



FINAL PROGRAM

Scoliosis Research Society 45TH ANNUAL MEETING & COMBINED COURSE

September 21-24, 2010 • Kyoto, Japan
Kyoto International Conference Center



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RESEARCH SOCIETY AND THE AMERICAN
ACADEMY OF ORTHOPAEDIC SURGEONS





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We are pleased to acknowledge and thank those companies that provided financial support to SRS in 2009. Support levels are based on total contributions throughout the year and include the Annual Meeting, IMAST, Worldwide Conferences, Global Outreach Scholarships, Edgar Dawson Memorial Scholarships, SRS Traveling Fellowships and the Research Endowment Fund. Their support has helped SRS to offer high quality medical meetings and courses throughout the world, fund spinal deformity research, develop new patient materials, and provide educational opportunities for young surgeons and those from developing nations.

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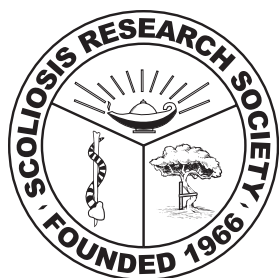
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SRS Mission Statement

The purpose of the Scoliosis Research Society is to foster the optimal care of all patients with spinal deformities.

Future SRS Educational Events

Annual Meeting & Course

September 14-17, 2011 – Louisville, Kentucky, USA

International Meeting on Advanced Spine Techniques (IMAST)

July 13-16, 2011 – Copenhagen, Denmark

Worldwide Conferences

For more information on the worldwide conferences and all upcoming events, please visit the SRS web site at www.srs.org.

Scoliosis Research Society

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Nilda Toro – Membership Manager

President's Message



The Scoliosis Research Society is privileged to be able to hold the 45th Annual Meeting in the lovely and historic center of Japan Kyoto. For those of you traveling to the Far East for the first time, I feel confident you will find the time spent traveling to this exotic location worthwhile and rewarding. The Kyoto International Conference Center is easily accessible via a short, direct, and efficient subway ride from the area hotels.

The Combined Pre-Meeting Course with the Japanese Society for Spine Surgery and Related Research has appropriately chosen as its topic "Cervical Spine: A Multinational Approach". The chairmen, Dr. Kuniyoshi Abumi of Japan and Dr. Daniel Riew of the US have assembled an incredibly knowledgeable faculty to address a challenging and important topic on the day prior to the meeting.

The Opening Ceremonies on Tuesday evening be led by myself and our gracious host, Dr. Nobumasa Suzuki and we will be entertained with an intriguing lecture, "Zen and Sake-Forbidden yet Inseparable Relationship" by Revered Daiko Matsuyama, a Buddhist monk who is an authority in this area. We will also honor Dr. Jean Dubosset for his broad contributions to mankind, especially in the area of understanding spinal deformities. He will receive the prestigious Blount Award in recognition for his achievements. With traditional Japanese fanfare, we will begin the festivities with entertainment by the SRS Band and libations.

The Program Committee, under the strong guidance of Dr. Michael Yazemski and Dr. Noriaki Kawakami, has assembled an academic program that promises to be very informative and educational. The lunchtime symposium will discuss "The Effect of Osteoporosis on Surgery in Adult Deformity Patients" on Tuesday at the Pre-Meeting Course, and on Wednesday, two symposia will be available to choose from: "Current Concepts: Is There Value in School Screening in AIS?" or "Navigation and Image Guidance, Role in Spine Surgery." Additionally, on Thursday, an Instructional Course Lecture will be offered for a small fee on "Growing Spine Surgery: Options, Tips/Techniques and Results".

We are very pleased and honored to have Dr. Kiyoshi Kaneda as our Harrington Lecture on Wednesday morning addressing "The Role of Anterior Reconstruction Surgery in Treatment of Scoliosis and Thoracolumbar Spinal Fractures." This is a topic dear to Dr. Kaneda who has played a pivotal role in the history of Japanese spinal surgery and influences spinal surgeons throughout the world.

A celebratory dinner will take place on Thursday evening at the Westin Miyako where our Local hosts have assembled a must-see cultural event with lots of local color and flare, followed by an evening of music and dancing. In spite of characterizing this as the Farewell Dinner, the academic program will continue on Friday morning with the transfer of the SRS Presidency to Dr. Lawrence Lenke.

All members are encouraged to attend the Business Meetings Wednesday through Friday to support and share in the workings of your society.

This year's meeting promises to be an incredibly exciting meeting and venue location. The schedule has been set up to allow for maximum enjoyment of the enchanting surroundings and all of Japan. Be sure to experience the Nightingale floor home protection system at the Palace and close your eyes to highlight your senses in the many lovely gardens. Have an enjoyable and memorable time in Kyoto.

This is my last official communication as your President. I want each of you to know how honored I am to have had this opportunity to serve as the President of this great organization. Watching the inner workings of SRS through its members has made me aware that the power to spread healing world-wide is awe inspiring!

With warmest regards,

A handwritten signature in black ink that reads "Richard E. McCarthy, MD".

Richard E. McCarthy, MD
SRS President

2009 – 2010 Board Of Directors



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Director



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Director



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Director

Annual Meeting Committees

Local Host Committee

Chair:

Nobumasa Suzuki, MD, PhD

Members:

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Katsuji Shimizu (JSS President 2010)
Joji Mochida (JSS President 2009)
Kensei Nagata (JSS President 2011)
Yukihiro Matsuyama
Shouhei Minami
Kuniyosi Abumi
Manabu Ito
Hideo Hosoe
Morio Matsumoto
Koki Uno
Noriaki Kawakami
Masato Tanaka
Katsuki Kono

Advisors:

Tosinobu Onomura
Kiyosi Kaneda
Yoshiharu Takemitsu
Hirosi Yamamoto

Program Committee

Co-Chairs:

Noriaka Kawakami, MD, Co-Chair
Michael J. Yaszemski, MD, PhD, Co-Chair

Members:

Laurel C. Blakemore, MD, Chair-Elect
Peter O. Newton, MD, Past Chair
Todd J. Albert, MD
R. Haluk Berk, MD
Andrew M. Casden, MD
Patrick J. Connolly, MD
William F. Donaldson, III, MD
Marinus de Kleuver, MD
Lawrence G. Lenke, MD
Peter S. Rose, MD
Daniel J. Sucato, MD, MS

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Michael Albert, MD
Todd Albert, MD
Elizabeth Ames, MD
Eric Buchl
Michael Daubs, MD
Ujjwal Debnath, FRCS
Mark Dekutoski, MD
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Brian Hsu, MD
Paul Huddleston, III, MD
Henry Iwinski, Jr., MD
Khaled Kebaish, MD
Timothy Kuklo, MD, JD
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Stephen Lewis, MD, MSc, FRCS
Sean Molloy, MBBS, MSc, FRCS
Praveen V. Mummaneni, MD, UCSF
Greg Mundis, Jr., MD
Michael O'Brien, MD
Brian O'Shaughnessy, MD
Kenneth Paonessa, MD
Steve Richards, III, MD
Michael Roh, MD
Yutaka Sasao, MD
Suken Shah, MD
Hawart Singh, MD
Brian Smith, MD
Joseph Verska, MD

Education Committee

Chair:

Joseph H. Perra, MD, Chair

Members:

Kamal N. Ibrahim, MD, Chair Elect
Allen W. Carl, MD, Past Chair
Ahmet Alanay, MD
Phillip S. Anson, MD
Mark Dekutoski, MD
John R. Dimar, II, MD
Lawrence L. Haber, MD
Eric T. Jones, MD
Noriaki Kawakami, MD
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Paul D. Sponseller, MD
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Michael J. Yaszemski, MD, PhD

Combined Course Japanese Program Committee

Kuniyosi Abumi, MD
Manabu Ito, MD
Morio Matsumoto, MD
Yutaka Nohara, MD
Toshihiko Yamashita, MD

We are pleased to acknowledge and thank the following Japanese Partners



CME and Disclaimer Information

Meeting Description

The Scoliosis Research Society Annual Meeting & Combined Course is a forum for the realization of the Society's mission and goals, the improvement of patient care for those with spinal deformities. Presentations at the Annual Meeting & Combined Course are given by leading experts in the field and have value for health care professionals who treat spinal deformities at all levels and in all ages. Over 100 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

At the conclusion of the SRS 45th Annual Meeting and Combined Course, participants should be able to:

- 1) Recognize and address factors which may contribute to higher complication rates or risk of reoperation in children and adults with spinal deformities;
- 2) Incorporate pre- and peri-operative steps that may help to avoid complications in spinal deformity surgery in children, adolescents and adults;
- 3) Assess clinical and radiographic factors that contribute to positive or negative outcomes in spinal deformity surgery;
- 4) Improve treatment plans for patients with spinal deformity through a better understanding of long term results from various options;
- 5) Understand the relationship between spinal deformity treatments and quality of life, including body image in adolescent scoliosis, as perceived by patients.

Target Audience

Presentations at the SRS Annual Meeting and Combined 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.

Physician Accreditation

American Academy of Orthopaedic Surgeons (AAOS) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to sponsor continuing medical education for physicians.

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 joint sponsorship of the American Academy of Orthopaedic Surgeons (AAOS) and Scoliosis Research Society (SRS). The AAOS is accredited by the ACCME to provide

continuing medical education for physicians. The AAOS designates this educational activity for a maximum of 22.5 *AMA PRA Category 1 Credits™* (7.5 credits for the Pre-Meeting Combined Course and 15 for the Annual Meeting). Physicians should only claim credit commensurate with the extent of their participation in the activity.

Disclosure

It is the policy of AAOS and SRS to ensure balance, independence, objectivity, and scientific rigor in all its educational activities. All faculty participating in our programs are expected to disclose any relationships they may have with commercial companies whose products or services may be mentioned, so that participants may evaluate the objectivity of the presentations. In addition, any discussion of off-label, experimental, or investigational use of drugs or devices will be disclosed by each of the faculty members.

The SRS does not view the existence of these disclosed interests or commitments as necessarily implying bias or decreasing the value of the author's participation in the Annual Meeting & Combined Course.

CME Certificates

CME Certificates will be available immediately upon the close of the meeting at www.srs.org/professionals/meetings/am10.

Delegates should log onto the website listed above and enter their last name and the ID# listed at the top of the Annual Meeting registration confirmation form. The system will then ask delegates to indicate which sessions they attended, to complete evaluation forms for each of those sessions, and then generate a PDF certificate which may be printed or saved. Session attendance and evaluation information are saved in the database, and certificates may be assessed again, in the event the certificate is lost or another copy is required.

Please note that certificates will not be mailed or e-mailed after the meeting. The online certificate program is the only source for this documentation. If you have any questions, please visit the Registration Desk, or e-mail the SRS office at meetings@srs.org.

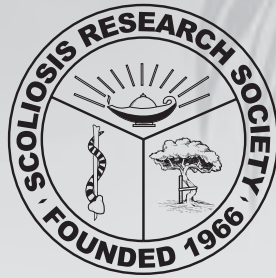
Disclaimer

The material presented at the SRS Annual Meeting 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 background features a light gray gradient with faint, stylized line art of bamboo stalks and cherry blossom branches. A vertical dark gray bar on the right side contains white line art of bamboo stalks and cherry blossom branches, creating a layered effect.

GENERAL MEETING INFORMATION



The Scoliosis Research Society gratefully acknowledges K2M for their support of the Final Program, E-Poster Kiosks, E-Posters on Disc, Message Board, and Electronic Newsletter.



General Meeting Information

Abstract Volume

All abstracts accepted for presentation at the 45th Annual Meeting have been published in the Final Program (pages 51-172). Each attendee will receive one copy of the program along with their registration materials. Abstracts have also been posted online at www.srs.org.

Guest Hospitality Room

Due to the large number of hotels being used by delegates in Kyoto, there will be no hospitality room offered this year. We encourage spouses, partners, and friends of SRS meeting attendees to plan any gatherings in advance.

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 time inside the Kyoto International Conference 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 Instructional Course Lecture requires a ticket for admission. Tickets for this session are not included in the meeting's regular registration fees, but are available for an additional \$30. Tickets will be collected at the door by ushers. A limited number of tickets may be available, inquire at the Registration Desk.

In addition, tickets will be required for admission to the Farewell Dinner. The Farewell Dinner will take place at the Westin Miyako Hotel at an additional \$25 fee. If you pre-registered, tickets may be found in your registration packets. A limited number of tickets may be available at the Registration Desk.

Tickets are required for optional tours and activities, and the cost of tour tickets is in addition to the delegate or guest registration fee. If you pre-registered for a tour, tickets may be found in your registration packet. There may be a limited number of tickets for tours available at the Registration Desk, in the event a delegate or guest has chosen not to attend a tour.

Attire

Business casual (polo or dress shirts, sport coats) is appropriate for meeting sessions and for the Welcome Reception. The Farewell Dinner is black tie optional.

Business Center

The Kyoto International Conference Center offers self-serve, pay-per-use, business services. It is available for the duration of the Annual Meeting. Services include printing, copying, and faxing.

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 Kyoto International Conference 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.

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.

Guest Attendance

Adults and children over the age of 10 may register as guests to attend the social events (Welcome Reception and Farewell Dinner). Tickets for these events must be requested at the time of registration. For those guests who have pre-registered and requested social event tickets, these tickets can be found in the delegate's registration packet. Guests may register and request social event tickets at the Registration Desk. Registered guests are also able to participate in optional tours, at an additional fee, although pre-registration for tours is required.

Internet Kiosks

Location: Sakura

Attendees can search the Internet and check e-mail at the Internet kiosks, supported by a grant from Trans1.

Tuesday, September 21 – 07:00 – 18:00

Wednesday, September 22 - 06:30 – 16:00

Thursday, September 23 - 06:30 – 13:00

Friday, September 24 - 06:30 – 12:30

Wireless Internet access is available in the Registration Area outside the Main Hall.

Language

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

Lost & Found

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

General Meeting Information

Members Business Meetings

Location: Annex Hall

All SRS members, including Candidates, are encouraged to attend the Members' Business Meetings on Wednesday, September 22 through Friday, September 24 from 06:30 – 07:40 in the Annex Hall. Committee Chairs will share their reports, as well as reports from the SRS Traveling Fellows and Edgar Dawson Scholarship recipients. A hot breakfast buffet will be served.

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 by a grant from K2M.

Non-Members Continental Breakfast

Location: Sakura

All non-members are invited to meet with their colleagues and network over coffee and a continental breakfast on Wednesday, September 22 through Friday, September 24 from 06:30 – 07:40.

A Membership Information Session will be presented on Thursday, September 23 in the Main Hall from 07:00 – 07:40.

Photography Policy

SRS will be taking photographs throughout the Annual Meeting & Combined 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.

Cameras are not permitted in any Annual Meeting & Combined Course educational session or in the poster area.

Poster Hall Location & Hours

Location: Sakura

Wednesday, September 22 - 06:30 – 16:00

Thursday, September 23 - 06:30 – 13:00

Friday, September 24 - 06:30 – 12:30

E-Posters may be viewed on monitors located in Sakura or from your own laptop using the CD-ROM provided with your registration materials, courtesy of K2M.

Registration Desk Location & Hours

Location: Main Hall Lounge

Monday, September 20 – 11:00 – 17:00

Tuesday, September 21 - 07:00 – 18:00

Wednesday, September 22 - 06:30 – 16:00

Thursday, September 23 - 06:30 – 13:00

Friday, September 24 - 06:30 – 12:30

Smoking Policy

Smoking is not permitted during any meeting activity or event.

Speaker Presentation Upload

Location: Main Hall, Back Center of Room

All podium presentations must have been uploaded to the On-line Speaker Ready Room and reviewed by the SRS CME Committee in advance of the meeting. However, if presenters wish to make small changes to their presentations onsite, they may do so at the back of the Main Hall, in the general session room.

IMPORTANT: Only small changes will be allowed. New presentation files may not be uploaded to replace the files that have been reviewed by the CME committee.

Monday, September 20 - 14:00-18:00

Tuesday, September 21 - 07:00 – 18:00

Wednesday, September 22 - 06:30 – 16:00

Thursday, September 23 - 06:30 – 14:00

Friday, September 24 - 06:30 – 12:00

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.

Tour Information

Delegates and guests, including adults and children ages 10 and up, are able to attend optional tours. Tickets are required to participate in the tours and must have been requested at the time of pre-registration. Any tour tickets purchased will be included with the delegate's registration packet. Additional tour tickets may be available at the Registration Desk, in the event a delegate or guest has chosen not to attend a tour. For more information on tours, including a complete schedule, please see page XX.

Venue Information

The Kyoto International Conference Center is the location for the 45th Annual Meeting & Combined Course:

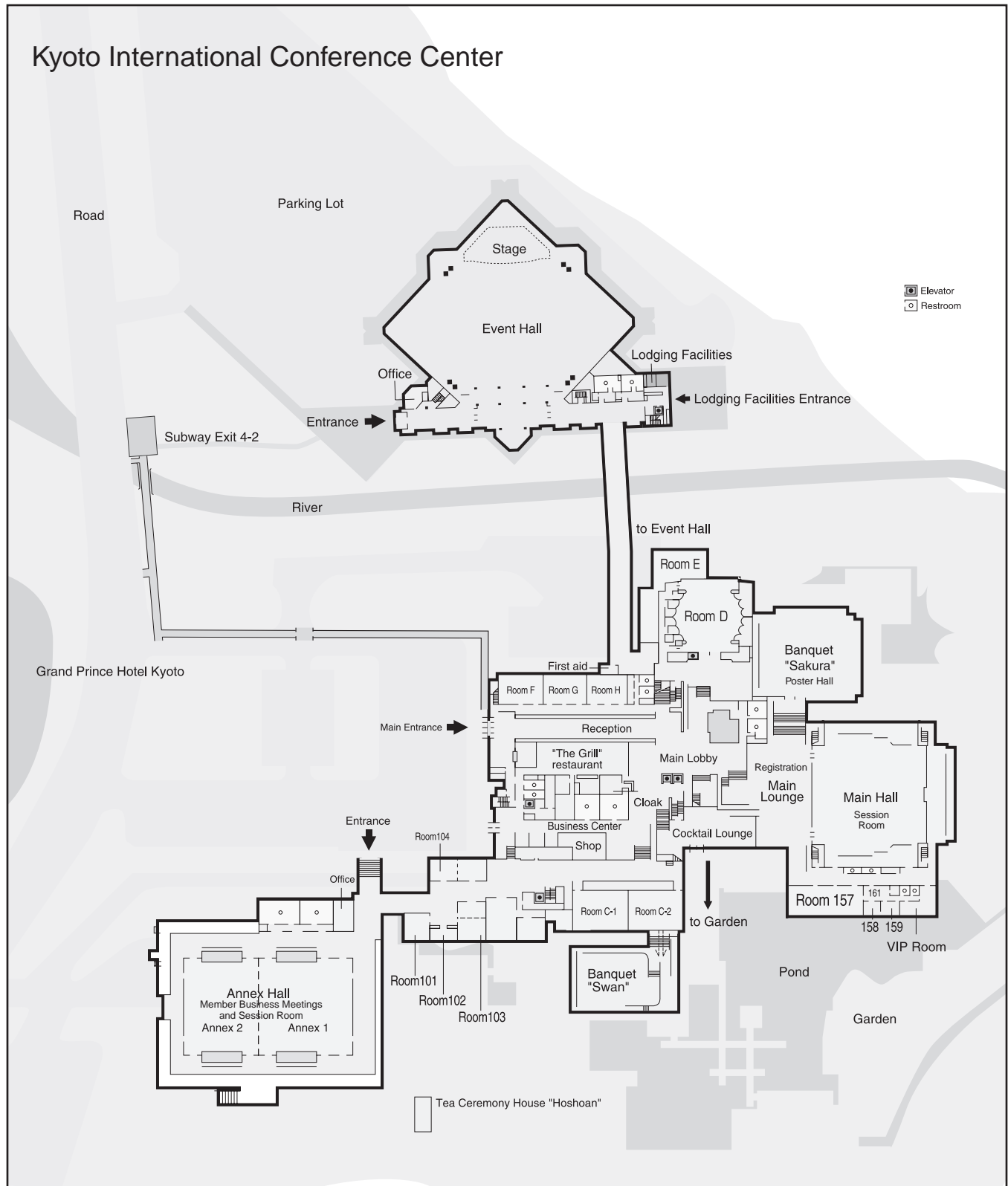
Kyoto International Conference Center (ICC Kyoto)

Takaragaike, Sakyo-ku, Kyoto 606-0001 Japan

Phone 81-75-705-1234 Fax 81-75-705-1100

<http://www.icckyoto.or.jp/en/>

Venue Floor Plans



Main Lounge: Registration Desk

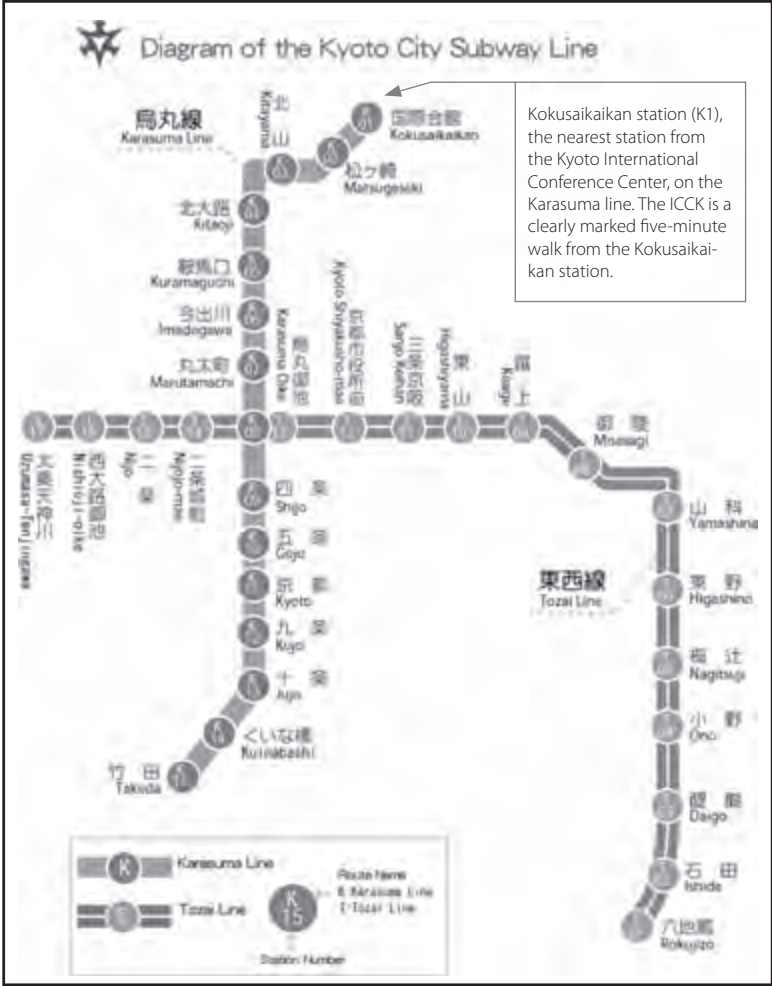
Sakura: Posters, Internet Kiosks, and Non-Member Breakfast

Room D: Hibbs Society Meeting

Main Hall: Pre-Meeting Combined Course, Scientific Sessions, Educational Symposium, and Instructional Course Lecture

Annex Hall: Members' Business Meeting, Concurrent Educational Symposium

Kyoto City Subway Map



The Kyoto International Conference Center (ICCK) is also easily accessible while in Kyoto using their clean, safe and dependable subway system. From Kyoto station (K11) participants travel quickly and easily to Kokusaikaikan station (K1), the nearest station from the Kyoto International Conference Center, on the Karasuma line. The ICCK is a clearly marked five minute walk from the Kokusaikaikan station. Trains depart every 4-10 minutes and travel time from Kyoto station is 20 minutes. Fare: JPY 280.

Most conference hotels will also be located within a short walk of subway stops.

Conference Subway Pass

Each SRS Annual Meeting attendee is offered a subway pass compliments of the Japanese Organizing Committee. Each pass will be valid for any three days during the period of September 20 – 27, 2010.

Please pick up your subway pass at the ICCK, SRS Registration Desk located in the Main Lounge. Limit one pass per attendee; please show your name badge for pick-up.

Meeting Outline

Monday, September 20, 2010

07:00 - 17:00	Board of Directors Meeting
11:00 - 17:00	Registration Open
12:00 - 17:00	Hibbs Society Program
18:00 - 22:00	SRS Leadership Dinner (by invitation only)

Tuesday, September 21, 2010

07:00 - 18:00	Registration Open
08:00 - 18:00	Poster Set-Up by Authors
08:00 - 18:00	Pre-Meeting Combined Course – Cervical Spine: A Multinational Approach
09:45 - 15:00	Nishiki Market and Japanese Cooking Class
12:00 - 17:00	Kyoto World Heritage Tour
12:35 - 13:35	Lunch Break
12:45 - 13:30	Lunchtime Symposium The Effect of Osteoporosis on Surgery in Adult Deformity Patients
18:00 - 19:00	Opening Ceremonies
19:00 - 21:00	Welcome Reception

Wednesday, September 22, 2010

06:30 - 16:00	Registration Open
06:30 - 16:00	Poster & E-Posters, Internet Kiosks Open
06:30 - 07:40	Members Business Meeting Breakfast
06:30 - 07:40	Non-Members Continental Breakfast
07:55 - 16:52	Scientific Sessions
08:30 - 16:30	Arashiyama and Saga Walking Tour
09:00 - 18:00	Kyoto Day Tour Famous Castles, Temples, and Historic Sites
12:00 - 16:00	Japanese Gardens Tour
12:15 - 13:15	Lunch Break
12:25 - 13:10	Lunchtime Symposia — Navigation and Image Guidance Role in Spine Surgery Current Concepts: Is There Value in Scoliosis Screening in AIS?

