lunch & Networking for Half-Day Course Participants Member Information Session
1:30 – 4:30 PM	Half-Day Courses

Friday, September 12, 2014

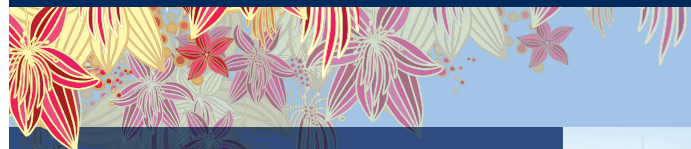
6:30 AM – 5:15 PM	Registration Open/ Internet Kiosks, E-Posters Open
6:30 – 7:45 AM	Members Business Meeting/ Non-Members Continental Breakfast
7:30 – 10:00 AM	Spouse Hospitality Suite (at Captian Cook)
7:55 – 11:50 AM	Scientific Program
12:00 – 1:00 PM	Lunchtime Symposia
1:15 – 5:15 PM	Scientific Program
7:00 – 10:00 PM	Farewell Reception

Saturday, September 13, 2014

6:30 AM – 12:45 PM	Registration Open/ Internet Kiosks, E-Posters Open
6:30 – 7:45 AM	Members Business Meeting/ Non-Members Continental Breakfast
7:30 – 10:00 AM	Spouse Hospitality Suite (at Captian Cook)
7:55 AM – 12:45 PM	Scientific Program



Scoliosis Research Society
presents...



IMAST2015

22nd International Meeting on
Advanced Spine Techniques

JULY 8–11, 2015 • KUALA LUMPUR, MALAYSIA



Supported by:

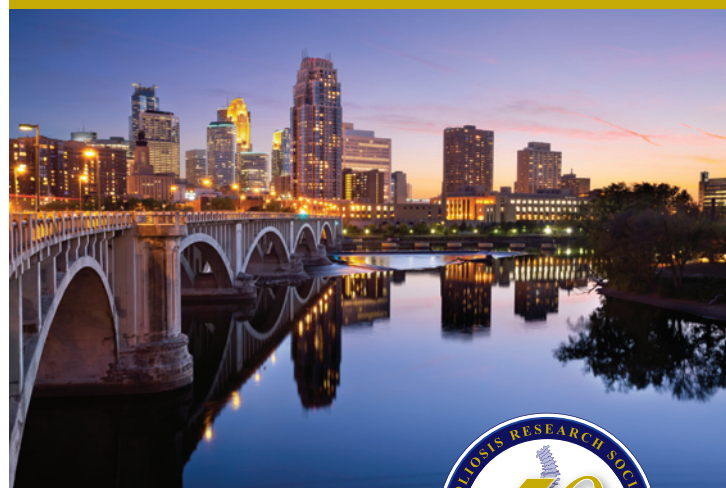


www.srs.org

Abstract submission open – November 1, 2014

Abstract deadline – February 1, 2015

Registration Open – February 2015



50th
ANNUAL MEETING & COURSE



September 30–October 3, 2015

MINNEAPOLIS, MINNESOTA, USA