Thursday, September 23, 2010

06:30 - 13:00	Registration Open
06:30 - 13:00	Poster & E-Posters, Internet Kiosks Open
06:30 - 07:40	Members Business Meeting Breakfast
06:30 - 07:40	Non-Members Continental Breakfast and Informational Session
08:00 - 12:30	Scientific Sessions
08:30 - 16:30	Arashiyama and Saga Walking Tour
12:00 - 17:00	Kyoto World Heritage Tour
12:00 - 17:30	Japanese Fushimi Sake Brewery Tour
12:30 - 14:30	Instructional Course Lecture Growing Spine Surgery: Options, Tips/Techniques and Results
18:00 - 23:00	Farewell Dinner

Friday, September 24, 2010

06:30 - 12:30	Registration Open
06:30 - 12:30	Poster & E-Posters, Internet Kiosks Open
06:30 - 07:40	Members Business Meeting Breakfast
06:30 - 07:40	Non-Members Continental Breakfast
08:00 - 12:25	Scientific Sessions
09:00 - 17:00	Nara Tour
12:30 - 16:00	Optional Activity: Kyoto Handicraft Center (Shuttle departs at 12:45, 13:45 and 15:45)
13:00 - 16:00	Board of Directors Meeting

Guest Lecturers

Howard Steel Lecturer



Tuesday, September 21, 2010

Revered Daiko Matsuyama

Zen and Sake—Forbidden Yet Inseparable Relationship

Revered Daiko Matsuyama was born in 1978 in Kyoto, Japan. In 2001 he received a BSc in Sake and Food Systems from The University of Tokyo and in 2003 achieved his M.Agric. from The University of Tokyo, specializing in Multi-functionality of Agriculture.

From 2003 to 2006 he trained at the Heirinji Zen Monas, where he completed a pilgrimage of walking back from Monastery to Taizoin after training (400miles). In 2006, Revered Daiko Matsuyama was appointed Deputy Priest of Taizoin zen temple in Kyoto. He hosted a G8 Summit Sherpa Meeting in 2008 and in 2009 was appointed as Yokoso! Japan National Goodwill Ambassador.

Harrington Lecturer



Wednesday, September 22, 2010

Kiyoshu Kaneda, MD

The Role of Anterior Surgery in Treatment of Scoliosis and Thoracolumbar Spinal Fractures

Kiyoshu Kaneda was born September 7, 1936 and graduated from Hokkaido University School of Medicine, Sapporo, Japan in 1962. In 1963 he finished his internship at Kyoto University Hospital (M.D) and in 1967 finished the post graduate course in Orthopedics (PhD) at Hokkaido University Postgraduate School of Medicine, Sapporo, Japan. Dr. Kaneda began his work at the Department of Orthopaedic Surgery, Hokkaido University in 1968 and in 1973 became the visiting clinical fellow under Prof. John E. Hall at The Children Hospital Medical Center, Harvard Medical School, Boston, USA. In 1974 he was the visiting clinical fellow under Prof. John Moe and Dr. Robert B. Winter at The Twin Cities Scoliosis Center, Minneapolis, Minnesota, USA and became Associate Professor at the Department of Orthopaedic Surgery, Hokkaido University School of Medicine in 1976. Dr. Kaneda joined the SRS in 1983 and in 1986 he was appointed Professor & Chairman of the Department of Orthopaedic Surgery, Hokkaido University. In 2000 Dr. Kaneda retired from his position as Professor at Hokkaido University School of Medicine and became the Director of Hokkaido Central Labor Hospital-Spinal Cord Injury Center; he retired from this position in 2008. Dr. Kaneda is currently an adviser at Orthopaedic Hokushin Hospital, Sapporo, Japan. In addition to the SRS, Dr. Kaneda is a member of the International Society for the Study of the Lumbar Spine (President 1996-97), American Academy of Orthopaedic Surgeons, and Japanese Orthopaedic Association (President 1997). He won the Orthopaedic Research Society's Arthur B. Steindler Award in 2000 and the International Society for Study of the Lumbar Spine's Wiltse Lifetime Achievement Award in 2004.

Lifetime Achievement Awards

The 2010 Lifetime Achievement Awards will be presented Friday, September 24. 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.



Clyde L. Nash, Jr., MD, MS MedEd

Clyde Lester Nash, Jr. graduated Amherst College 1955; Western Reserve School of Medicine 1962; Case Western Reserve University Orthopaedics 1968; Spine fellowship in 1969 with Drs. John Moe, Jacqueline Perry, Vernon Nichol, and Anders Langenskiold. He

joined the CWRU Orthopaedic Department in 1969 where he founded its first Spine Center, pioneered the technique of SSEP spine cord monitoring and established the Ohio school-screening program. He joined SRS in 1972, (president 1982). In 1981, Dr. Nash became the chairman of Surgery, St. Luke's Hospital of Cleveland and in 1999 chairman of Orthopaedics, MetroHealth Medical System where he established an Orthopaedic Learning Center for the CWRU program and served as Senior VP of Medical Affairs, Associate Dean at CWRU School of Medicine. In 2005 The Clyde L. Nash, Jr., MD endowed chair of Orthopaedic Education was established at CWRU SOM based at MetroHealth. He was an associate editor, *JBJS*, and reviews for *Spine*. Dr. Nash currently serves as Professor Emeritus at Case Western Reserve University School of Medicine. He has served on numerous community boards and organizations; Cleveland Opera (President), Apollo's Fire (baroque), Habitat for Humanity, Allen and MetroHealth Medical Libraries, Leadership Cleveland and has been a commissioner for two local villages. Dr. Nash and his wife of 55 years, Deb, have three children and eight grandchildren. In his spare time, he writes poetry.



John P. Kostuik, MD

Born in 1937 in Northern Canada, John P. Kostuik graduated medical school in 1961, Queen's University Kingston Ontario, Canada. Residency at University of Toronto 1961-1967. Certified in Orthopaedics in 1967. Faculty University of Toronto 1968-1991. Professor

(full) 1986 University of Toronto. Johns Hopkins University, Baltimore, Professor Orthopaedics/ Neurosurgery 1991-2004. President SRS 1987. President NASS 1991.

Awards: R.I.Harris 1967 Best Resident Orthopaedics, University of Toronto. McLaughlin Travelling Fellow Europe, 1968-69. ABC Travelling Fellow, 1975. Hibbs Award, SRS 1998. Selby Award, NASS. Wiltse Award, NASS. Johnston Award Johns Hopkins 1999. Senior Travelling Fellow Asia, SRS 1998.

Member SRS, NASS, CSRS, ISSLS, Canadian Orthopaedic Association, American Orthopaedic Association, Japanese Orthopaedic Association, Belgian Orthopaedic Association, Ecuadorian Ortopaedic Association.

Published 125 peer reviewed papers. Trained 125 fellows in spine. Visiting Professor 35 countries. 2009 SRS Harrington Lecturer.

Educational Events

Pre-registration is required for all Educational Events and space is limited. Instructional Course Lectures and the Hibbs Society program require tickets for admission. Tickets for these sessions are not included in the meeting's regular registration fees. Tickets will be collected at the door by ushers. There may be a limited number of tickets for sale at the Registration Desk.

Monday, September 20

Hibbs Society Program

12:00-17:00 - Room D

Over the years, the Russell A. Hibbs Society, a group formed in 1947 as an international travel club for continuing medical education and furthering orthopaedic knowledge, has held an educational meeting preceding or following the SRS Annual Meeting. These meetings address difficult and complex issues that do not lend themselves to the usual kind of scientific presentations. The meeting encourages interaction among international participants and new ideas, new concepts and reports on personal experience. The topics for the 2010 Hibbs Society program are "Diagnosis and Non-Operative and Operative Management of High-Grade Spondylolisthesis and Spondyloptosis" and "Diagnosis, Prevention and Management of DVT and PE During and Following Spinal reconstruction."

Tuesday, September 21

Lunchtime Symposium: The Effect of Osteoporosis on Surgery in Adult Deformity Patients

12:45-13:30 - Main Hall

John R. Dimar, MD, Chair

This session will cover evaluation, issues and management options in the treatment of patients with osteoporosis and adult deformities.

Planning Surgery in the Osteoporotic Adult Spinal Deformity Population

John R. Dimar, MD

Osteoporotic Compression Fractures of the Spine—Conservative vs. Intervention—What Does the Current Outcome Data Show?

Manabu Ito, MD

Adult Degenerative Scoliosis Indications in the Osteoporotic Spine—Indications for Surgical Management

Khaled Kebaish, MD

Questions and Discussion

Wednesday, September 22

Concurrent Lunchtime Symposium

12:25-13:10 - Main Hall

Navigation and Image Guidance Role in Spine Surgery

Mark Dekutoski, MD and Lawrence L. Haber, MD, Co-Chairs

This session will cover the description of current options, applications, indications and experience of use of navigation tools in spine deformity surgery

Introduction to Mechanics/Set up/Functionality

Mark Dekutoski, MD; Lawrence L. Haber, MD; David W. Polly, Jr., MD

Potential Benefits

David W. Polly, Jr., MD

Limitations

Lawrence L. Haber, MD

Case Examples

Mark Dekutoski, MD; Lawrence L. Haber, MD; David W. Polly, Jr., MD

Literature Based Data and Summary

Concurrent Lunchtime Symposium

12:25-13:10 - Annex Hall

Current Concepts: Is There Value in Scoliosis Screening in AIS?

Kenneth MC Cheng, MD, Chair

This session will review the latest evidence of the effect of scoliosis screening and the effect of its discontinuation in those countries where it has been practiced and has been discontinued. The role and outcome of bracing on screened individuals will also be discussed.

Scoliosis Screening—Why It's at Risk to be Discontinued in the USA

B. Stephens Richards, III, MD

Status of Scoliosis Screening in Asia: Japan

Noriaki Kawakami, MD

Status of Scoliosis Screening in Asia: Hong Kong

Keith Luk, MD

Efficacy and Cost Effectiveness of School Screening in Hong Kong

Daniel Fong, MD

Canadian Experience Before and After the Discontinuation of School Screening

Hubert Labelle, MD

Current Evidence for Bracing in AIS

John Lonstein, MD

Discussion

Educational Events

Thursday, September 23

Instructional Course Lecture

12:30-14:30 – Main Hall

Growing Spine Surgery: Options, Tips, Techniques & Results
Paul D. Sponseller, MD, Chair

This instructional course lecture will discuss various options for management of the growing spine. Both VEPTR and growing rods will be discussed. Experience experts will discuss their preferred techniques for handling problem situations.

Introduction

Paul D. Sponseller, MD

Basic Principles of Growing Spine

Charles E. Johnston, MD

Classification of Growing Spine Treatments and My Decision Algorithm

David L. Skaggs, MD

Non-Operative Treatment: Casting, Bracing and Traction—Indications, Techniques, Tips & Results

James O. Sanders, MD

VEPTR Guru: My Indications, Techniques, Tips & Results

Robert M. Campbell, Jr., MD

Growing Rod Guru: My Indications, Techniques, Tips & Results
Behrooz A. Akbarnia, MD

Novel Growing Spine Options and the Future of Growing Approaches

David L. Skaggs, MD

Case Discussion

Social Events & Tours

Additional fees are required for most social events. All attendees, guests, including children over the age of 10 must be pre-registered in order to participate. Tickets will not be available onsite.

Tuesday, September 21 • 18:00 – 21:00

Opening Ceremonies & Welcome Reception

Location - Opening Ceremonies: ICCK Main Hall;
Welcome Reception: ICCK Swan and Garden

The Annual Meeting will officially begin with Opening Ceremonies and the Howard Steel Lecture, presented by Reverend Daiko Matsuyama. The evening will include an introduction of the SRS officers, acknowledgement of Corporate Partners, honored presidents from other spine societies, and Kyoto culture. All guests are invited and encouraged to attend the Opening Ceremonies, followed by a hosted reception featuring heavy hors d'oeuvres, cocktails, and reunions with colleagues and friends. The Welcome Reception is supported by grants from Medtronic and Trans1. Attire for both events is business casual.

Tuesday, September 21 • 09:45 – 15:00

Nishiki Market and Japanese Cooking Class

The La carrière Cooking School has an 80-year history in Kyoto, with modern facilities. A qualified cooking instructor will demonstrate the making of Japanese cuisine.

Following the cooking class and lunch, you will visit the Kyoto Nishiki market. Shopkeepers at the Food Market, sometimes known as the "Kitchen of Kyoto," rise early to sell fish, meat, dried foods, side dishes, yuba (tofu skin), and Kyoto vegetables on the 400 meter path from Teramachi to Takakura.

Tuesday, September 21 • 12:00 – 17:00

Thursday, September 23 • 12:00 – 17:00

Kyoto World Heritage Tour

This world heritage course will take participants to beautiful Mt. Hiei's Enryaku-ji Temple. Enryaku-ji Temple is said to be one of the main spiritual centers of Japanese culture. An ancient monastery complex atop Mt. Hiei-zan, it is a richly atmospheric place with old temples and artifacts, misty ravines and towering cedars, and a long, fascinating history. It is a marvelous place to visit, combining choice hiking (and great views) with a chance to explore an important site of Japanese history. The tour will then proceed to Ginkaku-ji Temple, a temple belonging to the Buddhist Shokoku School of the Rinzaï Zen sect. Ginkaku-ji Temple (The Silver Pavilion) is an elegant temple set in beautiful grounds at the foot of Kyoto's eastern mountains. Its grounds are an outstanding example of Japanese landscape architecture. Whether one is sitting on the landing beside the unique sand garden with its 2-metre silver cone, or walking the trail and catching glimpses of the Pavilion from different vantage points, one is constantly aware of the lovely details which move the heart. This tour does not include lunch, please plan accordingly.

Social Events & Tours

Wednesday, September 22 • 08:30 – 16:30
Thursday, September 23 • 08:30 – 16:30

Arashiyama & Saga Walking Tour

This walking tour will take you to various Temples, through the Sagano Bamboo Grove, and over the Togetsukyo Bridge. Jakko-in Temple is a convent with a long history. Located north of Kyoto near the village of Ohara, the temple is secluded and the grounds are very quiet. Tenryu-ji is a major temple of the Rinzai School. It was built in 1339 on the former site of Emperor Go-Daigo's villa after a priest dreamt of a dragon rising from the nearby river. The main attraction of Tenryu-ji Temple is the Zen garden dating back to the 14th Century. A triumph of design, the garden features a large pond which catches the reflection of the maple trees and large rough-cut rocks on the periphery. The garden has a way of calming one's spirit and it was designed partly for this reason. A visit to Toji Temple will show the 5-story, 57-meter high pagoda which has long served as a city landmark and a vibrant center for spiritual and community life. Lunch is included in this tour.

Wednesday, September 22 •
09:00 – 18:00

Kyoto One Day Tour

This full day tour (which includes lunch) will visit: Nijo Castle, Kinkakuji Temple, Heian-jingu Shrine, Sanjusangendo and Kiyomizudera Temples. Kinkakuji Temple or the "Golden Pavilion", a temple richly adorned in gold leaf, reflects beautifully in the water of Kyokochi, the mirror pond. It is perhaps the most widely recognized image of Kyoto. Sanjusangendo temple name means literally "Hall with thirty three spaces between the columns," describing the architecture of the 125-meter long main hall of the temple. The longest wooden building in the world at a length of 118 meters, Sanjusangendo Temple houses one of the most impressive assemblies of statues in the world as well. Graceful statues carved out of cypress and covered with gold leaf, each has over twenty pairs of arms and is responsible for saving many worlds. One hundred and twenty-four of these statues, saved from the fire which claimed the original temple in 1249, date from the temple's founding in 1164. Kiyomizudera Temple - inspired the expression "to jump off the stage at Kiyomizu," is the Japanese equivalent of the English expression "to take the plunge". Kiyomizu-dera Temple is perhaps the most beloved of Kyoto's temples and is a fixture in the minds of the Japanese people. Several waterfalls dot the grounds, thus people come to the temple to drink water from the falls by collecting it in tin cups; the water is said to have therapeutic properties, and drinking from the three different streams is said to confer health, longevity, and success in studies. There is also a shrine on the grounds, and praying there is said to help one succeed in finding an appropriate love match.

Wednesday, September 22 •
12:00 – 16:00

Japanese Gardens Tour

This garden tour will reveal in the stunning simplicity and harmony of the principles of Zen meditation. A visit to the Ryoanji Temple, Japan's most famous "hiraniwa" (flat garden void of hills or ponds,) is known for its mysterious rock garden which defies attempts at explanation. After sitting and pondering the garden's "sermon in stone," you can stretch your legs by touring the extensive grounds of Ryoan-ji Temple, which includes larger gardens with trees and moss, and the Kyoyo-chi pond, which is particularly striking in autumn. Once refreshed, you can move to the Heian Jingu Shrine; a relatively recent addition to Kyoto's collection of sacred places. This tour does not include lunch, please plan accordingly.

Thursday, September 23 • 12:00 – 17:30

Japanese Fushimi Sake Tour

This tour will take participants to enjoy the Tofuku-ji Temple then on to the Gekkeikan

Okura Sake Museum. Tofuku-ji Temple is well known as one of the most popular spots for admiring Kyoto's beautiful autumn foliage. The maple trees beside the Tsuten Bridge in the temple are its centerpiece. Tofuku-ji Temple is also noted for its many excellent landscape gardens arranged with a fine blend of moss and stones. Throughout its history, it has been one of the largest and most important Kyoto Zen temples and gave rise to many famous monks. Gekkeikan Okura Sake Museum - Though Japanese rice wine is often referred to as sake in English, sake in Japanese refers to alcohol in general. In Japan, the preferred word for rice wine is "Nihonshu." There are approximately 2,000 nihonshu breweries in Japan producing more than 10,000 products. If you would like to find out more about nihonshu and brewing, the museum may interest you. This tour does not include lunch, please plan accordingly.

Thursday, September 23 • 18:00 – 23:00

Farewell Dinner

Location – Westin Miyako Kyoto, Mizuho-No-Ma Ballroom

The 45th Annual Meeting culminates with a spirited evening of culture. Delegates and their guests will enjoy a formal event including Samurai warriors, Miako dancers, and Sumo wrestling. Enjoy dinner and entertainment with your colleagues, and then dance the night away. Attire is black tie optional.

The Farewell Dinner is supported by a grant from Medtronic.

Social Events & Tours

Friday, September 24 • 09:00 – 17:30

Nara Tour

In 2010, Nara is celebrating its 1300th anniversary as the previous capital of Japan. The Nara City offers people, nature and a history of over 1,300 years. This tour, which includes lunch, will take participants to Nara with a visit at two temples. The world famous Todaiji Temple, designated as a world heritage site, contains various pavilions and halls, including many designated as national treasures of Japan. Horyuji Temple, Established in 607 A.D. by Prince Shotoku, a vigorous supporter of Buddhism, Horyuji Temple was inscribed on the world heritage list in 1993 as the oldest wooden structure in the world. Various national treasures representing Japanese Buddhist art are displayed, such as the statue of "Kudara Kannon" in the treasure house.

Friday, September 24 • 12:30 – 16:00

Kyoto Handicraft Center

Kyoto Handicraft Center (KHC) was opened in 1967. Since then has offered beautiful and skilful Japanese handicrafts which fascinate people all over the world. All kinds of Japanese and Kyoto traditional crafts and specialty goods wait for you at KHC. What is more, your shopping is all duty-free. Why not visit KHC and find something which makes your Kyoto trip more memorable? Shuttle busses will depart the Kyoto International Conference Center at 12:45, 13:45, and 15:45. Check your registration packet for more information and savings coupons!

The background features a light gray gradient with faint, stylized line art of bamboo stalks and cherry blossom branches. A vertical dark gray bar on the right side contains white line art of bamboo stalks and cherry blossom branches, creating a layered effect.

PRESENTER DISCLOSURES



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- Grants/Research Support
- Consultant
- Stock/Shareholder
- Speakers' Bureau
- Other Financial Support
- Over \$10,000

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Disclosure Information

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Alexander C. Disch	Germany	No Relationships
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Disclosure Information

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Disclosure Information

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Disclosure Information

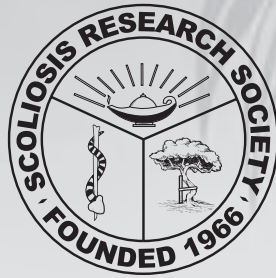
Presenter	Country	Relationship Disclosure
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SCIENTIFIC PROGRAM





The Scoliosis Research Society gratefully acknowledges Medtronic for their support of the Welcome Reception, Farewell Dinner, Beverage Breaks, the Instructional Course Lecture, and Lunchtime Symposium.



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Scientific Program

Wednesday, September 22, 2010

Session I – Adolescent Idiopathic Scoliosis/Basic Science

Moderators: Noriaki Kawakami, MD and B. Stephens Richards, III, MD

08:01-08:05

Paper #1

Clinical Effectiveness of School Screening for Adolescent Idiopathic Scoliosis: A Large Population-Based Retrospective Cohort Study

Keith D. Luk, MD; Chun Fan Lee; Kenneth M. Cheung, MD; Jack C. Cheng, MD; Bobby KW Ng, MD; Tsz Ping Lam, MB,BS; Kwok Hang Mak, MBBS, MSc Public Health; Paul SF Yip; [Daniel Y. Fong, PhD](#)

08:05-08:09

Paper #2

Brace Treatment Controls Progression in Adolescent Idiopathic Scoliosis

[Donald E. Katz, BS, CO](#); John A. Herring, MD; Richard Browne, PhD; Derek M. Kelly, MD; John G. Birch, MD, FRCS(C)

08:09-08:13

Paper #3

Vertebral Body Stapling (VBS) vs. Bracing for Patients with High-Risk Moderate Idiopathic Scoliosis (IS)

Laury Cuddihy, MD; Aina J. Danielsson, MD, PhD; Patrick J. Cahill, MD; John Richmond, MD; Amer F. Samdani, MD; Mary Jane Mulcahey, PhD; [Randal R. Betz, MD](#)

08:13-08:22

Discussion

08:23-08:27

Paper #4

Are Surgical Results in Larger Curves Inferior to Those in Smaller Curves?

[James O. Sanders, MD](#); Lawrence G. Lenke, MD; John B. Emans, MD; Charles E. Johnston, MD; B. Stephens Richards, MD; Daniel J. Sucato, MD, MS; Mohammad Diab, MD; Mark A. Erickson, MD; David W. Polly, MD

08:27-08:31

Paper #5

Larger Curve Magnitude is Associated with Increased Perioperative Healthcare Resource Utilization: A Multi-Center Analysis of 422 Adolescent Idiopathic Scoliosis Curves

[Firoz Miyajni, MD, FRCSC](#); Gerard P. Slobogean, MD, MPH; Amer F. Samdani, MD; Randal R. Betz, MD; Christopher W. Reilly, MD, FRCSC; Bronwyn Slobogean, PA-C; Peter O. Newton, MD

08:31-08:35

Paper #6

Should We Worry About Waiting Times for Idiopathic Scoliosis Surgery?

[Stefan Parent, MD, PhD](#); Marjolaine Roy-Beaudry, MSc; Emmanuelle Coindet; Julie Joncas, B.Sc; Jean-Marc Mac-Thiong, MD, PhD; Marie Beauséjour; Hubert Labelle, MD

08:35-08:44

Discussion

08:45-08:49

*Paper #7

Long-Term Follow-Up of Thoracic Idiopathic Scoliosis with Pedicle Screw Instrumentation - More Than Ten Years Follow-Up

Se-Il Suk, MD; Jin-Hyok Kim; [Dong-Ju Lim](#); Sung-Soo Kim; Tae-Hyung Kim; Jung-Il Han; Seung-Hyun Choi

08:49-08:53

*Paper #8

Long-Term Follow-Up Study of Unfused Segments of Idiopathic Scoliosis: Evaluation of X-Ray and MRI Images after More than 10 Years Postoperative

Noriaki Kawakami, MD; Kenji Seki, MD, PhD; Taichi Tsuji, MD; Kazuyoshi Mlyasaka, MD; Tetsuya Ohara; Ayato Nohara; Michiyoshi Sato; Kenyu Ito

08:53-08:57

*Paper #9

Long-Term Clinical Outcomes of Surgery for Adolescent Idiopathic Scoliosis 21 to 41 Years Later

[Tutomu Akazawa, MD](#); Shohei Minami; Toshiaki Kotani; Kazuhisa Takahashi

08:57-09:06

Discussion

Hibbs awards are given for the best Annual Meeting clinical and basic science presentations. Nominees are noted with the following annotations.

** Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation*

Scientific Program

Wednesday, September 22, 2010

09:07-09:11

Paper #10

Dual-Rod Anterior Spinal Fusion for Adolescent Idiopathic Scoliosis Outcomes at Minimum Five-Years Compared to Previous Two-Year Follow-Up

Lukas P. Zebala, MD; Jacob M. Buchowski, MD, MS; Keith H. Bridwell, MD; Linda Koester

09:11-09:15

Paper #11

A New Warning Criteria for Intraoperative Somatosensory Evoked Potential Monitoring in Scoliosis Surgery. A Prospective Multi-Center Study

Yong Hu, PhD; Wa Y. Wong, MD; Kenneth M. Cheung, MD; Keith D. Luk, MD; Fan Jiang; Guixing Qiu, MD; Yuguang Chen

09:15-09:19

Paper #12

Significant Differences Among Patients in Lenke Curve Types

Paul D. Sponseller, MD; John M. Flynn, MD; Peter O. Newton, MD; Baron S. Lonner, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Maty Petcharaporn, BS; Randal R. Betz, MD

09:19-09:28

Discussion

09:29-09:33

*Paper #13

Do Intra-Operative Antifibrinolytics Reduce Blood Loss in Adolescent Idiopathic Scoliosis? A Prospective Randomized Comparison

Kushagra Verma, MS; Thomas Errico, MD; Neil Bharucha; Christopher Diefenbach, BS; Laura E. Dean, BA; Shaun Xavier, MD; Joseph Dryer; Tessa Huncke, MD; Kirsten Boenigk, MD, PhD; Baron S. Lonner, MD

09:33-09:37

Paper #14

Traction X-Ray Under General Anesthesia (TrUGA) Helps To Save Motion Segment In Surgical Treatment of Lenke Type 3C and 6C Curves

Cagatay Ozturk, MD; Ahmet Alanay, MD; Mehmet Tezer; Mehmet Aydogan; Kursat Ganiyusufoglu; Azmi Hamzaoglu, MD

09:37-09:41

Paper #15

Role of Preoperative Cardiac Screening Studies in Adolescent Idiopathic Scoliosis Surgery

Roger F. Widmann, MD; Patrick A. Flynn, MD; Gilbert Chan; Jeanine M. Kozich, MD; Oheneba Boachie-Adjei, MD; John S. Blanco, MD; Daniel W. Green, MS, MD, FACS; Lisa S. Ipp, MD

09:41-09:50

Discussion

09:50-10:10

Break

Session II – Adolescent Idiopathic Scoliosis/Basic Science

Moderators: Nobumasa Suzuki, MD and Jack M. Flynn, MD

10:11-10:15

Paper #16

How Much is Too Much? Higher Degrees of Curve Correction Correlate with Worsened Sagittal Balance

Michael G. Vitale, MD, MPH; Omar F. Jameel, MD; Daniel J. Sucato, MD, MS; B. Stephens Richards, MD; John B. Emans, MD; Mark A. Erickson, MD; James O. Sanders, MD; Lawrence G. Lenke, MD

10:15-10:19

Paper #17

Residual Thoracic Hypokyphosis Following Posterior Spinal Fusion in Adolescent Idiopathic Scoliosis: Risk Factors and Clinical Ramifications

Nicholas Fletcher, MD; Jeffrey Hopkins, MSN, RN; Anna McClung, RN; Richard Browne, PhD; Daniel J. Sucato, MD, MS

10:19-10:23

Paper #18

Analysis of Internal Construct Validity of the SRS-24 Questionnaire

Dominique A. Rothenfluh, MD, PhD; Georg Neubauer, MD; Kan Min, MD

10:23-10:32

Discussion

Hibbs awards are given for the best Annual Meeting clinical and basic science presentations. Nominees are noted with the following annotations.

**Russell A. Hibbs Award Nominee for Best Clinical Presentation †Russell A. Hibbs Award Nominee for Best Basic Science Presentation*

Scientific Program

Wednesday, September 22, 2010

10:33-10:37

Paper #19

Validation of the Scoliosis Appearance Questionnaire

Leah Y. Carreon, MD, MSc; James O. Sanders, MD; David W. Polly, MD; Daniel J. Sucato, MD MS; Stefan Parent, MD, PhD; Beverly E. Diamond, PhD

10:37-10:41

Paper #20

Cognitive Testing of the Spinal Appearance Questionnaire (SAQ) with Typically Developing Youth and Youth with Idiopathic Scoliosis

Mary Jane Mulcahey, PhD; Anna Marie Santangelo, RN; Kim Costello; Lisa Merenda, RN; Ross Chafetz; Amer F. Samdani, MD; Randal R. Betz, MD

10:41-10:45

Paper #21

Body Image Disturbance Questionnaire-Scoliosis Version: Discriminant Validity in AIS

Jennifer Ahn, MS; Phedra Penn, MS; Neil Bharucha; Joshua D. Auerbach, MD; Suken A. Shah, MD; Baron S. Lonner, MD

10:45-10:54

Discussion

10:55-10:59

Paper #22

In Vivo Forces Resulting from Spinal Rod Instrumentation for Scoliosis Correction

Diana A. Glaser, PhD; Krishna C. Ravi; Thomas Nunn, BS; Tracey Bastrom, MA; Peter O. Newton, MD

10:59-11:03

Paper #23

Pedicle Response During Insertion of Pedicle Screws: in Pediatric and Adult Thoracolumbar Spine: A Biomechanical Comparison of Five Age Groups

Anthony S. Rinella, MD; Amy Wickman, MD; Patrick J. Cahill, MD; Mark Sartori; Alexander Ghanayem; Avinash G. Patwardhan, PhD; Robert M. Havey, BS

11:03-11:07

†Paper #24

Effect of Spinal Shortening on Motor-Evoked Potentials and Spinal Cord Blood Flow

Hitesh N. Modi, MS, PhD; Seung-Woo Suh, MD, PhD; Jae Hyuk Yang, MD; Jae-Young Hong, MD

11:07-11:16

Discussion

11:17-11:21

†Paper #25

Mechanism of Osteoporosis in Adolescent Idiopathic Scoliosis: Experimental Scoliosis in Pinealectomized Chickens

Masafumi Machida, MD; Hiroyuki Katoh; Hitoshi Kono; Shinjiro Kaneko; Kentaro Fukuda; Masashi Saito; Masakazu Takemitsu

11:21-11:25

†Paper #26

Vertebral Growth Modulation in the Porcine Scoliosis Model Assessed by Computed Tomography: 3-D Effect of a Corrective Tether

Frank J. Schwab, MD; Ashish Patel, MD; Virginie C. Lafage, PhD; Benjamin Ungar; Jean-Pierre C. Farcy, MD

11:25-11:29

Paper #27

The Role of Remodeling and Asymmetric Growth in Vertebral Wedging

David D. Aronsson, MD; Ian A. Stokes, PhD; Carole McBride

11:29-11:33

Paper #28

Innovation in Growing Rod Technique; Study of Safety and Efficacy of Remotely Expandable Rod in Animal Model

Behrooz A. Akbarnia, MD; Gregory M. Mundis, MD; Pooria Salari, MD; Burt Yaszay, MD

11:33-11:45

Discussion

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** Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation*

Scientific Program

Wednesday, September 22, 2010

11:45-11:48 Harrington Lecture Introduction

Richard E. McCarthy, MD
SRS President

11:48-12:15 Harrington Lecture

The Role of Anterior Reconstruction Surgery in Treatment of Scoliosis and Thoracolumbar Spinal Fractures

Kiyoshi Kaneda, MD

Session III – Adult Spinal Deformity

Moderators: Steven D. Glassman, MD and Frank J. Schwab, MD

13:15-13:19

Paper #29

The Impact of Adult Scoliosis on the Cervical Spine

Steven D. Glassman, MD; Leah Y. Carreon, MD, MSc; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Serena S. Hu, MD; Keith H. Bridwell, MD

13:19-13:23

Paper #30

Cervical Stenosis in Adult Spinal Deformity Surgery: Incidence, Treatment and Complications

Matthew J. Geck, MD; Dana Hawthorne, BS, MPAS; John K. Stokes, MD

13:23-13:27

Paper #31

Hospital Cost Analysis of Adult Scoliosis Surgery in 120 Consecutive Cases

Marc N. Ialenti, BA; Baron S. Lonner, MD; Phedra Penn, MS; Pedro A. Ricart-Hoffiz, MD; Shaun Xavier, MD; Lynne Windsor, BS; Frank J. Schwab, MD; Thomas Errico, MD

13:27-13:36

Discussion

13:37-13:41

***Paper #32**

Complications and Risk Factors of Primary Adult Scoliosis Surgery: A Multicenter Study of 306 Patients

Sebastien Charosky, MD; Pierre Guigui; Arnaud Blamoutier; Pierre Roussouly, MD; Daniel Chopin; Groupe d'étude sur la scoliose Ges

13:41-13:45

***Paper #33**

Risk Factors for Major Peri-Operative Complications in Adult Spinal Deformity Surgery: A Multi-Center Review of 953 Consecutive Patients

Frank J. Schwab, MD; Nicola Hawkinson, MA, NP; Virginie C. Lafage, PhD; Robert A. Hart, MD; Gregory M. Mundis, MD; Douglas C. Burton, MD; Breton Line, BSME; Behrooz A. Akbarnia, MD; Oheneba Boachie-Adjei, MD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Kirkham B. Wood, MD; Shay Bess, MD; International Spine Study Group

13:45-13:49

Paper #34

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

Christopher T. Martin, BS; Ahmed S. Mohamed, MD; Richard L. Skolasky, ScD; Khaled Kebaish

13:49-13:58

Discussion

13:59-14:03

Paper #35

A Prospective Study of Degenerative Lumbar Scoliosis Among Community-Based Female Volunteers

Shizuo Jimbo; Tetsuya Kobayashi, MD, PhD; Kiyoshi Aono; Yuji Atsuta; Takeo Matsuno

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Scientific Program

Wednesday, September 22, 2010

14:03-14:07

Paper #36

Myelography in the Assessment of Adult Degenerative Scoliosis

Wendy Bertram; Michael Katsimihias, FRCS Tr & Orth; John Hutchinson; Ian W. Nelson, MB, BS, MCh Orth FRCS; Ian J. Harding, BA, BM, BCh, FRCS(Orth)

14:07-14:11

Paper #37

Prophylactic Preoperative Inferior Vena Cava Filters for Major Spinal Reconstruction in Adults: Long-Term Follow-Up

Jamal McClendon, MD; Brian A. O'Shaughnessy, MD; Patrick A. Sugrue, MD; Ryan J. Halpin, MD; Tyler Koski, MD; Stephen L. Ondra, MD

14:11-14:20

Discussion

14:21-14:25

Paper #38

Long Term Survival After Long Primary Fusion for Adult Scoliosis More Than 40 Degrees. Prognostic Factors for Reoperation. Does Reoperation Associate Worse SRS22 and SF36 Final Follow-Up Scores?

Felisa Sánchez-Mariscal; Alejandro Gomez Rice, MD; Enrique Izquierdo, MD, PhD; Lorenzo Zúñiga, MD; Javier Pizones, MD, PhD; Patricia Álvarez González

14:25-14:29

Paper #39

Long Fusions to the Sacrum in Elderly Patients with Spinal Deformity

Charles H. Crawford, MD; Steven D. Glassman, MD; Leah Y. Carreon, MD, MSc; Keith H. Bridwell, MD

14:29-14:33

Paper #40

Prevalence and Outcomes of Coronal Decompensation Following Primary Multilevel Spinal Fusion for Adult Deformity

Joshua M. Pahys, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Lukas P. Zebala, MD; Samuel K. Cho, MD; Matthew M. Kang, MD; Woojin Cho, MD PhD; Christine Baldus, RN, MHS

14:33-14:42

Discussion

14:43-14:47

Paper #41

Thoracic Three Column Osteotomy for Adult Spinal Deformity Improves Regional Deformity and Pelvic Tilt

Shay Bess, MD; Frank J. Schwab, MD; Virginie C. Lafage, PhD; Richard Hostin, MD; Christopher P. Ames, MD; Eric Klineberg, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group

14:47-14:51

Paper #42

Comparison of Pedicle Subtraction Osteotomy in Fixed Vs. Flexible Sagittal Imbalance

Kyu-Jung Cho, MD; Ki-Tack Kim, PhD; Whoan Jeang Kim; Sang-Hun Lee; Jae-Hoon Jung

14:51-14:55

Paper #43

Interradicular Bone-Disc-Bone Osteotomy (BDBO): An Alternative to Other Osteotomy Types for the Correction of Thoracolumbar and Lumbar Spine Deformities

Cagatay Ozturk, MD; Mehmet Aydogan; Selhan Karadereler; Mehmet Tezer; Ahmet Alanay, MD; Azmi Hamzaoglu, MD

14:55-14:59

Paper #44

Changes in Thoracic Kyphosis Negatively Impact Sagittal Alignment Following Lumbar Pedicle Subtraction Osteotomy

Virginie C. Lafage, PhD; Eric Klineberg, MD; Frank J. Schwab, MD; Behrooz A. Akbarnia, MD; Christopher P. Ames, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Kirkham B. Wood, MD; Shay Bess, MD; International Spine Study Group

14:59-15:11

Discussion

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** Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation*

Scientific Program

Wednesday, September 22, 2010

15:12-15:16

Paper #45

Clinical and Radiographic Factors that Distinguish Between the Best and Worst Outcomes of Scoliosis Surgery for Adults 46-85 Years Old

Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Steven D. Glassman, MD; Leah Y. Carreon, MD, MSc; Frank J. Schwab, MD; Virginie C. Lafage, PhD; Sigurd H. Berven, MD; Keith H. Bridwell, MD

15:16-15:20

Paper #46

A Correlation of Radiographic and Functional Measurements in Patients Who Underwent Primary Scoliosis Surgery in Adult Age

Alejandro Gomez Rice, MD; Felisa Sánchez-Mariscal; Enrique Izquierdo, MD, PhD; Lorenzo Zúñiga, MD; Javier Pizones, MD, PhD; Patricia Álvarez González

15:20-15:24

Paper #47

Comparative Analysis of Clinical Outcome and Perioperative Complications in Primary vs. Revision Adult Scoliosis Surgery

Samuel K. Cho, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Matthew M. Kang, MD; Joshua M. Pahys, MD; Lukas P. Zebala, MD; Jin-Seok Yi; Woojin Cho, MD PhD; Christine Baldus, RN, MHS

15:24-15:33

Discussion

15:33-15:55

Break

Session IV – Adolescent Idiopathic Scoliosis

Moderators: Lawrence G. Lenke, MD and Peter O. Newton, MD

15:55-15:59

Paper #48

Does PSF with Pedicle Screws Control Idiopathic Scoliosis with Open Triradiate Cartilages?

Paul D. Sponseller, MD; Peter O. Newton, MD; Baron S. Lonner, MD; Suken A. Shah, MD; Harry L. Shufflebarger, MD; Randal R. Betz, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA

15:59-16:03

Paper #49

Which Lenke 1A Curves Are At The Greatest Risk for Adding-On...And Why?

Robert H. Cho, MD; Burt Yaszay, MD; Carrie E. Bartley, MA; Tracey Bastrom, MA; Peter O. Newton, MD; Harms Study Group

16:03-16:07

Paper #50

Selective Thoracic Fusion in Adolescent Idiopathic Scoliosis: Implications of Leveling of the Lowest Instrumented Vertebra on Lumbar Curvature and Coronal Balance

Melinda S. Sharkey, MD; John M. Flynn, MD; Paul D. Sponseller, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Peter O. Newton, MD; Harms Study Group

16:07-16:11

Paper #51

Motion of the Spine Pre and Post-Spinal Fusion Compared to Age-Matched

Adam Graf; Peter F. Sturm, MD; Sahar Hassani; Mary Riordan; Kim W. Hammerberg, MD; Joseph Krzak, PT; Purnendu Gupta, MD; Gerald F. Harris, PhD

16:11-16:23

Discussion

16:24-16:28

Paper #52

Meta-Analysis of the Safety and Efficacy of Pedicle Screw Spinal Instrumentation in Pediatric Spinal Deformity: Results of SRS and POSNA Task Force

David W. Polly, MD; Charles G. Ledonio, MD; Michael G. Vitale, MD, MPH; B. Stephens Richards, MD

16:28-16:32

Paper #53

Segmental vs. Non-Segmental Thoracic Pedicle Screws Constructs in Adolescent Idiopathic Scoliosis. Is There Any Implant Alloy Effect?

Mario Di Silvestre, MD; Georgios Bakaloudis; Francesco Lolli; Stefano Giacomini

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Wednesday, September 22, 2010

16:32-16:36

Paper #54

Incidence, Distribution, and Surgical Relevance of Abnormal Pedicles in Normal and AIS Spines: A CT Based Study of 6,624 Pedicles

Vishal Sarwahi, MD; Adam L. Wollowick, MD; Terry Amaral, MD; Etan P. Sugarman, MSIV; Lana Nirenstein; Beverly Thornhill, MD

16:36-16:40

Paper #55

Pedicle Screw Fixation Strategies of the Thoracic Curve in Adolescent Idiopathic Scoliosis

Dino Samartzis, DSc, PhD, MSc; Deepa Natarajan, MBBS; Kenny Kwan; Wai Yuen Cheung, MD; Jingfeng Li, MD; Yatwa Wong; Lawrence G. Lenke, MD; Keith D. Luk, MD; Kenneth M. Cheung, MD

16:40-16:52

Discussion

Thursday, September 23, 2010

Session V –Complications/Infections/Congenital Deformity

Moderators: Michael Ruf, MD and Muharrem Yazici, MD

08:00-08:04

*Paper #56

Morbidity and Mortality of Major Adult Spinal Surgery. A Prospective Cohort Analysis of 942 Consecutive Patients

John Street, MD, PhD; Brian Lenehan, MD; Michael Boyd, MD; Marcel F. Dvorak, MD; Brian K. Kwon, MD, PhD, FRCSC; Scott Paquette, MD; Charles G. Fisher, MD, MHSc

08:04-08:08

Paper #57

Preoperative ASA Grading is a Robust Predictor of Complication Rates in Patients Undergoing Surgery for Major Spinal Deformity

Kai-Ming Fu, MD, PhD; Justin S. Smith, MD, PhD; Joseph H. Perra, MD; David W. Polly, MD; Christopher P. Ames, MD; Sigurd H. Berven, MD; D. K. Hamilton, MD; Richard E. McCarthy, MD; Steven D. Glassman, MD; Dennis R. Knapp, MD; Christopher I. Shaffrey, MD

08:08-08:12

Paper #58

Major Complications in Revision Adult Deformity Surgery: Risk Factors and Clinical Outcomes with Two to Seven Year Follow-Up

Samuel K. Cho, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Jin-Seok Yi; Woojin Cho, MD PhD; Lukas P. Zebala, MD; Joshua M. Pahys, MD; Matthew M. Kang, MD; Christine Baldus, RN MHS

08:12-08:21

Discussion

08:22-08:26

Paper #59

Prevalence, Outcomes and Risk Factors for Proximal Junctional Kyphosis Following Surgical Correction of Adult Idiopathic Scoliosis

Mitsuru Yagi, MD, PhD; Oheneba Boachie-Adjei, MD; Akilah B. King, BA

08:26-08:30

Paper #60

Myelopathic Patients Who Lack Intraoperative Spinal Cord Monitoring Data Have the Highest Rate of Spinal Cord Deficits Following Posterior VCR Surgery

Samuel K. Cho, MD; Lawrence G. Lenke, MD; Shelly Bolon, BS, CNIM; Matthew M. Kang, MD; Lukas P. Zebala, MD; Joshua M. Pahys, MD; Woojin Cho, MD PhD; Linda Koester

08:30-08:34

Paper #61

Delayed Post-Operative Neurologic Deficits in Spinal Surgery

Joshua D. Auerbach, MD; Baron S. Lonner, MD; Kristin E. Kean, BA; Andrew H. Milby, BS; Kenneth J. Paonessa, MD; John P. Dormans, MD; Peter O. Newton, MD; Kit M. Song, MD

08:34-08:43

Discussion

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**Russell A. Hibbs Award Nominee for Best Clinical Presentation †Russell A. Hibbs Award Nominee for Best Basic Science Presentation*

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Thursday, September 23, 2010

08:44-08:48

Paper #62

Does BMP Increase the Incidence of Perioperative Complications in Spinal Fusion? A Comparison of 55,862 Cases of Spinal Fusion with and without BMP.

Brian J. Williams, MD; Justin S. Smith, MD, PhD; Kai-Ming Fu, MD, PhD; D. K. Hamilton, MD; Joseph H. Perra, MD; David W. Polly, MD; Christopher P. Ames, MD; Sigurd H. Berven, MD; Richard E. McCarthy, MD; Steven D. Glassman, MD; Dennis R. Knapp, MD; Christopher I. Shaffrey, MD

08:48-08:52

Paper #63

Surgical Outcome of 72 Cases of Tuberculous Paraplegia. A Retrospective Analysis

Shaligram Purohit; Mihir Bapat, MS, DNB; Kshitij S. Chaudhary, MS, DNB; Nanjundappa S. Harshavardhana, MS; Umesh Metkar, MD; Vinod Laheri, MS

08:52-08:56

Paper #64

Perioperative Complications of Pediatric Vertebral Column Resections

Peter O. Newton, MD; Lawrence G. Lenke, MD; Harry L. Shufflebarger, MD; Daniel J. Sucato, MD MS; John B. Emans, MD; Paul D. Sponseller, MD; Suken A. Shah, MD; Tracey Bastrom, MA

08:56-09:05

Discussion

09:06-09:10

Paper #65

Comparison of Spinal Deformity Surgery in Patients with Non-Insulin Dependent Diabetes Mellitus (NIDDM) vs. Controls

Woojin Cho, MD, PhD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Ian G. Dorward, MD; Naoki Shoda; Christine Baldus, RN, MHS; Samuel K. Cho, MD; Matthew M. Kang, MD; Lukas P. Zebala, MD; Joshua M. Pahys, MD; Linda Koester

09:10-09:14

Paper #66

Risks of Chemoprophylaxis for Venous Thromboembolism Following Spinal Fusions: A Retrospective Review of 351 Consecutive Patients

Tyler Koski, MD; Ryan J. Halpin, MD; Kenneth Vaz, BS; Jamal McClendon, MD; Sara E. Thompson; Patrick A. Sugrue, MD

09:14-09:18

Paper #67

A Comparison of Perioperative and Delayed Major Complications Following 1,630 AIS Procedures

Burt Yaszay, MD; Caitlin Schulte; Michelle C. Marks, PT, MA; Peter O. Newton, MD; Randal R. Betz, MD; Suken A. Shah, MD; Baron S. Lonner, MD; Harry L. Shufflebarger, MD; John M. Flynn, MD; Harms Study Group

09:18-09:27

Discussion

09:28-09:32

Paper #68

Morbidity and Mortality Associated with the Operative Treatment of Disorders of the Pediatric Spine: A Report From the SRS M&M Committee

Kai-Ming Fu, MD, PhD; Justin S. Smith, MD, PhD; D. K. Hamilton, MD; Joseph H. Perra, MD; David W. Polly, MD; Christopher P. Ames, MD; Sigurd H. Berven, MD; Richard E. McCarthy, MD; Steven D. Glassman, MD; Dennis R. Knapp, MD; Christopher I. Shaffrey, MD

09:32-09:36

Paper #69

Factors Associated with Loss of Coronal Deformity Correction in Patients with AIS

Steven W. Hwang, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Peter O. Newton, MD; Randal R. Betz, MD; Patrick J. Cahill, MD

09:36-09:40

Paper #70

Development of the Spinal Canal after Transpedicular Instrumentation in One and Two Year Old Children

Michael Ruf, MD; Jurgen Harms, MD

09:40-09:49

Discussion

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Scientific Program

Thursday, September 23, 2010

09:50-09:54

Paper #71

Posterior Vertebral Column Resection for Correction of Severe Rigid Spinal Deformity

Jingming Xie, MD; Yingsong Wang, MD; Ying Zhang, MD; Zhi Zhao, MD

09:54-09:58

Paper #72

Surgical Management of Congenital Scoliosis (CS) with Split Cord Malformation (SCM)

Jianxiong Shen, MD; Guixing Qiu

09:58-10:02

Paper #73

Impact of Halo-Gravity-Traction (HGT) on Curve Rigidity and Pulmonary Function: Refining Indications for HGT in the Treatment of Rigid Scoliosis & Kyphoscoliosis

Heiko Koller, MD; Vera Gajic; Oliver Meier; Luis Ferraris, MD; Axel Hempfing; Patrick S. Schmitt; Juliane Zenner, MD

10:02-10:06

Paper #74

Various Treatment Options of Congenital Scoliosis -Analysis of Long-Term Follow-Up Results

Martin Repko, PhD; Richard Chaloupka, CSc.; Jan Burda; Jan Pesek

10:06-10:18

Discussion

10:18-10:38

Break

Session VI – Diagnostic Methods/Early Onset Scoliosis

Moderators: Daniel J. Sucato, MD, MS and Koki Uno, MD, PhD

10:38-10:42

Paper #75

Prevalence, and Association of Scoliosis with Syrinx with or without Chiari Malformation

Christian L. Sybrowsky, MD; Walter F. Krengel, MD

10:42-10:46

Paper #76

Global Sagittal Spinal Balance: Normative Values From a Prospective Cohort of 715 Asymptomatic Adults and 646 Asymptomatic Children

Jean-Marc Mac-Thiong, MD, PhD; Pierre Roussouly, MD; Eric Berthonnaud, PhD; Pierre Guigui; Hubert Labelle, MD

10:46-10:50

Paper #77

Is Radiation-Free Diagnostic Monitoring of Adolescent Idiopathic Scoliosis Feasible Using Upright Positional MRI?

Christopher Diefenbach, BS; Baron S. Lonner, MD; Joshua D. Auerbach, MD; Neil Bharucha; Laura E. Dean, BA; Yael Goldstein

10:50-10:59

Discussion

11:00-11:04

*Paper #78

Growing Rod Graduates: Lessons From 58 Patients Who Have Completed Their Lengthenings

John M. Flynn, MD; Lauren A. Tomlinson, BS; Jeff Pawelek, BS; George H. Thompson, MD; Richard E. McCarthy, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group

11:04-11:08

Paper #79

Outcomes of Growing Rod Techniques in Early Onset Scoliosis: Does the Etiology Matter?

Behrooz A. Akbarnia, MD; Pooria Salari, MD; George H. Thompson, MD; Paul D. Sponseller, MD; John B. Emans, MD; Growing Spine Study Group

11:08-11:12

Paper #80

Pedicle Screws Have Fewer Complications than Hooks in Children with Growing Rods

David L. Skaggs, MD; Karen S. Myung, MD, PhD; Charles E. Johnston, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group

11:12-11:21

Discussion

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Scientific Program

Thursday, September 23, 2010

11:22-11:26

Paper #81

Growing Rods for Pediatric Spinal Deformity: Examining Principles and Practice

Justin S. Yang, MD; Mark McElroy, MS; George H. Thompson, MD; Behrooz A. Akbarnia, MD; Paul D. Sponseller, MD; Growing Spine Study Group

11:26-11:30

Paper #82

Preoperative Thoracic Kyphosis Can Predict Complications in Growing Rod Surgery for Early Onset Scoliosis

Samuel Schroerlucke, MD; Pooria Salari, MD; Jeff Pawelek, BS; Gregory M. Mundis, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group

11:30-11:34

Paper #83

Nutritional Improvement Following Growing Rod Surgery in Children with Early Onset Scoliosis

Karen Myung, MD; David L. Skaggs, MD; George H. Thompson, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group

11:34-11:43

Discussion

11:44-11:48

Paper #84

Early Onset Scoliosis: The Value of Serial Risser Casts

Sean R. Waldron, MD; Connie Poe-Kochert, BSN; Jochen P. Son-Hing, MD, FRCS; George H. Thompson, MD

11:48-11:52

Paper #85

Hybrid Growth Rods Using Spinal Implants on Ribs

Karen S. Myung, MD, PhD; David L. Skaggs, MD; Muharrem Yazici, MD; Mohammad Diab, MD; Hilali H. Noordeen, FRCS; Michael G. Vitale, MD, MPH; Charles E. Johnston, MD

11:52-11:58

Discussion

11:58-12:00

2011 IMAST Preview

Todd J. Albert, MD
IMAST Committee Chair

12:00-12:03

2011 Annual Meeting Preview

Steven D. Glassman, MD
John Dimar, MD
Mohammad Majd, MD
Louisville Local Hosts

12:03-12:06

Worldwide Conference Preview

Kamal N. Ibrahim, MD, FRSC(c), MA
Ahmet Alanay, MD
Worldwide Conference Committee Co-Chairs

12:06-12:10

Introduction of President

12:10 -12:30

Presidential Address

Richard E. McCarthy, MD
SRS President

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**Russell A. Hibbs Award Nominee for Best Clinical Presentation †Russell A. Hibbs Award Nominee for Best Basic Science Presentation*

Scientific Program

Friday, September 24, 2010

Session VII – Etiology/Genetics/Innovative Methods/Kyphosis/Miscellaneous

Moderators: James W. Ogilvie, MD and Noberto Ventura, MD, PhD

08:00-08:04

†Paper #86

Genome-Wide Array Scan Identified Copy Number Variants Loci Associated with Adolescent Idiopathic Scoliosis (AIS)

Rakesh Chettier, MS; Lesa M. Nelson, BS; [James W. Ogilvie, MD](#); Roberto A. Macina, PhD; Kenneth Ward, MD

08:04-08:08

†Paper #87

Genome-Wide Study Reveals Genetic Loci Associated with Idiopathic Scoliosis

Swarkar Sharma, PhD; Xiaochong Gao; Douglas Londono, PhD; Matthew B. Dobbs, MD; Christina Gurnett, MD, PhD; John A. Herring, MD; Derek Gordon, PhD; [Carol Wise, PhD](#)

08:08-08:12

Paper #88

Scoliosis Surgery in Patients with Adolescent Idiopathic Scoliosis Does Not Alter Lung Volume: A Three-Dimensional CT Based Study

[Terry Amaral, MD](#); Etan P. Sugarman, MSIV; Adam L. Wollowick, MD; Beverly Thornhill, MD; Vishal Sarwahi, MD United States

08:12-08:21

Discussion

08:22-08:26

Paper #89

Matched Cohort Analysis of Posterior Only Vertebral Column Resection vs. Combined Anterior/Posterior Vertebrectomy for Severe Spinal Deformity

[Joshua M. Pahys, MD](#); Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Samuel K. Cho, MD; Lukas P. Zebala, MD; Matthew M. Kang, MD; Woojin Cho, MD PhD; Linda Koester

08:26-08:30

Paper #90

Multicenter Analysis of 147 Consecutive Vertebral Column Resections for Severe Pediatric Spinal Deformity

[Lawrence G. Lenke, MD](#); Peter O. Newton, MD; Daniel J. Sucato, MD, MS; Harry L. Shufflebarger, MD; John B. Emans, MD; Paul D. Sponseller, MD; Suken A. Shah, MD; Brenda Sides, MA; Kathy Blanke, RN

08:30-08:34

Paper #91

Prompt Response to Critical Spinal Cord Monitoring Changes During Vertebral Column Resection Results in a Low Incidence of Permanent Neurologic Deficit

[Scott J. Luhmann, MD](#); Sara Fuhrhop; June C. Smith, MPH

08:34-08:43

Discussion

08:44-08:48

Paper #92

Comparison Between PSO and Anterior Corpectomy and Plating for Treating Post-Traumatic Kyphosis. A Multicenter Study

[Mohammad M. El-Sharkawi, MD](#); Wael Koptan, MD; Yasser ElMiligui, MD, FRCS

08:48-08:52

Paper #93

Loss of Correction in Treatment of Thoracolumbar Kyphosis Secondary to Ankylosing Spondylitis: A Comparison Between Smith-Petersen Osteotomies and Pedicle Subtraction Osteotomy

Xinhua Wang; Yong Qiu, MD; [Zezhang Zhu, MD](#); Feng Zhu; Bin Wang, MD; Yang Yu; Bangping Qian; Xu Sun, MD, PhD; Weijun Wang, PhD

08:52-08:56

Paper #94

Sterility of Posterior Elements of Spine in Posterior Correction Surgery

[Morio Matsumoto, MD](#); Yuta Shiono; Youhei Takahashi; Kota Watanabe; Kazuhiro Chiba, MD, PhD; Yoshiaki Toyama

08:56-09:05

Discussion

Hibbs awards are given for the best Annual Meeting clinical and basic science presentations. Nominees are noted with the following annotations.

** Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation*

Scientific Program

Friday, September 24, 2010

09:06-09:10

Paper #95

A Prospective, Randomized, Double-Blind, Placebo-Controlled Study on Efficacy of Intraoperative Ketamine in Reduction of Postoperative Pain in Opiate-Dependent Chronic Back Pain Patients Undergoing Spinal Surgery

Randy W. Loftus, MD; Dilip K. Sengupta, MD

09:10-09:14

Paper #96

Antifibrinolytic Agents Substantially Reduce Blood Loss During Vertebral Column Resection Procedures

Peter O. Newton, MD; Tracey Bastrom, MA; John B. Emans, MD; Suken A. Shah, MD; Harry L. Shufflebarger, MD; Paul D. Sponseller, MD; Daniel J. Sucato, MD, MS; Lawrence G. Lenke, MD

09:14-09:18

Paper #97

The Natural History of Dural Ectasia in Marfan Syndrome

Addisu Mesfin, MD; Nicholas Ahn, MD; John Carrino, MD; Paul D. Sponseller, MD

09:18-09:27

Discussion

09:28-09:32

Paper #98

Analysis of Preexistent Vertebral Rotation in the Normal, Non-Scoliotic Infantile, Juvenile and Adolescent Spine

Michiel Janssen; Jan Willem M. Kouwenhoven, MD, PhD; Tom P. Schlösser; Koen L. Vincken, PhD; Rene M. Castelein, MD, PhD

09:32-09:36

Paper #99

Is Iliac Crest Bone Graft Still the Gold Standard in Spinal Fusion Surgery? A Survey of Spine Surgeons

Michelle E. Aubin, MD; Jason C. Eck, DO, MS; Anthony Lapinsky, MD; Patrick J. Connolly, MD

09:36-09:40

Paper #100

Does Preoperative Bowel Preparation Reduce Post-Operative Bowel Morbidity and Length of Stay After Scoliosis Surgery?

John T. Smith, MD

09:40-09:49

Discussion

09:50-09:58

Transfer of Presidency

09:58-10:15

Awards Presentation

Russell A. Hibbs Awards

Louis A. Goldstein Award

John H. Moe Award

Lifetime Achievement Awards

10:15-10:35

Break

Session VIII – Neuromuscular Deformity/Spondylolisthesis/Tumors

Moderator: Morio Matsumoto, MD and Paul D. Sponseller, MD

10:35-10:39

Paper #101

Long-Term Results From Steroid (Deflazacort) Treatment in the Development of Scoliosis in Duchenne Muscular Dystrophy

Benjamin Alman, MD; Doug Biggar

10:39-10:43

Paper #102

Is Pre-Operative Pulmonary Function Test Valuable in Surgery for Flaccid Neuromuscular Scoliosis?

Hak-Sun Kim, MD; Eun-Su Moon, PhD; Hwan-Mo Lee; Seong-Hwan Moon, PhD, MD; Hyon-su Chong, MD; Do-Hyun Kim; Dong-Eun Shin, PhD

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Scientific Program

Friday, September 24, 2010

10:43-10:52

Paper #103

Growing Rods for Scoliosis in Spinal Muscular Atrophy

Paul D. Sponseller, MD; Mark McElroy, MS; Rishi Kadakia; Adam Shaner, BS; George H. Thompson, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group

10:52-11:01

Discussion

11:01-11:05

Paper #104

The Patient with Myelomeningocele: Is Untethering Necessary Prior to Deformity Correction?

Amer F. Samdani, MD; Anthony Fine, BS; Sukhdeep S. Sagoo, DO; Shailja C. Shah; Patrick J. Cahill, MD; David H. Clements, MD; Randal R. Betz, MD

11:05-11:09

Paper #105

Combined Anterior-Posterior vs. Posterior Only Fusion for Severe Non-Spastic Neuromuscular Deformity

Michael S. Chang, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Woojin Cho, MD, PhD; Yu-Hui H. Chang, MPH, MS; Ljiljana Bogunovic, MD; Linda Koester; Joshua D. Auerbach, MD; Charles H. Crawford, MD; Brian A. O'Shaughnessy, MD

11:09-11:13

Paper #106

Subsequent, Unplanned Spine Surgery and Life Survival of Patients Operated for Neuropathic Spine Deformity

Marc A. Asher, MD; Sue Min Lai, PhD; Douglas C. Burton, MD

11:13-11:17

Paper #107

Surgical Treatment of Scoliosis in Non-Ambulatory Spastic Quadriplegic Cerebral Palsy Patients: A Matched Cohort Comparison of Luque-Galveston Technique and All-Pedicle Screw Constructs

Scott J. Luhmann, MD; Kathryn A. Keeler, MD; Sara Fuhrhop; Murat Oto; Freeman Miller, MD; Kirk W. Dabney, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD

11:17-11:29

Discussion

11:29-11:33

Paper #108

The Importance of Sagittal Spino-Pelvic Alignment in Low-Grade Spondylolisthesis

Jean-Marc Mac-Thiong, MD, PhD; Pierre Roussouly, MD; Michael T. Hresko, MD; Hubert Labelle, MD

11:33-11:37

Paper #109

Relationship Between HRQL Measures and Spino-Pelvic Alignment in Adolescent Spondylolisthesis Compared to a Control Population

Hubert Labelle, MD; Pierre Roussouly, MD; Jean-Marc Mac-Thiong, MD, PhD; Stefan Parent, MD, PhD; Michael T. Hresko, MD

11:37-11:41

Paper #110

Trends in Lumbar Spine Surgery Rates and Hospital Costs for Pediatric Patients with Spondylolysis and Spondylolisthesis

Hongbo Liu; Charles T. Mehlman, DO, MPH; Jun Ying, PhD

11:41-11:45

Paper #111

Correlation Between Lumbar Lordosis and Isthmic Spondylolisthesis in Young Patients. A Radiographic Study in 1,667 Spine Patients

Dietrich Schlenzka, MD, PhD; Mauno Ylikoski, MD; Timo A. Yrjonen; Leena Ristolainen, MSc, PT; Jyrki Kettunen

11:45-11:57

Discussion

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Scientific Program

Friday, September 24, 2010

11:57 -12:01

Paper #112

Introducing a New Health Related Quality of Life Outcome Tool for Metastatic Disease of the Spine. Content Validation using the International Classification of Functioning, Disability and Health

John Street, MD, PhD; Brian Lenehan, MD; Sigurd H. Berven, MD; Charles G. Fisher, MD, MHSc

12:01-12:05

Paper #113

The Effect of Surgery on Health Related Quality of Life and Functional Outcome in Patients with Metastatic Epidural Spinal Cord Compression: Initial Results of the AOSpine North America Prospective Multicenter Study

Michael G. Fehlings, MD, PhD; Branko Kopjar; Alexander R. Vaccaro, MD, PhD; Paul Arnold; Charles G. Fisher, MD, MHSc; Ziya L. Gokaslan, MD; James Schuster; Mark B. Dekutoski, MD

12:05-12:09

Paper #114

Clinical and Radiographic Examinations of Vertebral Arch Reconstruction Based on 90-Degree Rotational Laminoplasty After Removal of Spinal Cord and Cauda Equina Tumors

Takashi Asazuma, MD; Yoshiyuki Yato; Hideaki Imabayashi, MD; Yohei Iguchi; Koichi Nemoto, MD

12:09-12:13

Paper #115

Combined En Bloc Chest Wall Resection and Vertebrectomy of Primary Malignant Spine Tumors

Claudia Druschel; Alexander C. Disch; Ingo Melcher; Norbert Haas; Klaus-Dieter Schaser

12:13-12:25

Discussion

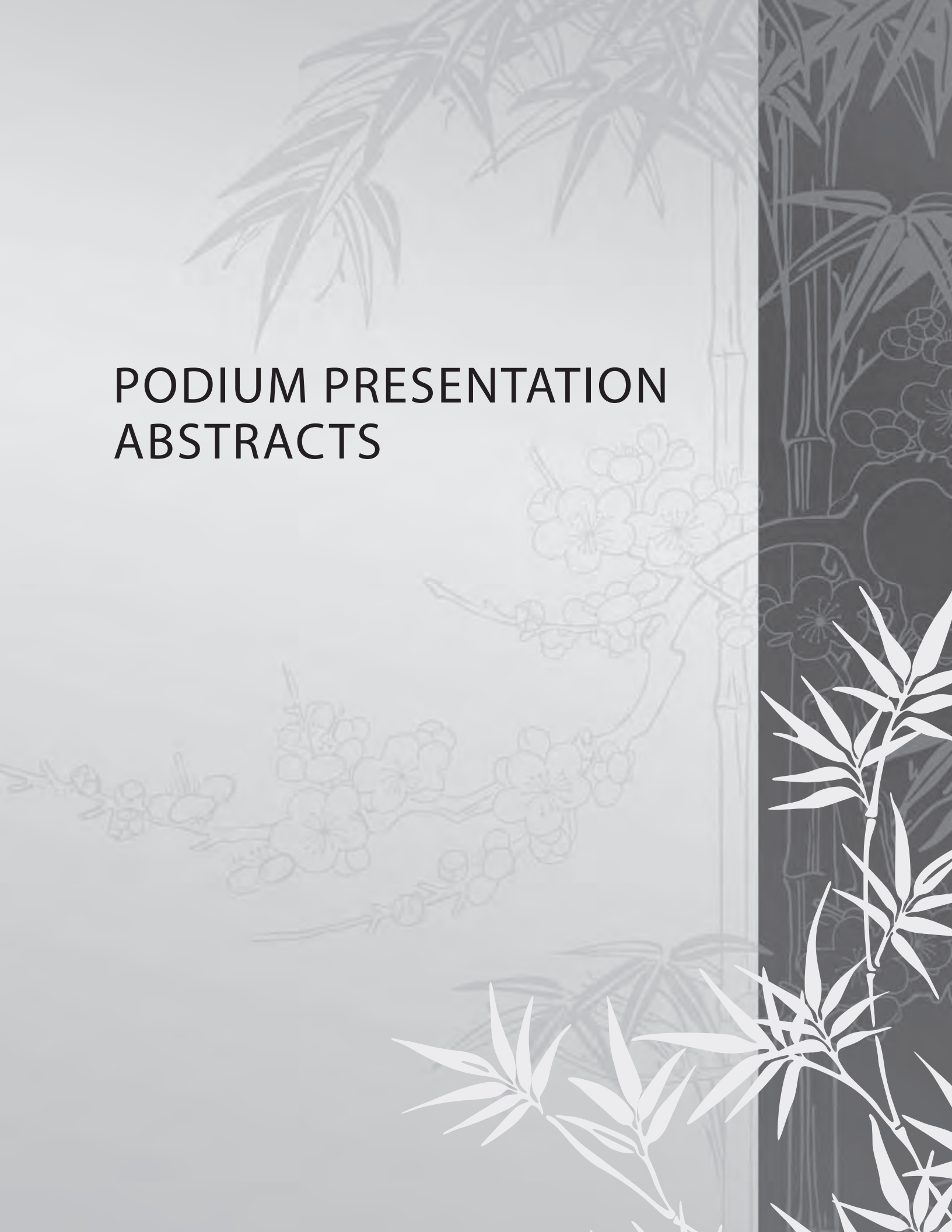
12:25

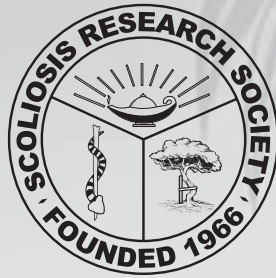
Adjourn

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PODIUM PRESENTATION ABSTRACTS





The Scoliosis Research Society gratefully acknowledges Stryker Spine for their support of the Instructional Course Lecture, Lunchtime Symposium, and general Educational Grant.

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Podium Presentation Abstracts

Paper #1

Clinical Effectiveness of School Screening for Adolescent Idiopathic Scoliosis: A Large Population-Based Retrospective Cohort Study

Keith D. Luk, MD; Chun Fan Lee; Kenneth M. Cheung, MD; Jack C. Cheng, MD; Bobby KW Ng, MD; Tsz Ping Lam, MB, BS; Kwok Hang Mak, MBBS, MSc Public Health; Paul SF Yip; Daniel Y. Fong, PhD
China

Summary: The diversely reported clinical effectiveness of school scoliosis has called for the need of large studies with sufficient follow-up of children. Based on a large cohort of children who participated in the Hong Kong scoliosis screening program and were followed until the age of 19, the program appears to be sensitive and predictive for screening AIS patients with only a low referral rate for radiography. Screening should thus be continued in order to facilitate early administration of conservative treatments.

Introduction: School screening for adolescent idiopathic scoliosis (AIS) has been criticized as resulting in over-referrals for radiography and having low predictive values. Indeed, all but one previous retrospective cohort studies had no follow-up assessments of students until their skeletal maturity, leaving any late-developed curves undetected. The one study that completed this follow-up was well conducted but had low precisions due to its small sample size. Therefore, we aimed to evaluate the clinical effectiveness of school scoliosis screening using a large and long-term-followed cohort of students in Hong Kong.

Methods: A retrospective cohort study was performed on a total of 157,444 students who were eligible for a biennial scoliosis screening, and their screening results and medical records up to 19 years of age were available. Screening tests included a forward bending test (FBT), angle of trunk rotation (ATR), and moiré topography for those who showed signs of AIS. Students with an ATR $\geq 15^\circ$, ≥ 2 moiré lines, or significant clinical signs were referred for radiography and had their Cobb angle measured.

Results: Of the 115,190 screened students in the cohort, 3,228 (2.8%, 95% CI = 2.7% to 2.9%) were referred for radiography. At the final follow-up, the positive predictive values were 43.6% (41.8% to 45.3%) for a Cobb angle $\geq 20^\circ$ and 9.4% (8.4% to 10.5%) for needing treatment, while the sensitivities were 88.1% (86.4% to 89.6%) and 80.0% (75.6% to 83.9%), respectively.

Conclusion: This study demonstrated that school scoliosis screening in Hong Kong is predictive and sensitive with a low referral rate. Screening should thus be continued in order to facilitate early administration of conservative treatments.

Significance: This was the largest study that responds to the need of large, retrospective cohort studies with sufficient follow-up to properly assess the clinical effectiveness of school scoliosis screening.

Paper #2

Brace Treatment Controls Progression in Adolescent Idiopathic Scoliosis

Donald E. Katz, BS, CO; John A. Herring, MD; Richard Browne, PhD; Derek M. Kelly, MD; John G. Birch, MD, FRCS(C)
United States



Summary: In 100 patients treated with monitored Boston Braces we found a direct correlation between hours of brace wear and control of curve progression with greatest effect in those with open triradiates who were most likely to progress.

Introduction: The ability of a brace to control progression of idiopathic scoliosis is unproven. Estimates of brace compliance are unreliable. We compared exactly measured hours of brace wear with curve progression to determine treatment efficacy.

Methods: 100 patients with AIS with initial curves 25-45 degrees at Risser 0 (n=75), 1 (n=15), or 2 (n=10) were treated with Boston Braces with high accuracy heat sensors which recorded actual brace wear throughout the treatment period. Treating teams prescribed either 16 or 23 hours of wear. Failure was defined as >6 degrees of progression.

Results: The hours of brace wear correlated highly with lack of curve progression. 82% of patients who wore braces >12 hours per day did not progress while only

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31% of those wearing braces <7 hours per day did not progress, $p=0.0005$. The correlations were strongest in those at Risser 0 and open triradiate cartilage status. Consistent wear at school and between school and bedtime resulted in better curve control than night wear. 72 patients who did not progress to surgery had 8.1 hours per day of wear compared to 28 patients who had surgery who had 4.3 hours per day average wear, $p=0.0005$

Conclusion: There is a linear relationship between actual hours of wear of a Boston Brace and the prevention of curve progression in AIS. We conclude that progression of idiopathic scoliosis is prevented by consistent brace wear.

Significance: We now can counsel patients about treatment with data which shows not only that bracing works but also with knowledge of the amount of wear-time required for success.

Paper #3

Vertebral Body Stapling (VBS) vs. Bracing for Patients with High-Risk Moderate Idiopathic Scoliosis (IS)

Laury Cuddihy, MD; Aina J. Danielsson, MD, PhD; Patrick J. Cahill, MD; John Richmond, MD; Amer F. Samdani, MD; Mary Jane Mulcahey, PhD; Randal R. Betz, MD
United States

Summary: This is a retrospective comparison study of vertebral body stapling (VBS) versus bracing for patients with moderate idiopathic scoliosis (IS) (25-44°) using identical inclusion criteria. The results of treatment of thoracic curves measuring 25-34° and all lumbar curves, whether by VBS or bracing, appear to be similar. For thoracic curves 35-44°, the results were worst with stapling, which has led to alternative fusionless surgery strategies.

Introduction: We retrospectively compared VBS versus bracing for patients with moderate IS to determine which is more effective at maintaining or improving curve magnitude.

Methods: Inclusion Criteria: 1) Diagnosis of idiopathic scoliosis; 2) age ≥ 8 years 3) curve 25-44°; 4) Risser 0 or 1; 5) minimum 2-year follow-up. The VBS cohort was derived from a retrospective IRB-approved analysis of a consecutive series of 160 patients of which 49 met the inclusion criteria. 43 of the 49 (88%) were available for follow-up. The bracing cohort (N=165) was derived from a bracing database from Sweden. "Improvement" was defined as improvement in the pre-treatment Cobb angle of $> 10^\circ$. "No change" was defined as $+10^\circ$ to -10° change, inclusive. "Progression" was defined as worsening of the curve $> 10^\circ$.

Results: The average age at initiation of treatment of the VBS group vs. the bracing group was 10.5 yrs vs. 12.7 yrs. Average curve size was 31 vs. 32° and average follow-up was 41 vs. 43 months. For thoracic curves 25-34°, VBS had a success rate of 80% versus 64% for bracing. In thoracic curves 35-44°, VBS and bracing had success rates of 18% and 57%, respectively. For lumbar curves 25-34°, VBS had a 79% success rate versus 69% for bracing. For lumbar curves 35-44°, VBS had a 60% success rate versus 60% for bracing (Table 1).

Conclusion: In this comparison, the results for treatment of smaller thoracic curves ($<35^\circ$) and all lumbar curves appear to be similar for both VBS and bracing, suggesting that VBS could be used as an alternative to bracing. For thoracic curves 35-44°, the results were poor with stapling, which has led to alternative fusionless strategies.

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).

Paper #4

Are Surgical Results in Larger Curves Inferior to Those in Smaller Curves?

James O. Sanders, MD; Lawrence G. Lenke, MD; John B. Emans, MD; Charles E. Johnston, MD; B. Stephens Richards, MD; Daniel J. Sucasato, MD, MS; Mohammad Diab, MD; Mark A. Erickson, MD; David W. Polly, MD
United States

Summary: Surgery in large curves ($>70^\circ$) results in more frequent allogenic blood transfusion, osteotomy, complications, longer surgical time, lower pulmonary function, larger residual curvature, and fusion into the lower lumbar spine than surgery in smaller curves ($<60^\circ$). Because the surgery is more complex and difficult for larger curves, early detection and referral for scoliosis remains important for optimum surgical results.

Introduction: If surgical results in larger curves are inferior to those in smaller curves, then earlier detection and referral should improve outcomes. The purpose of this study is to evaluate surgical results comparing larger to smaller curves.

Methods: From a prospectively collected database of adolescent idiopathic scoliosis surgery, patients with curves $<60^\circ$ (smaller curves) preoperatively were compared to those $>70^\circ$ (larger curves) both for perioperative issues and 2 year postoperative results. Chi-Square or Fisher's Exact Tests were used for categorical comparisons, and unpaired t-tests or Wilcoxon Ranked Sums for continuous variables.

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Results: 1729 patients had main curves $<60^\circ$ and 414 had curves $>70^\circ$ preoperatively. Larger curves were more common in non-Caucasians than Caucasians ($p<0.0001$) and in males than females ($p=0.0253$).

Patients with larger curves more frequently underwent osteotomies ($p<0.0001$), were more likely to receive perioperative allogenic blood ($p<0.0001$), have longer operative times (347min vs. 272 min, $p<0.0001$), and experience complications ($p=0.0022$) than patients with smaller curves. Compared to patients with smaller curves, pulmonary function was significantly lower both preoperatively and postoperatively ($p<0.001$) for those with larger curves. They also had larger residual curves postoperatively ($p<0.0001$). For each Lenke curve type, there was a shift for larger curves to have instrumentation lower into the lumbar spine, which was statistically significant for types 1, 2, 3, and 6.

On the other hand, those with larger curves had greater curve magnitude percent correction and improvement in SRS and SAQ scores than those with smaller curves

Conclusion: Surgery for larger curves, which is more common in minority populations, is more likely to result in blood transfusion, lower pulmonary function, complications, and fusion into the lower lumbar spine than surgery in smaller curves.

Significance: Because surgery for larger curves is more difficult with potential long-term effects than surgery in smaller curves, early detection and referral for scoliosis appears important for surgical results regardless of whether or not non-operative treatment is effective.

Paper #5

Larger Curve Magnitude is Associated with Increased Perioperative Healthcare Resource Utilization: A Multi-Center Analysis of 422 Adolescent Idiopathic Scoliosis Curves

*Firoz Miyanji, MD, FRCSC; Gerard P. Slobogean, MD, MPH; Amer F. Samdani, MD; Randal R. Betz, MD; Christopher W. Reilly, MD, FRCSC; Bronwyn Slobogean, PA-C; Peter O. Newton, MD
Canada*

Summary: Lengthy surgical waitlists for patients with Adolescent Idiopathic Scoliosis (AIS) often result in significant increases in curve magnitude. Curve progression has been suggested to increase the predicted complexity of surgery with implications on healthcare resource utilization. We found that larger curves lead to increased surgical time, number of levels instrumented, and the need for blood transfusion confirming that prolonged waitlists for scoliosis result in greater utilization of perioperative healthcare resources.

Introduction: Lengthy waitlists for surgery are common in publicly funded healthcare systems. Prolonged delays in scoliosis surgery can however lead to increasing deformity which can have significant implications on the surgical and peri-operative care required, subsequently impacting healthcare resources with greater costs to the healthcare system. We aimed to determine whether surgical correction of larger AIS curves increased the use of health care resources, and to identify potential predictors associated with increased peri-operative healthcare resource utilization in the surgical care of AIS patients.

Methods: A prospective longitudinal multi-center study evaluating operative outcomes of AIS yielded patients with Lenke 1A and 1B curves. Surgical time, number of levels instrumented, length of hospitalization, lowest instrumented vertebrae (LIV) and allogenic blood transfusion were the primary outcomes studied. Multivariable regression was used to identify potential predictors influencing these healthcare resources.

Results: 422 subjects with a mean age of 15 ± 2 years were included. The mean thoracic curve was $51.6^\circ\pm 9.5^\circ$. Larger curves lead to increase in surgical time ($p<0.0001$), number of levels instrumented ($p<0.0001$), and the need for blood transfusion with every 10 degree increase associated with a 1.5 times greater odds for receiving blood transfusion. Surgeon, bone graft method, and LIV were strong predictors of surgical time ($R^2=0.73$). Length of hospital stay was influenced by surgeon and intra-operative blood loss ($R^2=0.59$), while percentage curve correction, upper instrumented vertebrae, and surgeon were predictive of the number of levels instrumented ($R^2=0.66$).

Conclusion: Correction of larger curves is associated with increased utilization of perioperative healthcare resources, specifically surgical time, number of levels instrumented, and the need for blood transfusion.

Significance: Policies affecting prolonged waitlists for scoliosis surgery must consider the added costs to the healthcare system when treating larger curves and should focus on reducing the wait times.

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Paper #6

Should We Worry About Waiting Times for Idiopathic Scoliosis Surgery?

Stefan Parent, MD, PhD; Marjolaine Roy-Beaudry, MSc; Emmanuelle Coindet; Julie Joncas, BSc; Jean-Marc Mac-Thiong, MD, PhD; Marie Beauséjour; Hubert Labelle, MD

Canada

Summary: Four years of consecutive AIS patients were analyzed to find if a long waiting time affects surgery and which characteristics can help to prioritize patients on a waiting list. Long waiting time implied considerable progression of curves, modification of surgical plan and increase of potential complications. Two variables were related to progression, age and curve type. Young patients and patients with double curves should be prioritized.

Introduction: Curve progression while on a waiting list is a significant concern in AIS, especially when waiting time exceeds 6 months. The goals of this study is to analyze if waiting time can affect surgical planning, to determine associated complications and to define criteria to prioritize patients on waiting lists.

Methods: 177 consecutive AIS patients who underwent scoliosis surgery between January 2006 and December 2009 were analyzed. Selected dependant variables: patient characteristics, waiting time, blood loss and surgical time. Patients with significant progression ($>10^\circ$) while waiting for surgery were analyzed by three spine surgeons to determine if initial surgical planning needed to be changed. ANOVA tests were conducted on Cobb max differential (max Cobb angle when patient was enlisted compared to pre-operative max Cobb angle).

Results: Mean waiting time was 225.7 ± 127.3 days with a mean Cobb angle progression of $7.7^\circ \pm 8.6$. 47 patients had Cobb angle progression of more than 10° with a mean of $19.5^\circ \pm 8.1$ and mean waiting time of 221.0 ± 117.3 days. Surgical plan was modified for 28 patients between the time they were enlisted and the final surgery done; a combined anterior and posterior fusion was needed in 19 subjects, while longer posterior fusion was needed in 23 and pre-operative halo traction in 2. These changes in surgical planning significantly increased blood loss to 1408ml compared to 1019ml ($p=0.001$) and surgery time increased from 323 to 418 min ($p \leq 0.001$) respectively for combined procedures versus single approaches. Analyses confirmed that young age ($p \leq 0.001$) and Lenke type ($p=0.006$) were related to progression, with Lenke types with 2 or more structural curves progressing more than single curve Lenke types.

Conclusion: Long waiting time is associated with significant curve progression, change in surgical planning and potential increase of complications. Young patients and patients with double curves should be prioritized.

Significance: This study demonstrates the importance of reducing waiting time for elective AIS surgery.

*Paper #7

Long-Term Follow-Up of Thoracic Idiopathic Scoliosis with Pedicle Screw Instrumentation - More Than 10 Years Follow-Up

Se-Il Suk, MD; Jin-Hyok Kim; Dong-Ju Lim, doctor; Sung-Soo Kim; Tae-Hyung Kim; Jung-Il Han; Seung-Hyun Choi
Korea, Republic of

Summary: Selective thoracic fusion in thoracic idiopathic scoliosis was well maintained in 10 years follow up.

Introduction: Selective thoracic fusion with pedicle screw instrumentation has been proven to be an effective method. The purpose of this paper is to evaluate the outcome of selective thoracic fusion with pedicle screw fixation in thoracic idiopathic scoliosis with a minimum 10 year follow-up.

Methods: Ninety idiopathic scoliosis patients with 113 thoracic curves corrected by segmental pedicle screw fixation were analyzed. The minimum follow-up was 10 yrs (10~15.1 yrs). The deformity correction and spinal balance were evaluated by preop and postop standing PA and lateral radiographs. Measurements were made preoperatively, in 1 month, 1, 2, 5 yr and most recent follow-up.

Results: A total of 1,332 thoracic pedicle screws were inserted in the thoracic region (T1~T12). The average age at the time of operation was 14.6 yrs (8.9~22.4 yrs). The preop thoracic curve of 53.0 was corrected to 14.8 (71.8% correction) at 1 month after surgery. At latest follow up the curve correction was 16.4 (69.1%, 2.6% loss of correction). The non-instrumented lumbar curve of 31.7 was corrected to 9.6 (71.1% correction) at 1 month after surgery and measured 10.2 (69.6% correction, 0.6% loss of correction) at most recent follow-up. The preop thoracic kyphosis of 17.6 was improved to 23.1 one month after surgery and the 22.6 at latest follow up. The lumbar lordosis of 43.7 was corrected to 44.4 one month after surgery and was 45.7 at most recent follow-up. Coronal decompensation occurred in 6 patients in most recent follow-up. Postop distal adding on occurred in 16 patients who were fused short of the neutral vertebra. Adding on was seen in 6 patients in postop 1 year, 4 in 2 years and 6 in 5 years. No thoracic hypokyphosis or junctional kyphosis was found.

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Conclusion: Selective thoracic fusion with pedicle screw fixation in thoracic idiopathic scoliosis resulted in correction that was well maintained in long term follow up over 10 years. There was no change of correction after 5 years. Distal fusion to the neutral vertebra was imperative to avoid adding on deformity that occurred up to 5 years postoperatively.

Significance: Selective thoracic fusion in thoracic idiopathic scoliosis was well maintained in 10 years follow up.

*Paper #8

Long-Term Follow-Up Study of Unfused Segments of Idiopathic Scoliosis: Evaluation of X-Ray and MRI Images after More than 10 Years Postoperative

Noriaki Kawakami, MD; Kenji Seki, MD, PhD; Taichi Tsuji, MD; Kazuyoshi Mlyasaka, MD; Tetsuya Ohara; Ayato Nohara; Michiyoshi Sato; Kenyu Ito
Japan

Summary: This retrospective study was conducted to investigate the existence of disc degeneration (DD) in distal unfused segments and clinical outcomes over follow-up (F/U) periods of more than 10 years. 61 patients who matched the inclusion criteria: age at op. 11-25 years, AIS, MRI and X-ray images, and postop. F/U period of more than 10 years. Although patients did not exhibit any significant symptoms, DD was found in 42.6% patients, 76.9% of DD was located on the L4/5 or L5/S1.

Introduction: The purpose of this study was to investigate the existence of DD in distal unfused segments and clinical outcomes in IS over F/U Siperiods of more than 10 years.

Methods: This was a retrospective study. For 10 years from 1990 to 1999, 307 scoliosis patients underwent surgical correction. Of them, 61 patients (male 3, female 28) matched the inclusion criteria: 1) age at op. 11-25 years, 2) adolescent IS, 3) MRI and X-ray images, 4) postoperative F/U more than 10 years. Preop., postop., and final F/U main and lumbar curves, DD according to Pfirmann's grading system, and SRS-30 were evaluated by a spine surgeon who neither operated on the patients nor performed routine postop. check-ups on them.

Results: Patients ages were 15.2 at the time of op. and 27.1 years at F/U. Preop., Postop, and final F/U main scolioses were 59.0°, 22.7° and 25.2°, respectively. Lumbar curves were 38.7°, 16.0°, and 17.2°. Sagittal curves did not show any significant changes. 38 discs of 261 (14.6%) showed DD (Grade III-21, IV-17). 30 of 39 had degenerated discs on L4/5 (11) or L5/S1 (19). Of the Grade IV degenerated discs, 2 were lower adjacent to the fusion segments and 11 were located on L5/S1. 26 patients (42.6%) showed DD at the final F/U time (D-group) and the final scoliosis angle (30.0°) was significantly higher than those who did not show any DD (N-group, 21.5°) ($p=0.004$). Lumbar curve magnitude did not show any significant difference between the two groups. The number of distal mobile segments in group D was significantly less than that of N-group ($p=0.03$). Clinical outcomes evaluated with SRS-30 also demonstrated no significant difference between two groups.

Conclusion: Surgical correction and fusion of AIS provided good clinical outcomes for more than 10 years. Although patients did not exhibit any significant symptoms, DD was found in 42.6% patients, 76.9% of DD was located on the L4/5 or L5/S1.

Significance: Patients did not exhibit any significant symptoms during postop. F/U period more than 10 years, DD was found in 42.6% patients, 76.9% of DD was located on the L4/5 or L5/S1.

*Paper #9

Long-Term Clinical Outcomes of Surgery for Adolescent Idiopathic Scoliosis 21 to 41 Years Later

Tsutomu Akazawa, MD; Shohei Minami; Toshiaki Kotani; Kazuhisa Takahashi
Japan

Summary: Surgery had no effects on pain and mental health in middle age AIS patients 31 years later.

Introduction: Several long-term follow-up studies of surgically treated adolescent idiopathic scoliosis have been published that report on clinical outcomes for patients who have reached their 20s or 30s. However, clinical outcomes when patients reach middle age remain unknown. The purpose of this study was to determine the clinical outcome for a group of patients surgically treated for adolescent idiopathic scoliosis who have reached middle age.

Methods: Two hundred fifty-six patients surgically treated for adolescent idiopathic scoliosis (AIS) between 1968 and 1988 were included in this study. All patients were less than 20 years-old when they underwent surgery. The SRS-22 Patient Questionnaire and Roland-Morris Disability Questionnaire (RDQ) were used for evaluating long-term clinical outcomes. Sixty-six (25.8%) of the 256 patients answered the questionnaires, comprising 62 females and 4 males with a mean age of 46.0 (range 34-56) years and a mean follow-up period of 31.5 (range 21-41) years. Seventy-six healthy age- and sex- matched individuals were selected as a control (CTR) group, comprising 71 females and 5 males with a mean age of 46.6 (range 35-62) years.

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Results: The SRS-22 responses showed that the AIS patients had significantly decreased function (AIS: 4.3 ± 0.6 , CTR: 4.7 ± 0.5 , $p < 0.01$) and decreased self-image (AIS: 3.0 ± 0.8 , CTR: 3.7 ± 0.5 , $p < 0.01$) in comparison with the controls, but they identified no significant differences between the two groups with respect to pain (AIS: 4.3 ± 0.6 , CTR: 4.2 ± 0.5 , $p = 0.14$) or mental health (AIS: 3.9 ± 0.9 , CTR: 3.7 ± 0.7 , $p = 0.14$). The RDQ responses showed that back pain was not significantly increased in the AIS group compared with the CTR group (AIS: 1.8 ± 3.5 , CTR: 1.4 ± 3.1 , $p = 0.36$).

Conclusion: Surgery had no demonstrable adverse effects on pain and mental health in these middle age AIS patients 31 years later (on average), but the AIS patients did have significantly lower function and lower self-image than the age- and sex-matched healthy controls.

Paper #10

Dual-Rod Anterior Spinal Fusion for Adolescent Idiopathic Scoliosis Outcomes at Minimum 5-Years Compared to Previous 2-Year Follow-Up

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United States*

Summary: Dual-rod anterior spinal fusion for adolescent idiopathic scoliosis provides significant deformity correction. Coronal and sagittal deformity correction was maintained from 2-year to average 6-year follow-up. While no radiographic evidence of pseudarthrosis was present at 2-years, 1% of dual-rod ASF patients developed a pseudarthrosis after their 2-year follow-up. Patients with pseudarthrosis did not have significant worsening of their deformity but did trend towards worse SRS pain scores than at 2-year follow-up.

Introduction: Our prior study on 60 dual-rod anterior spinal fusions (ASF) at 2-years showed improved radiographic and clinical outcomes without pseudarthrosis. This study assesses dual-rod instrumentation outcomes at a minimum 5-year follow-up.

Methods: 92 consecutive patients had dual-rod ASF by 2 surgeons at 2 hospitals from 7/97-6/04 and were eligible for analysis. 55 patients (average age 15 yrs) (39/60 in prior study) with thoracic ($n=11$) (9/18 in prior study) or thoracolumbar/lumbar ($n=44$) (30/42 in prior study) curves and average 6 year (range, 5-10 yrs) follow-up had radiographic and clinical assessment. Pseudarthrosis was diagnosed if instrumentation failure or lack of disc space bridging bone were evident on radiographs.

Results: Dual-rod ASF maintained deformity correction at last follow-up compared to 2-years and coronal and sagittal deformity was significantly improved from preop (Table 1). Clinically, the thoracic and lumbar groups had similar radiographic deformity correction. At 2-years, no radiographic evidence of pseudarthrosis was present. Between 2- and 5-years, 4 patients (2 from prior 60 patients) had pseudarthrosis on x-ray. 3 patients lacked complete disc space bridging bone in at least 1 disc space, but had no implant failure. 1 of these 3 patients had complaints of back pain at last follow-up. 1 patient had implant failure with rod migration and underwent revision surgery. Despite pseudarthrosis, the 4 patients maintained their improved coronal and sagittal deformity correction from 2- to 5-years. There was no significant change in SRS pain, self-image or function for the Total group. Patients with pseudarthrosis had a trend for worse SRS pain scores at last follow-up.

Conclusion: This largest single institution study of dual-rod ASF with minimum 5-year follow-up revealed that dual-rod implants maintained deformity correction from 2- to 5-years. 4 patients had radiographic evidence of pseudarthrosis after 2-years, but maintained their deformity correction and SRS outcomes from 2-years. Assessment of fusion for dual-rod ASF may require a minimum 5-year follow-up.

Paper #11

A New Warning Criteria for Intraoperative Somatosensory Evoked Potential Monitoring in Scoliosis Surgery. A Prospective Multi-Center Study

*Yong Hu, PhD; Wa Y. Wong, MD; Kenneth M. Cheung, MD; Keith D. Luk, MD; Fan Jiang; Guixing Qiu, MD; Yuguang Chen
Hong Kong*

Summary: This is a prospective multi-centre study conducted in 3 University teaching hospitals. The aim is to evaluate a new set of warning criteria for intraoperative somatosensory evoked potential (SEP) monitoring considering both gradual and rapid SEP change. The study enrolled 703 scoliosis patients who underwent surgical correction with SEP monitoring. The proposed new warning criterion was found to provide higher specificity, sensitivity and accuracy of monitoring outcomes when compared with the conventional criteria.

Introduction: The conventional criteria for intraoperative somatosensory evoked potential (SEP) monitoring is a decrease of $>50\%$ in the amplitude and/or increase of $>10\%$ in the latency. However, it did not consider the time course of SEP change, i.e. whether the drop of amplitude is gradual or rapid. We proposed a set of new criteria which takes the time course into account would provide a more reliable method than conventional one. The criteria includes either a drop in SEP as $>10\%$ increase in la-

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tency, or >60% amplitude decrease gradually, or a reduction in amplitude by >30% within 30 minutes. This study was designed to evaluate the reliability of intraoperative SEP monitoring based on these new criteria.

Methods: This prospective multi-centre study was carried out in three University teaching hospitals with a consecutive series of 703 scoliosis surgeries from Jan 2003 to Dec 2007. All patients were monitored by posterior tibial nerve SEP. The monitoring outcomes were compared between the conventional criteria and the proposed criteria. Differences were analyzed using the χ^2 test for proportions.

Results: Nine patients showed postoperative neurological complications. Eight of them were detected by the proposed new criteria, while only 5 were detected by the conventional criteria. Within these 9 positive cases, one patient presented permanent neurological complication, which was detected by the new criteria showing a rapid reduction of 39%. The other 8 patients presented transient motor and sensory deficits. There were only 3 false positive cases, much less than 13 false positive cases by conventional criteria. The monitoring outcomes (Table 1) showed that the proposed criteria have less false cases and higher specificity, sensitivity and monitoring accuracy than the conventional criteria.

Conclusion: The proposed warning criteria taking into consideration the rapidity of onset of SEP changes was found to decrease false-positive warning, as well as avoiding false negative outcomes. This modified criteria were recommended as the reliable warning criteria for intraoperative spinal cord monitoring.

Significance: The proposed monitoring criteria can improve the reliability of intraoperative SEP monitoring for scoliosis surgery.

Paper #12

Significant Differences Among Patients in Lenke Curve Types

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United States

Summary: Lenke 3 and 4 curves have largest magnitude; 5 are oldest and smallest. Males have more thoracic curve types (Lenke 1-4) and less lumbar apical translation. Larger curves are seen in younger surgical patients.

Introduction: The use of Lenke curve types (for surgical planning, research and perhaps future genetic study) raises an important question: do Lenke types distribute in a homogeneous way, or are there significant differences in gender, age, frequency, magnitude at surgery, etc? We studied nearly 2000 surgical patients to answer this.

Methods: Methods: Parameters of 1912 AIS patients <21 y/o at operation were studied. Lenke type (LT) was verified. Curves were stratified as <50°, 50-75°, and >75°. Age, primary curve magnitude and gender were compared among types.

Results: *LT vary by gender:* males were more likely to have a major thoracic curve (types 1-4, 22% male) than major TL/L (5 & 6; 15% male) ($p=0.005$); Males also had fewer lumbar C modifiers (32 vs 44%, $p=0.001$) and less apical lumbar translation (1.1 vs 1.7 cm, $p=0.001$). *LT vary by frequency:* 50% were Lenke 1; least common were Lenke 3(5%) and 4(4%). *LT vary by magnitude at surgery* (Fig 1): Type 4 had the greatest % of large curves (52% > 75°); most smaller curves were LT 1 & 5. The largest mean curve was Type 4 (78°)*, followed by 3 (63°), 2 (60°), 6(59°), 1(52°)* and 5(46°)*(* comparisons $p<0.001$). *LT vary by age at surgery:* patients with Lenke 5 curves were oldest (15.4 yrs vs. 14.6 for all others) despite lowest mean magnitude ($p=0.001$). Curve size was negatively correlated with age at surgery ($r=-0.16$, $p=0.001$); Mean age at surgery was 14.2 for curves >75°, 14.6 for curves 50-75°, and 15.2 for curves < 50°. *LT vary by patient self image:* Lenke 4 patients had lower preop SRS scores for self image than Lenke 1 ($p=0.005$) and a trend toward lower total scores than most other LT ($p<0.079$).

Conclusion: Lenke curve types do not distribute among patients homogenously. Instead, this careful analysis of surgical AIS patients reveals that each Lenke type has its own "personality", characterized by age, gender, severity at surgery and patient self-image.

Significance: These differences should be considered in research design.

*Paper #13

Do Intra-Operative Antifibrinolytics Reduce Blood Loss in Adolescent Idiopathic Scoliosis? A Prospective Randomized Comparison

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United States

Summary: The benefit of using antifibrinolytics during spinal fusion surgery for AIS is controversial. We found a significant reduction in blood loss but not transfusion rate with antifibrinolytics compared with placebo. TXA may be more effective than EACA in reducing post-operative drain output.

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Introduction: Antifibrinolytics are known to reduce blood loss. However, the benefit of using these medications for patients with Adolescent Idiopathic Scoliosis (AIS) is unclear. No study has compared tranexamic acid (TXA), epsilon aminocaproic acid (EACA), and placebo to assess blood loss, transfusion rate, and post-operative drain output in a prospective randomized study.

Methods: This is a prospective, randomized, double blinded comparison of TXA, EACA and placebo used intra-operatively in patients with AIS. 60 patients with AIS were randomly assigned to one of the treatment arms or the placebo group. The physicians, patients, and researchers were blinded to this assignment. TXA was administered at 10mg/kg for a loading dose followed by 1mg/kg-hr, while EACA was given at a 10-fold higher dose. Estimated blood loss (EBL), pre and post-operative hematocrit, blood product usage, and post-operative drain output were recorded. An ANOVA with Tukey's post hoc analysis was used to compare groups. No pharmaceutical funding was received for this study.

Results: AIS patients received TXA (n=14), EACA (n=18), or saline (n=28) in the operating room (46F, 14M, mean age 15, range 11-21). Average blood loss with either TXA (794 ± 544 ml) or EACA (754 ± 484 ml) was less than placebo (1074 ± 738 ml) ($p < 0.05$). Total drain output was decreased with TXA (633 ± 427 ml) compared to EACA (1332 ± 585 ml) ($p < 0.05$), but not placebo (1080 ± 558 ml). There was no difference in the number of units transfused or the change in hematocrit during surgery comparing either medication against placebo. There were no thromboembolic, renal, or wound complications.

Conclusion: We report that intra-operative antifibrinolytics reduce blood loss but not transfusion rate in AIS. Total drain output was reduced with TXA compared to EACA, but both treatment options were equivalent in terms of operative blood loss.

Significance: Our study provides level-one evidence comparing TXA, EACA, and placebo in terms of blood loss, transfusion rate, and post-operative drain output.

Paper #14

Traction X-Ray Under General Anesthesia (TrUGA) Helps to Save Motion Segment in Surgical Treatment of Lenke Type 3C and 6C Curves

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Summary: TrUGA is an effective method for selection of fusion levels and may help to save L4 when compared to traditional x-ray methods in surgical treatment of Lenke type 3 and 6 curves.

Introduction: Several studies have shown the importance of saving L4 and stopping fusion lowest at L3 in patients with structural lumbar curves. However, fusing L4 may be necessary in many patients with structural lumbar curves (i.e. Lenke type 3 and 6) when the selection of fusion levels are done by using the traditional x-ray methods (TXR) (side bending, fulcrum and traction). The aim of this retrospective study was to evaluate if TrUGA helps to save L4 in patients with Lenke type 3C and 6C patients.

Methods: Eighty-nine consecutive patients (77 female and 12 male) with AIS Lenke type 3C (46 patients) and 6C (43 patients) curves underwent an instrumented posterior spinal fusion. The selection of fusion levels was done using the criteria of "stable vertebrae to be (SVTB)" and it was defined as the uppermost vertebrae of the lumbar curve that is not bisected by CSVL at the standing A-P film, but becomes parallel to sacrum and is bisected by CSVL or CSVL passes through the medial side of the concave pedicle at the TXR or TrUGA. The disc wedging under "SVTB" should be corrected to parallel and rotation should be corrected at least one to 2 grades. Preoperative radiological evaluation included standing A-P, lateral, supine lateral bending, traction radiographs, and also supine TrUGA. "SVTB" was determined by using TXR and TrUGA. Then pre-postop and follow-up curve magnitudes, LIV tilt, disc wedging below LIV and CSVL-LIV distance were measured (Table 1).

Results: The average follow-up was 5.4 years. Average age was 15.5 years. Pedicle screw constructs (PS) were used in all patients. LIV was L3 in 85 patients while it was L4 in 4 patients. Using the same selection criteria L3 was LIV according to both the TXR and TrUGA in 39 cases (44%) and fusion was stopped at L3. In 46 (52%) cases, TXR determined L4 as LIV while in all those patients L3 was the LIV according to TrUGA and fusion was stopped at L3 in all patients. LIV was L4 according to both methods in 4 (4%) patients and fusion was stopped at L4. None of the patients required additional surgery for decompensation and adding on.

Conclusion: TrUGA is an effective method for selection of fusion levels and may help to save L4 when compared to TXR in surgical treatment of Lenke type 3 and 6 curves.

Significance: -

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Paper #15

Role of Preoperative Cardiac Screening Studies in Adolescent Idiopathic Scoliosis Surgery

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United States

Summary: The prevalence of asymptomatic cardiac disease in adolescents with idiopathic scoliosis (AIS) has not been well documented. We have identified significant cardiac findings in our cohort of asymptomatic patients with severe AIS presenting for surgery. We were particularly interested in the novel findings of aortic root and valve abnormalities which are not present in the randomly selected, healthy adolescent patient.

Introduction: We sought to evaluate the incidence of occult cardiac disease in the severe AIS patient by reviewing the echocardiograms and EKGs performed at their pre-operative evaluation for spinal fusion.

Methods: Retrospective chart review of all surgical AIS patients from 2000-2007 was completed. Demographic information including age at surgery, sex, curve magnitude, fusion type, instrumentation, and surgical course was compiled. Patients with neuromuscular scoliosis or known/suspected cardiac disease were excluded. Pre-surgical screening 12 lead EKG, 2D-Doppler and M-mode echocardiograms were analyzed.

Charts of 215 pre-operative AIS patients were reviewed. 3 patients were excluded because the studies were not ordered. All patients were examined by a pediatrician and had normal cardiac examinations.

Results: 212 subjects (age 12-18) 154(73%) female, and 58(27%) male. 141(67%) had normal EKGs and echocardiograms. In 32(15%) subjects with EKG abnormalities, 28(88%) had normal variant readings, as outlined by the AHA statement on screening EKGs in ADHD patients (Vetter) and 4 subjects' EKGs met LVH by voltage criteria. However, echocardiograms were within normal limits in these patients.

Significant echocardiogram findings (table 1) revealed 2(0.94%) subjects with atrial septal defects (that delayed surgery) and 7(3.3%) subjects with aortic root/valve abnormalities.

Conclusion: In our cohort of pre-operative AIS patients, cardiac abnormalities ranged from mild to severe, and in 2 cases, affected the surgical timing. Novel findings of aortic abnormalities were identified in 3.3% of patients. Interestingly, the incidence of mitral valve prolapse was only 4.7% which is lower than described in prior studies, (14%-26%), and closer to the rate in the general population (3.2%)(Dhuper).

In a study which examined the prevalence of heart disease in randomly selected healthy adolescents with previously unknown cardiac disease (Steinberger), there was a rate of 3.6%(13/357) of cardiac anomalies. Of note, none had aortic root/valve findings.

Significance: The aortic root/valve abnormalities appear to be unique findings in patients with severe AIS, and suggest a possible collagen vascular component in this disease. Echocardiograms may be indicated in patients with AIS.

Paper #16

How Much is Too Much? Higher Degrees of Curve Correction Correlate with Worsened Sagittal Balance

Michael G. Vitale, MD, MPH; Omar F. Jameel, MD; Daniel J. Sucato, MD, MS; B. Stephens Richards, MD; John B. Emans, MD; Mark A. Erickson, MD; James O. Sanders, MD; Lawrence G. Lenke, MD

United States

Summary: Modern day techniques of correction of spinal deformity allow dramatic correction in both the frontal and axial plane, but concerns have mounted about unintended hypo-kyphosing effects and negative sagittal balance. This study reviews sagittal considerations in patients with adolescent idiopathic scoliosis (AIS) and demonstrates an association between worsened sagittal balance and >50% correction of the main coronal curve.

Introduction: Current methods of segmental fixation for the treatment of AIS allow higher degrees of frontal and axial plane curve correction, but can have unintended negative effects on sagittal balance.

Methods: Review of a large prospectively-collected multicenter dataset was performed to identify patients with AIS with neutral or negative sagittal balance at baseline, identifying 732 patients with 2 year postoperative follow up. Socioclinical variables and radiographic measures were reviewed to determine the association between major curve correction and sagittal balance.

Results: For the entire group, sagittal balance averaged -32.2 mm preoperatively and -29.6 mm postoperatively ($p=0.89$). However, 235 of 732 patients (32.1%) had a worsening of >10 mm in the negative direction at 2 years.

Patients with >50% major curve correction had significantly worse negative sagittal balance at 2 years than those who had <50% curve correction (-30.9 mm vs. -23.3mm, $p<0.01$). These two groups had equal sagittal balance at baseline (-31.2mm vs. -31.9mm, $p=0.76$).

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The relationship between postoperative sagittal balance and frontal plane correction was highly significant in Lenke type 1 ($p=0.01$) and 6 ($p=0.05$) curves, present but not significant in type 2 ($p=0.14$) and 3 ($p=0.23$) curves and not present in type 4 and 5 curves. Additionally among Lenke type 1 curves this relationship was especially strong in 1A curves ($p=0.02$), and present but not significant in Lenke type 1B ($p=0.12$) and 1C ($p=0.20$) curves. Finally this relationship was also marked for thoracic modifier "N" curves ($p=0.01$) and "+" curves ($p=0.05$) but not for "-" curves ($p=0.8$).

Conclusion: Roughly one-third of patients treated with modern day instrumentation techniques experience a significant worsening of preexisting negative sagittal balance at 2 years postoperatively. The effect of posterior spinal instrumentation on the sagittal plane must be carefully considered when surgeons are planning and executing correction of multidimensional spinal deformity.

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).

Paper #17

Residual Thoracic Hypokyphosis Following Posterior Spinal Fusion in Adolescent Idiopathic Scoliosis: Risk Factors and Clinical Ramifications

Nicholas Fletcher, MD; Jeffrey Hopkins, MSN, RN; Anna McClung, RN; Richard Browne, PhD; Daniel J. Sucato, MD, MS
United States

Summary: We assessed risk factors for persistent thoracic hypokyphosis following posterior spinal fusion for adolescent idiopathic scoliosis (AIS) and to compare clinical outcomes between patients with residual thoracic hypokyphosis and those with normal kyphosis. Risk factors for residual thoracic HK included preoperative thoracic hypokyphosis and curves with less main thoracic scoliosis. The use of smaller rods and pedicle screws was also associated with persistent hypokyphosis. Clinical outcomes were no different in the hypokyphotic group than in the normokyphotic patients.

Introduction: Adolescent idiopathic scoliosis (AIS) is characterized by thoracic hypokyphosis which should be corrected at the time of surgical treatment. Risk factors for residual thoracic hypokyphosis and the clinical ramifications have not been studied.

Methods: A review of a consecutive prospective series of patients at a single institution with AIS and a primary structural main thoracic (MT) curve who underwent PSF was performed. A radiographic and clinical assessment using the Scoliosis Research Society (SRS) 30 and Spinal Appearance Questionnaire (SAQ) were performed preoperatively and at 2 years. Patients were divided into two groups based on a threshold of 20° of thoracic kyphosis measured at two years follow up: <20° (HK group) and normal kyphosis >20° (NK group).

Results: There were 214 patients with an average age of 14.5 years with a T5-T12 kyphosis of 18.9° and a MT coronal curve of 60.9° preoperatively. Residual hypokyphosis <20° was seen in 83 (38.8%) patients. Preoperative risk factors for being hypokyphotic at 2 years were: male gender (21.69% vs 12.21%, $p=0.084$), preoperative kyphosis (11.4° vs 22.8°, $p<0.0001$) and smaller preoperative MT coronal curves (58.4° vs 62.0°, $p=0.004$). 71.5% of patients instrumented with 6.35mm rods were kyphotic at two years compared to 47.0% instrumented with 5.5mm rods ($p=0.0043$). 64.7% of patients with all-pedicle screw constructs remained hypokyphotic compared to 36.6% with hybrid constructs ($p=0.035$). There was no difference in proximal junctional kyphosis between groups (T2-T5: 11.6° (HK) vs 11.1° (NK), $p=0.71$) but thoracolumbar lordosis (T10-L2) was increased in the HK group (-8.0°(HK) vs -2.8°(NK), $p=0.0004$). Both groups had similar clinical results on the SRS-30 and SAQ at two year follow up ($P>0.05$).

Conclusion: Scoliosis patients with persistent thoracic hypokyphosis are usually hypokyphotic preoperatively and are more likely to have a smaller MT curve, perhaps due to less contouring of the rod prior to rod rotation. Use of pedicle screws and 5.5mm rods increased the risk of having residual hypokyphosis. Hypokyphosis did not seem to decrease clinical outcomes at two year follow up.

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).

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Paper #18

Analysis of Internal Construct Validity of the SRS-24 Questionnaire

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Switzerland*

Summary: The SRS-24 questionnaire does not meet properties of internal construct validity. Adjustments are recommended for a valid linear and unidimensional change score

Introduction: The SRS-24 questionnaire is widely used for outcome assessment in adolescent idiopathic scoliosis patients. While the questionnaire was validated using methods of classical test theory, internal construct validity has never been shown. Internal construct validity, i.e. unidimensionality and linearity, is a fundamental arithmetic requirement and needs to be shown for a scale for summing any set of Likert-type items

Methods: 250 SRS-24 questionnaires distributed to 116 patients pre-operatively and at follow-up were analyzed. All patients were diagnosed with adolescent idiopathic scoliosis. The questionnaires were subjected to Rasch analysis using the RUMM2020 software package. Rasch analysis involves an iterative process on which items are analyzed for psychometric properties such as threshold ordering, linearity, unidimensionality and reliability indices, contrasting traditional methods

Results: The SRS-24 questionnaire as a summated score is multidimensional and shows misfit to the Rasch model and therefore lacks linearity. Disordered thresholds between response options were found in 10/24 items. The response options had to be collapsed in order to achieve threshold ordering. While the 7 different domains still showed misfit to the Rasch model, 4/7 were unidimensional as would be expected. Unidimensionality and linearity, i.e. fit to the Rasch model, could only be achieved for an aggregate score by separating pre- and postoperative items and omitting items which caused model misfit. Reducing the questionnaire to 7 pre-operative items ($p=0.062$; 1.28% t-tests) and 5 postoperative items ($p=0.267$; 3.70% t-tests) yields model fit and unidimensionality for both summated scores. The person-separation indices (PSI) were 0.67 and 0.69 respectively, corresponding to the Cronbach alpha of the original questionnaire

Conclusion: The SRS-24 score is a non-linear and multidimensional construct. In principle, adding the items into a single value is therefore not supported and invalid. Making profound changes to the questionnaire, yields a score which fulfills the properties of internal construct validity and supports its use as a change score for outcome measurement

Significance: Internal construct validity is fundamental requirement for calculation of change scores

Paper #19

Validation of the Scoliosis Appearance Questionnaire

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United States*

Summary: The SAQ is a valid measure of self-image in patients with adolescent idiopathic scoliosis. It has higher correlation coefficient to curve magnitude than the SRS Appearance domain and total score. It also discriminates between patients who require surgery from those who do not.

Introduction: The Scoliosis Appearance Questionnaire (SAQ) was originally developed from the Walter Reed Visual Assessment Scale. Although the SAQ has been administered to a large sample of patients with adolescent idiopathic scoliosis (AIS) treated surgically, its psychometric properties have only been studied in a small sample of patients. The purpose of this study is to evaluate the validity of the SAQ.

Methods: The SAQ was administered to patients seen in the clinic for evaluation of AIS. This included patients who were being observed, braced or scheduled for surgical treatment of their curves. The SAQ was administered concurrently with the Scoliosis Research Society-22 (SRS-22) questionnaire. Standard demographic data was collected. Radiographic measures including Lenke type and curve magnitude were also collected.

Results: Of the 1802 patients that participated, 83% were female; with a mean age of 14.8 ± 2.1 years and mean Cobb angle of 55.8 ± 13.7 degrees. From the original 32 items of the SAQ, 14 items were found to have significant correlations across all Lenke types, producing 2 factors: an Appearance factor (Items 1 to 10) and an Expectations factor (Items 12 to 15). The responses to the items are summed giving a range of 10 to 50 for the Appearance domain and 4 to 20 for the Expectations domain. Higher scores represent worse measures. Baseline data comparing patients who were observed, braced and had surgery are summarized in Table 1. In patients who had surgery, domain scores were statistically significantly different from the one-year scores for Appearance (24.9 vs 14.8, $p<0.0001$), Expectations (15.7 vs 8.3, $p<0.0001$) and Total (40.5 vs 23.0, $p<0.0001$). Correlations with the major curve magnitude were higher for the SAQ Appearance (0.361) and SAQ Total (0.324) scores compared to correlations between the SRS Appearance (0.033) and SRS Total (0.160) scores.

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Conclusion: The SAQ is a valid measure of self-image in patients with adolescent idiopathic scoliosis. It has higher correlation coefficient to curve magnitude than the SRS Appearance domain and total score. It also discriminates between patients who require surgery from those who do not.

Paper #20

Cognitive Testing of the Spinal Appearance Questionnaire (SAQ) with Typically Developing Youth and Youth with Idiopathic Scoliosis

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United States

Summary: The spinal appearance questionnaire (SAQ), a patient-reported outcome measure of appearance for youth with idiopathic scoliosis, underwent cognitive testing to evaluate reading, comprehension, and interpretation of the items. Not one item was read, answered, and interpreted without problem. Difficulties were encountered with medical words, vagueness of questions, and illustrations that were misidentified. This study does not support the use of the SAQ with youth and highlights the importance of field testing measures for readability and comprehension prior to use.

Introduction: This cross-sectional study evaluates the readability, comprehension, and interpretation of items on the SAQ. Cognitive interview methodology of 57 youth (8-16 yrs; average age 13) included 22 with scoliosis and 35 typically developing.

Methods: SAQ written and pictorially illustrated items and responses were read aloud. Subjects were required to think aloud to capture cognitive processes about the items and responses. For each item, subjects were asked "in your own words tell me how you would ask this question and what you think this question is asking." Interviews were audio taped and transcribed verbatim. Percent of subjects with at least one problem per SAQ item was calculated. Problems were categorized and frequencies for each category were calculated.

Results: Not one SAQ item was read, answered, and interpreted without problem (Table 1). Subjects (12%) had least difficulty with item 16 ("I want to have more even shoulders") and most difficulty (96%) with items 2 & 3 (rib prominence, flank prominence). Subjects did not understand the meaning of "prominence" and "flank;" these words were also problematic for subjects (84%) on items 7 & 8. 65% of subjects reported item 12 ("I want to be more even") as too vague, and 84% of subjects were unable to understand item 14 ("I want more even breasts") either because they were not yet developed (40%) or the meaning was unclear (44%). The pictorial illustrations for items 2 and 3 were problematic for 58% and 49% of subjects, respectively. The illustrations of the lungs (item 4) and hips (items 4 & 5) were problematic for 42% and 27% of subjects, respectively. The lungs were misinterpreted as the heart, stomach, and breasts and the hips as the bladder, reproductive system, stomach, and digestive system. These results were consistent regardless of age or diagnoses.

Conclusion: This study does not support the use of the SAQ as currently used with youth due to use of complex medical words, vague questions, difficult illustrations, and various interpretations of the intent of many of the items. A modification of the SAQ is under development.

Significance: Acknowledgements: The study was funded in part by the Shriners Hospitals for Children-Philadelphia and a grant from DePuy-Spine, Inc.

Paper #21

Body Image Disturbance Questionnaire-Scoliosis Version: Discriminant Validity in AIS

Jennifer Ahn, MS; Phedra Penn, MS; Neil Bharucha; Joshua D. Auerbach, MD; Suken A. Shah, MD; Baron S. Lonner, MD

United States

Summary: The BIDQ-S has been validated for internal consistency and construct validity in AIS patients. To establish discriminant validity, 75 operative and non-operative AIS patients and 205 healthy adolescents completed the BIDQ-S. Analysis revealed a significant difference in scores between the groups (1.55 vs. 1.08, $p < 0.001$), between females of the groups (1.59 vs. 1.05, $p < 0.001$), and between males of the groups (1.44 vs. 1.09, $p < 0.001$). This finding further validates the BIDQ-S as a reliable and unique tool to assess psychosocial outcomes of AIS.

Introduction: Psychosocial construct measurements have become increasingly valuable in evaluating the impact of adolescent idiopathic scoliosis (AIS) on patients. The Body Image Disturbance Questionnaire-Scoliosis Version (BIDQ-S) has been validated for internal consistency and construct validity in 50 AIS patients, proving to be a reliable instrument for measuring appearance-related distress in this population. The purpose of this study was to establish discriminant validity of the BIDQ-S by comparing responses of operative and non-operative AIS patients with those of normal adolescents without AIS.

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Methods: 75 AIS patients (age: 14.0; 80% F), and 205 healthy adolescents without AIS (age: 16.1; 50.9% F) were enrolled into a single-center, cross-sectional study. Subjects completed two self-report questionnaires: the BIDQ-S and a race/demographic form. Patients completed them pre-treatment. Independent sample t-tests and Pearson correlation coefficients were calculated.

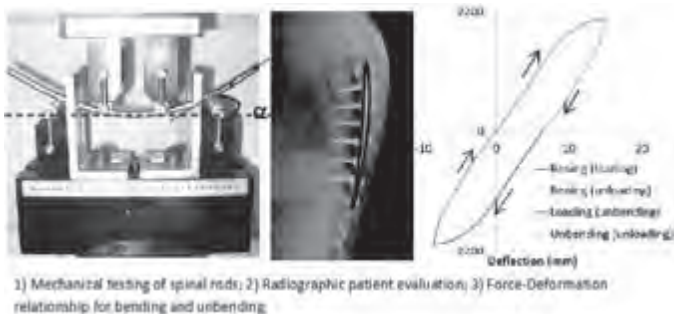
Results: There was a significant difference in BIDQ-S scores between AIS patients and healthy adolescents (1.55 vs. 1.08, $p < 0.001$), between females of the groups (1.59 vs. 1.05, $p < 0.001$), between males of the groups (1.44 vs. 1.09, $p < 0.001$) and between non-operative AIS patients and healthy adolescents (1.51 vs. 1.08, $p < 0.001$), establishing discriminant validity of the questionnaire. There was no significant effect of age, race, or BMI on BIDQ-S scores in each group. The difference in BIDQ-S scores between operative and non-operative AIS patients did not reach significance (1.58 vs. 1.51 $p = 0.50$) despite greater curve severity in operative patients (major Cobb: 50.9° vs. 24.0°, $p < 0.001$). There was no significant difference in scores between male and female AIS patients.

Conclusion: In contrast to healthy adolescents in the general population, the scores of AIS patients are indicative of greater back-related body image disturbance and social impairment as a result of this distress. This finding further validates the BIDQ-S as a unique tool to quantify psychosocial disease outcomes for AIS.

Paper #22

In Vivo Forces Resulting from Spinal Rod Instrumentation for Scoliosis Correction

Diana A. Glaser, PhD; Krishna C. Ravi; Thomas Nunn, BS; Tracey Bastrom, MA; Peter O. Newton, MD
United States



Summary: The present study analyzed the corrective forces applied to the spine resulting from “over contouring” of scoliosis rod instrumentation. The deformation and the forces exerted by the instrumented spine were determined by combining 3 research approaches: 1) Mechanical analysis of the force-deformation characteristics of straight 5.5mm Ultra Strength Steel (USS) rods; 2) forces required to unbend pre-contoured rods; and 3) pre- and post-op rod shape changes for extraction of *in vivo* forces.

Introduction: Instrumentation for scoliosis correction and fusion commonly employs surgical rods. However,

there is a lack of understanding of the forces applied to the spine from those implants.

Methods: Initially, 4-point bending tests of nine 5.5mm USS rods were performed using MTS858 test frame. Next, pre-bent rods were straightened via the same method. This testing defined the force-deformation curves during both bending and unbending allowing mathematical equations to be derived by curve fitting. Lastly, 29 patients with surgical scoliosis correction had pre-op (rod tracings) to post-op (sagittal x-rays) rod contour changes measured extracting *in vivo* rod deflections. *In vivo* corrective forces were calculated using the derived equations (from the 4 pt rod bending/unbending tests).

Results: The force-deformation relationship shows the typical linear region of elastic deformation as well as the typical unloading curve parallel to the original elastic portion of the curve, with an Ultimate Load (UL) for this material of 2080N. For the 29 clinical cases examined, the surgeons majority (97%) of the rods on the concave (left) side were contoured to a large kyphotic deflection of 25.5 ± 5.1 mm (kyphosis of 34°) which then unbent after implantation to $54 \pm 18\%$ of the pre-bent deflection with a corresponding bending force in the sagittal plane of 1761 ± 718 N. Contrarily, on the convex side, rods were pre-bent to only 15.1 ± 2.7 mm (kyphosis of 20°, $p < 0.001$) and 66% of them were bent further after implantation to 16.6 ± 3.9 mm (kyphosis of 22°, $p = 0.01$). The resultant convex rod bending force averaged 1249N ($p = 0.001$).

Conclusion: Concave rod forces were significantly larger than forces in the convex rod ($p = 0.025$) and were more likely to further unbend after implantation ($p = 0.001$) resulting in high pull-out forces for the screws. For the first time, *in vivo* spinal rod forces have been determined using biomechanical and clinical information. This study will help surgeons select the ideal pre-operative spinal rod shape and screw dimensioning for optimal and safe surgical correction.

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Paper #23

Pedicle Response During Insertion of Pedicle Screws in Pediatric and Adult Thoracolumbar Spines: A Biomechanical Comparison of Five Age Groups

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United States

Summary: While biomechanical properties are different for pediatric and adult bone, it is unknown whether changes finalize with skeletal maturity or serve as a continuum over time.

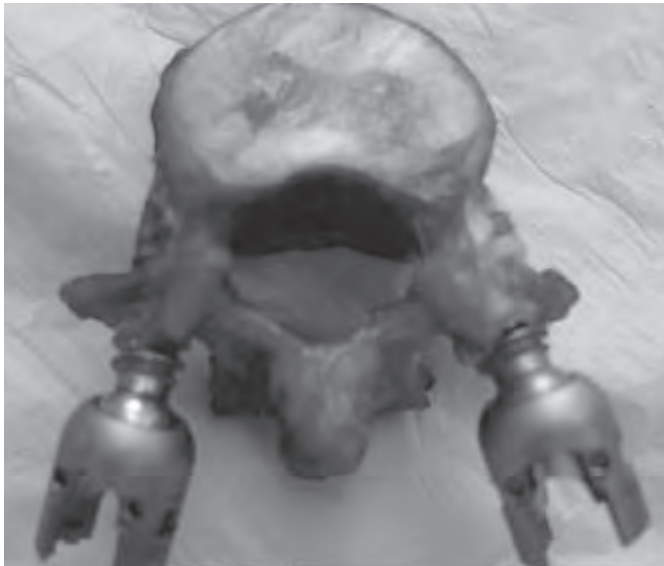
Introduction: Our objective was to clarify pedicle bone elasticity and stratify the biomechanical differences over time. We hypothesized that pedicles of increasing age would demonstrate diminished viscoelastic properties during screw placement.

Methods: Two pediatric cadaveric specimens (9 and 13 years old) were compared to three adult specimens. All specimens were instrumented bilaterally from T2-L5. A 2-mm gearshift, 4.75 mm tap, and screws were sequentially placed in 0.75 mm increments (5.5 - 8.5 mm). This continued until: (1) we reached the largest screw of (8.5 mm), or (2) there was medial or lateral cutout. We used digital calipers/measuring devices to record the height, width, and circumference of the pedicle. We recorded measurements before instrumentation, and before/after every tap and screw placement. Pre/Post-instrumentation radiographs and post-instrumentation axial cuts of the vertebral bodies confirmed cortical integrity. Cutouts were determined visually.

Results: The results are summarized in table 1. Circumferential pedicle expansion occurred in all specimens in the thoracic spine. In all age groups, the most marked changes occurred in pedicle width, especially in the thoracic spine ($p < 0.05$). Pediatric pedicles expanded circumferentially more than their adult counterparts ($p < 0.05$). Most pedicles in all age groups were able to accept a screw much larger than their endosteal diameter ($p < 0.05$) based upon CT measurements.

Conclusion: Our study confirms that the pediatric pedicle undergoes plastic accommodation followed by circumferential expansion in response to pedicle screw placement. Similarly, adult specimens demonstrate viscoelastic circumferential expansion in the thoracic spine, and to a less predictable degree in the thoracolumbar junction and lumbar regions. Most pedicles in all age groups were able to accept screws much larger than their endosteal diameter. These findings may support the use larger screws for instrumentation of the pediatric and adult spines.

Significance: To our knowledge, this is the first study to confirm viscoelastic accommodation and circumferential pedicle expansion in children and adults after the placement of pedicle screws.



Pediatric pedicle expansion after screw placement

† Paper #24

Effect of Spinal Shortening on Motor-Evoked Potentials and Spinal Cord Blood Flow

Hitesh N. Modi, MS, PhD; Seung-Woo Suh, MD, PhD; Jae Hyuk Yang, MD; Jae-Young Hong, MD
Korea, Republic of

Summary: Animal study for spinal cord injury using spinal shortening is imperative to be helpful.

Introduction: Objectives were to study effect of spinal cord injury (SCI) on trans-cranial motor-evoked potential (Tc-MEP) and changes in the spinal cord blood flow (SCBF) on the LASER Doppler.

Methods: Experiment was performed in 10 farm-pigs under general anesthesia. Neuromonitoring was done using Tc-MEP, and SCBF was measured using LASER Doppler flow meter. After dissection, pedicle screws were inserted in T10 and T13 level; which was followed by osteotomy and two level (T11-T12) corpectomy. A gradual staged (phase 1: without morphological change, phase 2: cord buckling, and phase 3: cord kinking) spinal shortening was performed, and simultaneously Tc-MEP and SCBF was monitored. After 30 minutes wake-up test was performed and animal was sacrificed and cord biopsy was obtained.

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Results: During spinal shortening MEP signals were maintained in phase1 and phase2; however, during phase 3, all leads were lost suggesting complete SCI (32.2 ± 3.6 mm). The average spinal shortening showing SCI (35 ± 2.7 mm) was similar to average vertebral body height of T11-12 (33.6 ± 1.9 mm) ($p=0.115$). However, when the distance of spinal shortening was compared with the average segmental height (27.7 ± 1.3 mm) of spinal column (T1-L6), it showed a statistically significant difference ($p < 0.0001$). Considering into percentage of spinal column length, SCI was not occurred at the shortening of 5.1% length of spinal column (safe zone); however, SCI occurred at shortening of 6.3% length of spinal column (unsafe zone). On SCBF measurement, during phase 3 of shortening where it produced SCI, SCBF decreased by $43.1 \pm 11.4\%$ ($p < 0.0001$). On wake-up test, we could not observe movements. Histopathology exhibited axonal cutting with ischemic and necrotic changes.

Conclusion: Spinal shortening at TL level can be done safely with the shortening of average segmental height or 5.1% length of spinal column (T1-L6); however, it creates SCI if shortening is of average vertebral body height at T11-T12 or 6.3% length of spinal column.

Significance: Spinal shortening induced SCI model in pig will highlight its relation with spinal shortening amount in future.

†Paper #25

Mechanism of Osteoporosis in Adolescent Idiopathic Scoliosis: Experimental Scoliosis in Pinealectomized Chickens

Masafumi Machida, MD; Hiroyuki Katon; Hitoshi Kono; Shinjiro Kaneko; Kentaro Fukuda; Masashi Saito; Masakazu Takemitsu
Japan

Summary: The radiological and histological changes in the cervical spine were evaluated in experimental scoliosis in chickens. Melatonin deficiency plays a crucial role in the development of scoliosis and osteoporosis.

Introduction: The radiological and histological changes in the cervical spine were evaluated in experimental scoliosis in chickens. Melatonin deficiency plays a crucial role in the development of scoliosis and osteoporosis.

Methods: Forty new-hatched broiler chickens were divided into equal four groups: sham operated chickens serving as control (CNT); pinealectomized chickens (PNX); sham operated (CNT+MLT) and pinealectomized chickens (PNX+MLT) that received intraperitoneal administration of melatonin (MLT) (8 mg/kg BW) at 22:00 hr daily. Surgeries were performed at the age of 3 days. Before killing the chickens at 2 months of age, blood samples were collected in the middle of the light-dark cycle and melatonin levels were measured by radioimmunoassay. Postmortem X-rays were examined for the presence of a scoliosis, and microCTs were taken to evaluate the microstructure of the cervical vertebrae. A midsagittal section of the scanned cervical vertebrae was stained with HE and TRAP to evaluate osteoblasts and osteoclasts respectively.

Results: Scoliosis developed at the thoracic spine in all PNX and in 2 of the PNX+MLT groups. MLT levels in the PNX group were reduced remarkably, while normal levels were restored in the PNX+MLT group and were normal in the CNT and CNT+MLT groups. The data from microCT was evaluated for several architectural parameters such as bone volume fraction (BV/TV), trabecular number (Tb.N), trabecular thickness (Tb.Th), star volume of marrow space ($V^*m.space$) and of the trabeculae (V^*tr), and revealed that pinealectomized chickens had generalized osteoporosis. The number of osteoblasts was significantly decreased in the PNX group, while no significant difference observed between the CNT and PNX+MLT groups. The number of osteoclasts were similar in all groups.

Conclusion: Our results suggest that MLT stimulates osteoblast proliferation and that MLT deficiency plays a crucial role in the development of scoliosis and osteoporosis. The restoration of MLT levels prevented the development of scoliosis and osteoporosis, indicating that the levels of MLT might be the key to scoliotic deformity and osteoporosis in AIS.

Significance: This is the first report indicating that the levels of MLT might be the key to scoliotic deformity and osteoporosis in AIS.

†Paper #26

Vertebral Growth Modulation in the Porcine Scoliosis Model Assessed by Computed Tomography: 3-D Effect of a Corrective Tether

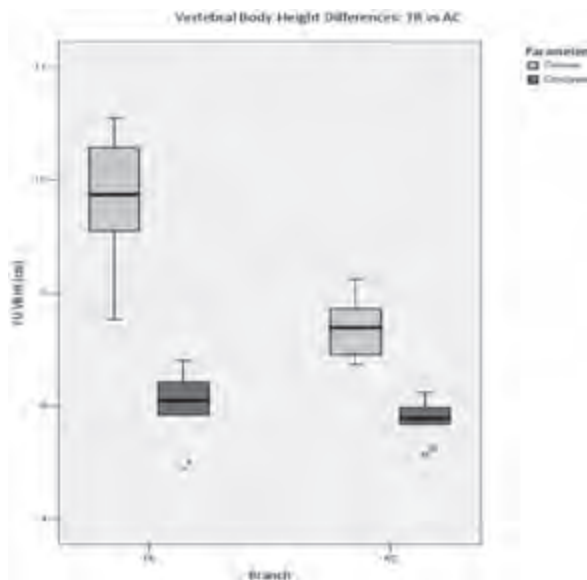
Frank J. Schwab, MD; Ashish Patel, MD; Virginie C. Lafage, PhD; Benjamin Ungar; Jean-Pierre C. Farcy, MD
United States

Summary: Using an established porcine scoliosis model, this study aimed to investigate the 3D effect of an anterior corrective tether (non-fusion technology). Thin CT scan reconstructions were obtained and analyzed to compare the corrective group ($n=5$) to a control group ($n=5$). This study demonstrated that using an anterior tether, favorable growth modulation was possible without affecting the overall vertebral volume and lead to a 3 plane correction of the scoliosis: correction of coronal Cobb, reduction of axial rotation, restoration of sagittal kyphosis

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Introduction: In theory, vertebral growth modulation through a convexly placed tethering implant in the setting of scoliosis would lead to progressive vertebral correction in the coronal plane (Hueter-Volkman Principle). Using an established Porcine Scoliosis Model, this study aims to investigate the impact of a non-fusion corrective anterior convex spinal tether on an induced deformity, examining detailed vertebral morphology and axial rotation.



Methods: This IACUC approved Study included 10 immature Yorkshire Pigs divided into 2 groups; tether release group (TR, n=5) and corrective tether group (CR, n=5). All animals underwent induction of scoliosis. Once $>50^\circ$ was noted on radiographic follow up a second surgical intervention was pursued: TR had release of the inducing tether; AC had tether release and placement of a corrective tether over the 5 apical vertebrae. Both groups were observed for 20 weeks then euthanized. Fine cut CT scans were used to create a volumetric 3D reconstruction of the apex (3vertebrae, 2discs). Student T-test was used to evaluate differences between groups.

Results: Regarding absolute vertebral heights, no significant differences were observed between TR and AC in posterior and concave dimensions. However, significant reduction was found in anterior and convex AC vertebral heights; TR 8.9cm vs. AC 7.9cm ($p<0.01$) and TR 9.8cm vs. AC 8.7cm ($p<0.01$) respectively. No significant difference was found in apical vertebral body volumes between TR 18.3cm³ and AC 17.7cm³ while the AC group presented bigger vertebral enplates: TR=5cm², AC=5.5cm² ($p=0.01$) A significant reduction in coronal wedging angle of 18° was found

between TR= 36.1° and AC= 18.1° ($p<0.01$). A significant increase in sagittal kyphosis was observed over the apex: TR= $+6^\circ$ AC= -9.6° ($p=0.04$). A 25% correction in apical rotation was demonstrated in the transverse plane

Conclusion: This study demonstrated that using an anterior tether, favorable growth modulation was possible without affecting the overall vertebral volume and lead to a 3 plane correction of the scoliosis: correction of coronal cobb, reduction of axial rotation, restoration of sagittal kyphosis

Paper #27

The Role of Remodeling and Asymmetric Growth in Vertebral Wedging

David D. Aronsson, MD; Ian A. Stokes, PhD; Carole McBride
United States

Summary: In a rat tail model, an external fixator imposed a scoliosis of 30° with compression for 6 weeks creating scoliosis with vertebral wedging in immature and mature animals. Serial micro CT scans and fluorochrome labels were administered to measure the amount of asymmetric growth and remodeling. All animals developed scoliosis with vertebral wedging. The majority of wedging in immature animals was caused by asymmetric growth, whereas the majority of wedging in mature animals was caused by remodeling.

Introduction: Scoliosis with vertebral wedging is caused by asymmetric growth (Hueter-Volkman law), but vertebral diaphyseal remodeling (Wolff's law) may also contribute to the deformity. Since malaligned teeth can be straightened in adults, we investigated if vertebral wedging in scoliosis might involve both mechanisms. We applied an external fixator to rat tail vertebrae to impose a 30° scoliosis and compression loading in immature and mature animals for 6 weeks. In each group, the contribution of asymmetric growth and remodeling to the overall wedging of the apical vertebra was calculated.

Methods: An external fixator was used to impose a 30° scoliosis and compression of 0.1 or 0.2 MPa in 3 groups of 10 Sprague-Dawley rats. Group 1: immature animals with 30° scoliosis and 0.1 MPa compression, Group 2: mature animals with 30° scoliosis and 0.1 MPa compression, and Group 3: mature animals with 30° scoliosis and 0.2 MPa compression. Vertebral wedging and diaphyseal curvature were measured from micro CT scans performed at weeks 1, 3, and 6. Wedging due to asymmetrical growth and remodeling was calculated from Calcein labels administered at week 3, and from Xylenol labels administered 24 hours prior to euthanasia.

Results: The growth rate of the loaded vertebrae as a per cent of control vertebrae was 60% in Group 1, 40% in Group 2, and 30% in Group 3. The growth rate of control vertebrae in mature animals was 16% that of immature animals. The animals in all 3 groups developed a scoliosis with vertebral wedging.

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The results are summarized below and in Table 1.

1. Asymmetric growth was much greater in Group 1 (young) animals.
2. The ossified epiphyses became wedged.
3. Diaphyseal remodeling occurred in all groups.

Conclusion: Scoliosis with apical vertebral wedging was created in all animals. The major contribution to the vertebral wedging was asymmetric growth in the immature animals and diaphyseal remodeling in the older animals.

Significance: The results support the concept that if appropriate loads can be applied to human vertebrae through minimally invasive techniques, scoliosis and vertebral wedging can be corrected without a spinal fusion in both adolescents and adults.

Acknowledgments: Funded by a Scoliosis Research Society Grant

Paper #28

Innovation in Growing Rod Technique; Study of Safety and Efficacy of Remotely Expandable Rod in Animal Model

Behrooz A. Akbarnia, MD; Gregory M. Mundis, MD; Pooria Salari, MD; Burt Yaszay, MD

United States

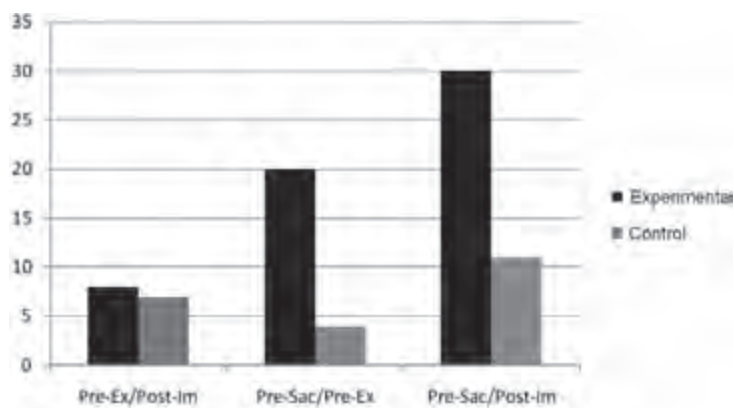


Figure: Growth ratio (%) in vertebral levels between cephalad and caudal foundations.

Summary: Growing rods (GR) are commonly used in treatment of early onset scoliosis (EOS). They require multiple surgeries for lengthening and have a high complication rate. This is the first study evaluating the safety and efficacy of a remotely expandable rod (RER) in an animal model. RER proved to be a safe and effective way to remotely distract the spine. This technique shows promise as an alternative treatment in the surgical management of EOS in the future.

Introduction: Treatment of severe early onset scoliosis (EOS) is challenging. GR are commonly used but require multiple surgeries for lengthening. Improved technology may allow remote lengthening without surgery. We aimed to evaluate the safety and efficacy of a remotely expandable rod (RER).

Methods: 9 immature male Yucatan pig were randomly assigned to experimental group (EG, 6 pigs) and sham group (SG, 3 pigs). All had 3 cephalad and 2 caudal foundation levels instrumented with 7-9 levels in between (12-14 levels). A unilateral RER was implanted in EG, and no rod in SG. RER contains a non-shapeable actuator. A small magnet in the actuator is used to distract or retract. Follow up was 10 weeks. EG had 7 mm of remote distraction under sedation for 7 weeks. Implants were removed after 7th week. Both groups had weekly AP and lateral XR. CT was obtained after the index surgery (IS), before implant removal (IR) and before sacrifice. The thoracic and lumbar spines were harvested for further study after sacrifice.

Results: Mean age in EG and SG was 7.1 and 7.3 months. No difference in weight at IS or throughout the study. 1 EG pig died after IS; neurologic complication (comp) caused by screw malposition. Mean distraction achieved in EG was 39 mm (32-46); less than 48mm planned distraction. We postulate fat thickness decreased distractions forces resulting in this difference. No complications resulted from distraction. 1 pig had a sterile fluid collection at lower foundation, treated with drainage and prophylactic antibiotics. A retained sponge was found after sacrifice. XRs and CTs showed no implant failure. In the non instrumented segment mean spinal growth at 7 weeks was similar in SG and EG (8% vs. 7%). However, after IR, spine growth increased significantly in EG while in SG growth followed a linear rate (Figure). At sacrifice total growth (12-14 levels) was greater in EG vs. SG (27% vs. 12%).

Conclusion: RER proved a safe and effective way to remotely distract the spine. No complications resulted from distraction. Distraction accuracy and retraction features of this device make it more reliable in controlled distraction. RER shows promise as an alternative treatment in the surgical management of EOS in the future.

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).

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Paper #29

The Impact of Adult Scoliosis on the Cervical Spine

Steven D. Glassman, MD; Leah Y. Carreon, MD, MSc; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Serena S. Hu, MD; Keith H. Bridwell, MD

United States

Summary: In a cohort of 1721 adult scoliosis patients, 420 (24.4%) had neck complaints. A more proximal Upper End Vertebra was predictive of the presence of neck pain complaints. The data suggests that an increased focus on the relationship between adult scoliosis and cervical spine pathology is warranted. It seems reasonable to presume that, analogous to the situation in the lumbar spine, degenerative changes in the cervical spine may impact the clinical course of an adult spinal deformity, and visa versa.

Introduction: Assessment of adult scoliosis typically involves evaluation of both the primary deformity and the lumbar spine. In contrast, little attention has been devoted to the impact of adult scoliosis or treatment on the cervical spine. The purpose of this study is to assess the frequency of cervical spine complaints in an adult scoliosis population, and to determine whether radiographic characteristics of the spinal deformity predict cervical symptoms.

Methods: We reviewed a cohort of adult scoliosis patients entered in a prospective data base of adult spinal deformity. Patients who indicated that their neck bothered them or limited their function were identified. Student's t-tests were used to determine any difference in continuous variables between patients who complained of neck pain and those that did not. Fisher's exact test was used to determine any difference in categorical variables between the groups. Binary regression analysis was done to determine factors predictive of the presence of neck complaints.

Results: 420 (24.4%) of 1721 patients included in the analysis had neck pain. Neck pain complaints were statistically greater in patients aged 40 to 60 years old (29.3%), followed by 18 to 39 years old (25.1%) and those older than 60 years (18.5%). A statistically greater proportion of patients who had neck pain were smokers ($p=0.043$). Neck complaints were more common ($p=0.003$) in patients with an major upper thoracic curve (42%) followed by thoracic curves (29%), thoracolumbar curves (23%), and lumbosacral curves (17%).

There was no statistically significant difference in BMI, gender distribution, or CCMI between patients who had neck complaints and those that did not. Curve magnitude, coronal and sagittal balance were unrelated to neck pain complaints. Binary logistic regression showed that a more proximal Upper End Vertebra was predictive of the presence of neck pain complaints in patients with adult spinal deformity ($p=0.001$).

Conclusion: The data suggests that an increased focus on the relationship between adult scoliosis and cervical spine pathology is warranted. It seems reasonable to presume that degenerative changes in the cervical spine may impact the clinical course of an adult spinal deformity, and visa versa.

Paper #30

Cervical Stenosis in Adult Spinal Deformity Surgery: Incidence, Treatment and Complications

Matthew J. Geck, MD; Dana Hawthorne, BS, MPAS; John K. Stokes, MD

United States

Summary: The cervical spines of patients with complex thoracolumbar deformities were routinely imaged as part of the preoperative workup at one practice. The incidence of anatomic and critical cervical stenosis, moderate to severe clinical signs of myelopathy, and cord edema was evaluated in this retrospective study. Surgical treatment of cervical stenosis in patients prior to adult spinal deformity correction, complications and future recommendations are also discussed.

Introduction: Adult spinal deformity patients with cervical stenosis have multiple risk factors for initiation or worsening of cervical myelopathy during and after spinal deformity surgery. These include prone positioning in slight extension, fluid shifts, variable intraoperative blood pressure, and prolonged anesthesia effects on spinal cord monitoring. One surgeon's practice was evaluated after a protocol for routine imaging of the cervical spine was initiated.

Methods: 80 spinal deformity patients over 50 yo were identified with 2 year follow up who had their cervical spine routinely imaged as part of their preoperative work up for thoracolumbar (TL) reconstructions (2005 to 2008). Clinic and hospital charts as well as radiographs were reviewed.

Results: Incidence of overt moderate to severe clinical cervical myelopathy was 5 of 80. Incidence of critical stenosis (AP canal diameter ≤ 7 mm) with mild myelopathy was 6 of 80. Incidence of cord edema was 1 of 80. 11 of these 12 had cervical spine surgeries performed prior to having surgical correction of the TL deformity. The one patient with critical stenosis (canal ≤ 7 mm) and mild myelopathy refused cervical surgery. Given her lower extremity deficits, she had deformity corrective surgery first. Intraoperative tcMEP and SSEP were stable. Postoperatively, the patient developed progressive cervical myelopathy. Surgery was

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then performed. The patient had stabilization but only mild improvement of her cervical myelopathy. Incidence of anatomic stenosis (AP canal diameter 8 - 10 mm) without overt clinical myelopathy was 30 out of 80 (37.5%). This group did not have cervical surgery prior to deformity corrective surgery and had no long term sequelae postoperatively.

Conclusion: Cervical myelopathy and occult severe cervical stenosis are often difficult to ascertain on H & P in older adult patients. Often, severe long tract signs are not present and gait dysfunction is attributed to the TL deformity. We recommend routine imaging of the cervical spine in addition to detailed exams of hand function as part of any preoperative work up for adult spinal deformity surgery.

Paper #31

Hospital Cost Analysis of Adult Scoliosis Surgery in 120 Consecutive Cases

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Summary: This retrospective review is designed to determine the surgical and hospitalization costs, charges, and reimbursements for adult scoliosis correction at one institution. Identification of specific contributors to cost will enable a targeted approach to cost reduction and resource allocation. We report a mean total cost of \$47,127. Implants remain the largest individual contributor to overall cost. Age, operative time, and number of screws used predicted overall cost.

Introduction: Achieving clinical success is the primary goal of surgical treatment for adult scoliosis. Socioeconomic pressures due to rising health care costs have made it imperative to do so in the most cost-effective manner possible. This study sets out to determine the surgical and hospitalization costs, charges, and reimbursements for adult scoliosis correction at one institution.

Methods: We performed a retrospective review of 30,185 individual costs, charges, and reimbursements on 120 consecutive patients who underwent primary spinal fusion for adult scoliosis by three different surgeons between 2006 and 2009. Demographic, surgical, and radiographic data were recorded for each patient. Stepwise multivariate linear regression was used to determine factors predictive of increased cost. Pearson correlation was used to assess the correlation between cost, charge, and reimbursement.

Results: The patients' (86 females, 34 males) mean age was 40 (range 18-82), and the average number of levels fused was 10. The mean total surgical and hospital cost was \$47,127, mean total charge was \$140,286, and mean total reimbursement was \$62,138. The hospital was reimbursed 44% of total charges and 132% of total costs. Reimbursement correlated most with charge ($r=.611$, $p<0.001$). Cost and charge were also highly correlated ($r=.772$, $p<0.001$). The largest contributor to overall cost was implants (29%). Other large contributors to overall cost were inpatient room/ICU (20%), operating room/recovery room (12%), operating room instruments (8%), and bone graft (6%). Age, operative time, and number of screws used predicted overall cost.

Conclusion: Surgical correction for adult scoliosis remains expensive, with a mean total cost of \$47,127. Implants remain a large contributor to overall cost. Reimbursement was highly correlated with charge, but not with cost. This study characterizes the relative contributions of factors that contribute to total cost, charge, and reimbursement for the surgical correction of adult scoliosis. These contributors serve as targets for overall cost reduction or resource re-allocation.

*Paper #32

Complications and Risk Factors of Primary Adult Scoliosis Surgery: A Multicenter Study of 306 Patients

Sebastien Charosky, MD; Pierre Guigui; Arnaud Blamoutier; Pierre Roussouly, MD; Daniel Chopin; Groupe d'etude sur la scoliose Ges France

Summary: Multicenter study of 306 patients operated for primary adult or degenerative scoliosis. Complications and risk factors as well as survival curves are analyzed. Overall complication rate was 39% and 26% of the patients were reoperated for mechanical or neurological complications. Risk factors include number of instrumented vertebra, fusion to the sacrum, pso, and pre-op pelvic tilt $\geq 26^\circ$. Half of the patients are at risk for a new operation in the 6 year period following the primary procedure

Introduction: Adult deformity surgery is associated with a high rate of complications. This multicenter study describes complications rate and risk factors as well as survival curves

Methods: A retrospective review of prospectively collected data from 6 centers in France. 306 Primary lumbar adult or degenerative scoliosis patients aged over 50 operated between 2002-2007 were included. Demographics, comorbidities, xray parameters, surgical data and complications were analyzed. Statistical analysis was performed to obtain correlations and risk factors for complications. Reoperation risk was calculated with Kaplan Meier survival curves

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Results: 306 patients age 63 yrs (range 50-83) with 83% females. Mean CIRS was 5 (range 0-26). Main curve was 50° (range 4-96) with apex between T12 and L2. 10% patients had anterior surgery only, 18% double ant-post and 72% posterior only. 74% (226 patients) had long fusions ≥ 3 levels and 44% (134 patients) were fused to the sacrum. 40% (122 patients) had a decompression performed and 18% an osteotomy. There were 175 complications for 119 patients (39%). No deaths, no blindness. General complication rate 13.7%; Early infection appeared in 4% (12 patients) and late infection in 1.2%. Neurologic complications were present in 7% with 2 cases (0.6%) of late cord level deficits, and 12 reoperations (4%). Prevalence of mechanical complications was 24% (73 patients) with 58 patients (19%) needing a reoperation. Risk factors for mechanical or neurological complications were number of instrumented vertebra ($p \leq 0.01$) fusion to the sacrum ($p \leq 0.001$), PSO ($p = 0.01$) and a high pre-op pelvic tilt $\geq 26^\circ$ ($p \leq 0.05$). Kaplan Meier survival curves showed reoperation risk of 44% at 70 months. Long fusions risk was 40% at 50 months and fusions to the sacrum reoperation risk of 48% at 49 months

Conclusion: Overall complication rate was 39% and 26% of the patients were reoperated for mechanical or neurological complications. Risk factors include number of instrumented vertebra, fusion to the sacrum, pso and pre-op pelvic tilt $\geq 26^\circ$. There is a 44% risk of a new operation in the 6 year period following the primary procedure

Significance: Surgeons should inform patients that there is a high risk of complications with a reoperation risk of 44% in the 6 year period following primary surgery

*Paper #33

Risk Factors for Major Peri-Operative Complications in Adult Spinal Deformity Surgery: A Multi-Center Review of 953 Consecutive Patients

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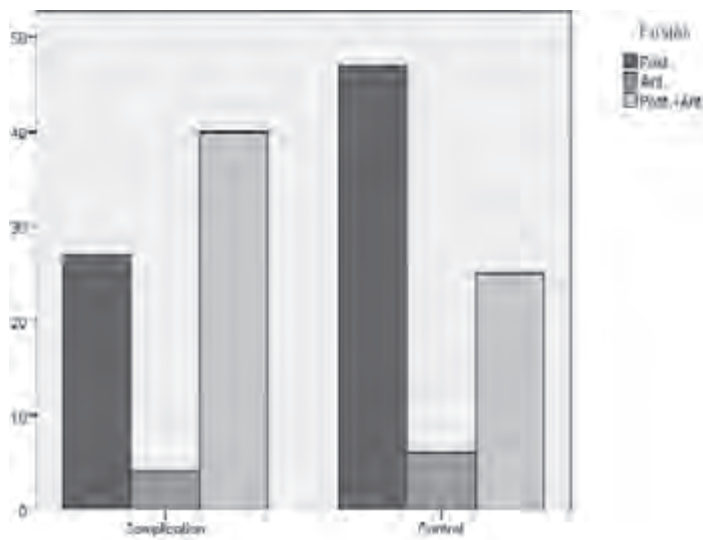


Figure 1: Surgical approaches among the two groups

Summary: Peri-operative major complications following adult spinal deformity surgery remain common. However, risk factors in terms of patient profile and surgical parameters have not been clearly identified. Using a retrospective consecutive review of 953 patients with at least 2y FU, we identified 72 patients who suffered a major peri-operative complication. Comparison to a case control group demonstrated that a major complication was more likely to occur with revision, staged, and anterior/posterior surgeries.

Introduction: Complications following adult spinal deformity (ASD) surgery have a reported incidence of 27%-80%. Understanding risk factors for complications may reduce their occurrence and permit improved operative risk-benefit ratios. The purpose was to identify patient and surgical parameters that correlate with development of major peri-operative complications following ASD surgery.

Methods: Multi-center (n=8), retrospective, consecutive, case-control series. A total of 953 patients (2y FU

minimum) with ASD were reviewed to identify patients with major peri-operative complications (Case). A randomization table was used to select a control group of patients that did not suffer major complications (Control). Data collected included demographics, past medical history, ASA grade, co-morbidities, preoperative lab values, intra/post-operative parameters, occurrence of peri-operative complication. The two groups were analyzed for differences using ANOVA and Chi Square analysis.

Results: We observed 99 major complications (average 1.4 per patient) in 72 patients (7.6%). The matched cohort consisted of 78. No differences were noted between groups for the following: demographics, pre-op vitals, lab-results, ASA grade, respiratory signs, alcohol or smoking habits, mean operative time, and ICU stay. Chi-square analysis demonstrated that the complica-

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tion group exhibited a higher percentage of staging procedures (46% versus 37%, $p=0.011$), a higher percentage of anterior/posterior approach (56% versus 32%, $p=0.011$; Figure) and a greater prevalence of postoperative anemia (16.7% versus 6.4%, $p=0.04$).

Conclusion: We report an incidence of 7.6% major complications among 953 consecutive patients. Improved understanding of risk profiles and procedure-related parameters may assist in pre-operative risk-benefit surgical discussions and pre-emptive approaches to reduce major complications. Patients should be counseled that a major complication is more likely to occur in the setting of revision, staged, and anterior/posterior surgery.

Paper #34

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

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Summary: Proximal junctional kyphosis (PJK) is a common complication following long posterior spinal fusion (PSF), and a subset of these patients will develop proximal junctional failure (PJF). No previous study has examined the use of prophylactic vertebroplasty for the prevention of PJK or PJF. Here, we show that prophylactic vertebroplasty in long PSF for adult spinal deformity is a safe and effective method for minimizing the incidence of PJF/PJK.

Introduction: PJK occurs in 9.2-46% of cases following long PSF, and a subset of these will develop PJF. No previous studies have prospectively examined the use of prophylactic vertebroplasty for prevention of PJK/PJF.

Methods: We enrolled 41 adult patients treated with long PSF who received prophylactic vertebroplasty at the upper instrumented vertebra (UIV) and supra-adjacent vertebra (UIV+1). PJK was defined as a change in the PJK angle ≥ 10 degrees between the immediate post-op and the final follow-up radiograph.

Results: There were 5 males and 36 females. Average age was 65.1 yrs (41-87). 38 patients had complete radiographic data & were included in the analysis. 15.8% (6/38) developed PJK/PJF. Two patients developed PJF and required revision surgery. One patient developed progressive sagittal imbalance following a fall 2 weeks post-op, while the other had acute subluxation 6 weeks post-op between the UIV & UIV+1. Both were treated with fusion extension. A third patient suffered a compression fracture at the supra-adjacent level and developed PJK, requiring vertebroplasty at that level. Three patients developed PJK according to radiographic parameters,

but did not require treatment. Five patients required revision for reasons other than PJK/PJF. One had revision for pseudarthrosis. Two had partial removal of instrumentation for pain. One had a lumbar osteotomy for residual sagittal imbalance. The fifth had revision for a sacral stress fracture. Increasing amounts of coronal curve correction were associated with an increased likelihood of PJK/PJF ($p=.039$). No other significant risk factors were identified. At final follow-up, there were differences in SRS Pain ($p=.049$) and SRS Mental Health ($p=.014$) between those with and without PJK/PJF. There was no difference in other SRS or ODI scores. Two patients had anterior cement leakage without consequences. None had posterior extravasation. Three patients developed surgical site infections, one superficial and two deep. One patient had a DVT, and two had a PE.

Conclusion: Prophylactic vertebroplasty in long PSF in adult spinal deformity is a safe and effective method of minimizing the incidence of PJF/PJK.

Significance: Prophylactic vertebroplasty can safely be used in long PSF in adults to minimize the incidence PJK/PJF.

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Paper #35

A Prospective Study of Degenerative Lumbar Scoliosis Among Community-Based Female Volunteers

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Japan

Summary: A prospective study of 144 community-based female volunteers revealed pre-existing DLS in 29.9% at baseline and the development of de novo DLS in 29.4% of those without baseline deformity during mean 12.1 years observation. DLS of more than 15° was associated with significant decrease in lumbar lordosis and forward shift in C7 plumb. L4 tilt and vertebral size were predictors of the progression of pre-existing DLS, and lateral osteophyte, disc wedge and vertebral size were predictors of de novo DLS.

Introduction: Degenerative lumbar scoliosis (DLS) is among the most frequent spinal deformity in the aging spine, however, development of this condition has not been elucidated. The purpose of this study was to clarify radiographic characteristics and predictors of pre-existing and de novo DLS.

Methods: 144 community-based female volunteers aged 40+ years were recruited and followed for more than 8 years. Up-right entire spine radiograph was taken at baseline and at final follow-up, and radiographic measurements included; thoracic kyphosis, lumbar lordosis, sacral inclination angle (SIA), sagittal balance (C7 plumb), coronal L4 endplate angle (L4 tilt), and scoliotic angle by Cobb method. More than 10° of scoliosis was diagnosed as DLS. L4 vertebral size, lateral osteophyte formation and lateral disc wedge were also recorded according to the previously-reported setting.

Results: Mean baseline age and follow-up period were 54.4 years and 12.1 years, respectively. Pre-existing DLS (pre-DLS) was found in 42 subjects (29.2%) at baseline, with the magnitude of 10° to 14° in 34 and more than 15° (marked pre-DLS) in 8. Marked pre-DLS subjects exhibited significantly smaller baseline values of lumbar lordosis (21.9° vs. 34.9°, $p=0.0059$), SIA (26.4° vs. 36.9°, $p=0.0026$), and more forward C7 plumb (68.1mm vs. 21.3mm, $p=0.0007$) than those without pre-DLS. Among pre-DLS, 12 subjects (29%) showed more than 5° progression in scoliosis. A Cox hazards model revealed L4 tilt (relative risk;RR 3.58, 95% confidence interval;CI 1.29-9.91) and vertebral size (RR 0.96, CI 0.92-0.99) to be the risk factors of progression of pre-DLS. DLS has developed de novo in 30 subjects (29.4%) among those without baseline scoliosis. A Cox hazards model revealed unilateral osteophyte formation (RR 22.68, CI 2.82-182.46), lateral disc wedge (RR 4.01, CI 1.13-14.17), and vertebral size (RR 1.17, CI 1.03-1.35) to be unique independent predictors of the development of de novo DLS.

Conclusion: DLS of more than 15° was associated with significant modification in sagittal spinal alignment. Current results indicated that patients with radiographic characteristics of asymmetrical disc degeneration were susceptible to the development of de novo scoliosis.

Significance: Level of evidence II (prospective cohort study)

Paper #36

Myelography in the Assessment of Adult Degenerative Scoliosis

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United Kingdom

Summary: Myelography was 'superseded' by low risk MRI and CT which was static and supine while myelography may be loaded and dynamic. In patients with degenerative scoliosis, differences between findings on myelography, MR and /CT were noted and whether this subsequently affected treatment. 85.7% myelograms revealed findings not seen on supine MRI. Myelography is a safe and useful tool in the management of patients with degenerative scoliosis, while MRI scan alone understates the true nature of central and lateral recess stenosis.

Introduction: Lumbar myelography was previously a commonly performed procedure for spinal conditions but was superseded by the advent of MRI and CT which were low risk and provided cross-sectional information. The majority of MRI and CT evaluations are static and supine and in degenerative scoliosis, the lumbar spine often assumes a very different position standing compared to supine. This study evaluates the role of myelography in patients with degenerative scoliosis in a modern surgical practice.

Methods: Patients with degenerative scoliosis and full imaging (plain radiographs, supine MRI, myelography, including CT myelography) were identified from our database between 2006-2009 and recorded. Differences between findings of MRI and myelography/CT myelography were noted and whether this subsequently affected treatment.

Results: 21 patients fulfilled inclusion criteria. Mean age 68 (range 45-82), 17 were female. MRI was analysed prior to myelography in 17 cases. Mean interval between investigations was 6.2 months. 18/21 (85.7%) myelograms revealed findings not seen on MRI. 15 patients had a single abnormality, 1 had two and in 2 patients there were 3 new abnormalities. Abnormalities

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seen were facet/ligamentous bulging in 13, a single spondylolisthesis, retrolisthesis and lateral subluxation. On CT a foraminal osteophyte and a pars defect were seen. In 4 cases supine investigation revealed more than MRI. In 7 patients management changed as a result of myelography/CT. There have been no complications of myelography in our unit using modern contrast media of the total 270 performed.

Conclusion: Myelography is a safe and useful tool in the management of patients with degenerative scoliosis. MRI scan alone understates the true nature of central and lateral recess stenosis. Not only does myelography show more stenosis in the loaded spine, but static myelography and CT myelography are also an invaluable tool in these patients.

Significance: Myelography shows more stenosis in the loaded spine than MRI.

Paper #37

Prophylactic Preoperative Inferior Vena Cava Filters for Major Spinal Reconstruction in Adults: Long-Term Follow-Up

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Summary: Venous thromboembolism (VTE) is a serious complication following major spinal reconstructive surgery in adults. Patients with at least two risk-factors for the development of VTE received a preoperative prophylactic inferior vena cava filter (IVCf). The lower extremity (LE) deep vein thrombosis (DVT) rate was noted to be 22.22%. Prophylactic IVCf placement is safe and efficacious.

Introduction: Pulmonary embolism (PE) can be a major cause of morbidity and mortality following major spinal reconstructive surgery in adults, and has been reported in up to 13% of patients. Prophylactic IVCf placement was instituted as standard protocol for high-risk patients after a pilot study demonstrated decreased mortality and VTE complication rate with its use.

Methods: After IRB confirmed approval, we reviewed retrospectively the medical records of all patients receiving an IVCf at one institution from 2000 to 2007. Age, sex, surgical approach, postoperative LE DVT, presence of PE or paradoxical embolus, mortality, and IVCf complications were reviewed. Placement indications included history of DVT or PE, malignancy, hypercoagulability, prolonged immobilization, staged procedures > 5 levels, combined anterior/posterior approaches, ilio caval manipulation during exposure, and anesthetic time > 8 hours.

Results: 171 patients were analyzed (121F, 50M) with mean age of 64.3 years (range 25-91 years). There were no complications from IVCf placement (58 Greenfield, 113 retrievable). The LE DVT rate was 22.22% (38 patients), the PE rate was 2.3% (4 patients), and the paradoxical embolus rate was 0.6% (1 patient). No statistical significance ($p < 0.05$) was noted with combined anterior/posterior approach (112 patients) versus posterior-only approach (59 patients) and the rate of DVT (23/112; 23% for former and 12/59; 20.3% for latter). There were a total of 8 deaths, none related to LE DVT, PE, or paradoxical embolus. Prophylactic IVCf use lowers the PE rate ($p=0.03$) as compared with a matched patient control. Mean follow-up was 2.7 years (median 2.3 years; 111 patients had at > 2 year follow-up).

Conclusion: The morbidity and mortality related to VTE have heightened the awareness of spine surgeons to the perioperative management of patients receiving major spinal reconstruction. Prophylactic IVCf resulted in no deaths related to VTE over the course of 8 years, and significantly lowers PE rate compared with a matched control patient population.

Significance: Preoperative prophylactic IVCf lower the mortality related to VTE as seen on this long-term follow up of high risk patients. Initiation of chemoprophylaxis in the postoperative setting may also lower VTE incidence.

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).

Paper #38

Long Term Survival After Long Primary Fusion for Adult Scoliosis More Than 40 Degrees. Prognostic Factors for Reoperation. Does Reoperation Associate Worse SRS22 and SF36 Final Follow-Up Scores?

Felisa Sánchez-Mariscal; Alejandro Gomez Rice, MD; Enrique Izquierdo, MD, PhD; Lorenzo Zúñiga, MD; Javier Pizones, MD, PhD; Patricia Álvarez González Spain

Summary: Prospective revision of a cohort of adult patients primary operated on scoliosis-main Cobb >40degrees-. Long term survival, SRS22/SF36 scores and prognostic factors for reoperation analysis was done.

Introduction: To know long term survival - event defined as reoperation(reop)- after long primary fusion in a cohort of adult patients with scoliosis, to define prognostic factors for reop and to determine if reoperation associates worse SRS22/SF36 scores.

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Methods: 168 patients were operated on adult scoliosis at a single centre. 59 satisfied inclusion criteria (older than 21y, frontal deformity >40 degrees, >5 level fusion, > 2 year follow-up). At the moment of the study patients were asked SRS22/SF36 questionnaires, clinical chart was examined and new X-rays were taken when necessary.

Results: 59 patients (51 women). Median age at primary surgery 42y.

Median preop frontal Cobb 59 degrees.

Etiology: Idiopathic 48. Degenerative 11.

Median postop follow-up 8.5 years.

21 patients - 35.6% - underwent revision surgery. Three patients underwent a 3rd surgery, and 3 had a 4th surgery.

Median time from primary procedure to 1st reop was 1.5 year.

No need for reop (Kaplan-Meier) was: 89.8% at 1 year, 64% at 5 years, 60.9% at 10 years

The most frequent reasons for reop were painful/prominent implants, adjacent segment degeneration (ASD) and infection.

Prognostic factors:

-Probability of reop for double approach was 52% and for unique approach 22%. Double approach has a 2.37 relative risk of reop (CI 95% 1.1 to 5.1; p= 0.017).

-Probability of reoperation for ASAll patients was 57% and for ASAI 24%. ASA II patients have a 2.43 relative risk of reoperation (CI 95% 1.2 to 4.9; p= 0.012)

-Patients with greater preoperative and postoperative thoracic kyphosis or maximum kyphosis were more frequently reoperated.

-Logistic regression revealed preop thoracic kyphosis (OR 1.07, CI 95% p=0.001) as a significant predictor of reop

Reoperation associated significantly worse SRS22 scores in every domain (except for mental), but only in some SF36 domains (FP, CP)

Conclusion: Need for reoperation at 10 years is 39%, mostly due to painful implants/ASD/infection. Unique significant predictor for reoperation after multivariate analysis is preoperative thoracic kyphosis. Reoperation associated significantly worse SRS22 and SF36 scores.

Paper #39

Long Fusions to the Sacrum in Elderly Patients with Spinal Deformity

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United States*

Summary: From a prospective database for adult spinal deformity, our findings show that properly selected patients over 65 years of age who have substantial sagittal imbalance, a considerable disease burden and a lesser degree of mental distress can obtain as much clinical benefit as their younger counterparts (<55 years of age) two-years following spinal deformity surgery that requires fusion from the thoracic spine to the sacrum with segmental instrumentation and iliac fixation.

Introduction: Long spinal deformity fusions in elderly patients continue to be controversial. However, there is a growing population of elderly patients with spinal deformities that may be optimally treated by surgery requiring fusion to the sacrum. The purpose of this study is to evaluate patient reported outcomes in elderly (>65) adult deformity patients who had a posterior instrumented reconstruction consisting of fusion from the thoracic spine to the sacrum with iliac fixation.

Methods: Patients in a prospective database for adult spinal deformity who had a posterior reconstruction with an instrumented fusion from the thoracic spine to the sacrum that included iliac fixation with minimum two year follow-up were identified. Patients who had a previous fusion were excluded. Two cohorts were compared: patients older than 65 and patients younger than 55. Student's t-test for independent groups was used to determine any significant differences between continuous variables. Chi-square was used to compare categorical demographic variables between the two groups.

Results: The older group consisted of 15 patients with an average age of 71 years (range, 65-78 years). The younger group consisted of 25 patients with an average age of 45 years (range, 30-55 years). The older group had a higher mean co-morbidity score (4.6 vs. 2.1). Baseline SRS scores were similar between groups. Baseline SF-12 data showed lower PCS (22.1 vs. 32.0, p=0.009) yet higher MCS (63.6 vs. 48.4, p<0.0001) in the older group. Although major curve magnitude was similar (47.1 vs. 42.6 degrees), the older group had more sagittal imbalance at baseline (115.7 vs. 54.2 mm, p=0.02). Number of levels fused, operative time, blood loss and incidence of complications were similar between groups. Two-year improvements in SRS sub-scores, SF-12 PCS and MCS were not significantly different between groups.

Conclusion: Properly selected patients over 65 years of age who have substantial sagittal imbalance, a considerable disease burden and a lesser degree of mental distress can obtain as much clinical benefit as their younger counterparts two-years following spinal deformity surgery that requires fusion from the thoracic spine to the sacrum with segmental instrumentation and iliac fixation.

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Paper #40

Prevalence and Outcomes of Coronal Decompenation Following Primary Multilevel Spinal Fusion for Adult Deformity

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United States

Summary: Coronal decompenation occurred in 3.7% of adult scoliosis patients after multilevel spinal fusion in our series. Predisposing factors included the presence of pelvic obliquity and a double major curve pattern in which the more flexible lumbar curve was corrected more than the thoracic. Postoperative CI persisted from initial to final follow up, with lower SRS self image and function scores compared to CB patients.

Introduction: The fate of adult scoliosis patients who develop significant coronal imbalance (CI) following spinal fusion has not been critically evaluated. We report the prevalence and outcomes of coronal decompenation in a consecutive series of multilevel spinal fusions for adult scoliosis.

Methods: A consecutive series of 148 patients with adult idiopathic/degenerative scoliosis who underwent a multilevel primary posterior spinal fusion (>5 levels fused) at a single institution from 2002-2007 were reviewed. A minimum two year followup was required. There were 133 females/15 males; mean age at surgery 48.2 years (range 18-81). Posterior fusion alone was performed in 66 patients (44.6%), while 82 patients (55.4%) had a combined posterior/anterior fusion.

Results: Five patients (3.7%) had CI of >4cm from the C7 plumb to the center sacral vertical line at two months postop. All CI patients had double major curve patterns, (avg thor Cobb: 56°, avg lumbar Cobb: 58.6°), increased lumbar flexibility on bending, and no preop CI. Compared to the coronally balanced (CB) patients, CI patients had statistically longer posterior fusions (14.0 vs. 10.0 levels, p=0.014), presence of preop pelvic obliquity (5.0° vs. 0.0°, p=0.027), and similar preop coronal balance (1.6cm vs. 1.9cm, p=0.46). All CI patients were fused to L4 or below compared to 25.9% of CB patients (p=0.33). CI patients had a larger coronal imbalance at initial followup (5.7cm vs. 2.1cm, p<0.001), which persisted at final followup (6.2cm vs. 1.7cm, p<0.001). Final pelvic obliquity was greater in CI patients (p=0.02). SRS scores at final followup for CI vs. CB were lower for self image (2.8 vs. 4.2, p=0.047) and function (3.0 vs. 3.8, p=0.06). CI and CB groups were similar in terms of age, gender, and preop coronal/sagittal Cobb angles.

Conclusion: CI developed in 3.7% of patients in our series. Risk factors for CI identified in this study include a double major curve with a more flexible lumbar curve and preexisting pelvic obliquity. In patients who developed CI, both the thoracic and lumbar curves were fused to L4 or below, and lumbar curve correction exceeded thoracic correction. CI did not improve from initial to final follow up. SRS self image and function scores were lower for CI vs. CB patients.

Paper #41

Thoracic Three Column Osteotomy for Adult Spinal Deformity Improves Regional Deformity and Pelvic Tilt

Shay Bess, MD; Frank J. Schwab, MD; Virginia C. Lafage, PhD; Richard Hostin, MD; Christopher P. Ames, MD; Eric Klineberg, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD;
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Table

	Pre-op	Post-op	Change	p
Thoracic kyphosis	62	37	-25	< 0.001
Thoracolumbar kyphosis	15	6	-9	0.006
Lumbar Lordosis	-63	-60	+3	NS
SVA (mm)	24	-2	-26	0.002
T1 SPI	-4	-4	0	NS
T9 SPI	-16	-10	+6	< 0.001
Sacral Slope	36	40	+4	< 0.001
Pelvic Tilt	15	11	-4	< 0.001
Pelvic Incidence	51	51	0	NS
Max Cobb angle	56	24	-32	< 0.001

Summary: Thoracic pedicle subtraction osteotomy (TPSO) improves focal thoracic deformity, however little data exists on the impact of TPSO upon global spinopelvic balance. Analysis of 41 TPSO procedures demonstrated that focal correction at the TPSO site favorably impacted regions of the spine remote from the osteotomy site, including improvement in global spinopelvic balance and normalization of pelvic parameters. Normalization of pelvic parameters, especially pelvic tilt, has previously been shown to strongly correlate with improved clinical outcome.

Introduction: Thoracic pedicle subtraction osteotomy (TPSO) can correct rigid thoracic deformity with significant focal

correction. However, little data exists on the impact of TPSO upon global spinopelvic parameters. Purpose: evaluate the radiographic outcome of TPSO on regional and global spinopelvic alignment.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

Methods: Multicenter, retrospective radiographic analysis of adult spinal deformity (ASD) patients receiving TPO. Analysis included focal and regional measures (kyphosis and scoliosis at TPO site) thoracic kyphosis (TK), thoracolumbar kyphosis (TLK), lumbar lordosis (LL), global measures: sagittal vertical axis (SVA), T1 and T9 spinopelvic inclination (SPI), and pelvic measures: pelvic tilt (PT), pelvic incidence (PI) and sacral slope (SS).

Results: Between 2003-2009, 41 patients received TPO for ASD. Deformities included; primarily sagittal (n=21), coronal (n=13), and multiplanar (n=7) deformities. Resection levels ranged from T2 to T12; T8 was most common level (n=9). Mean sagittal correction for primary sagittal deformities was 34 degrees. Mean coronal correction for primary coronal deformity was 43 degrees. Mean total angular correction (sagittal + coronal correction) for multiplanar deformities was 76 degrees. Postoperative TK, TLK and SVA were significantly less than preoperative values (Table). Mean SVA correction was 26 mm. Postoperative TK improvement generated favorable PT correction (Table).

Conclusion: TPO corrects regional and global spinal deformities. Total angular correction for all patients was 54 degrees, SVA correction was 26mm. Focal thoracic correction generated improved pelvic parameters including improved PT. Regional improvements in spinal balance following TPO favorably impact the pelvis allowing postoperative normalization of pelvic parameters. Normalization of pelvic parameters, especially PT, has been shown to correlate with improved clinical outcome.

Paper #42

Comparison of Pedicle Subtraction Osteotomy in Fixed vs. Flexible Sagittal Imbalance

*Kyu-Jung Cho, MD; Ki-Tack Kim, PhD; Whoan Jeang Kim; Sang-Hun Lee; Jae-Hoon Jung
Korea, Republic of*

Summary: Eighteen patients who underwent pedicle subtraction osteotomy for fixed sagittal imbalance were compared with thirty-six patients underwent PSO for flexible sagittal imbalance. The osteotomy was performed at one segment, mostly at L2 or L3. The correction of sagittal C7 plumb was not different in both groups, but loss of correction was more significant in the flexible group (P<0.01). In the fixed group, there were dural tears and neurologic deficit. In the flexible group, pseudarthrosis and implant failure were more common.

Introduction: Pedicle subtraction osteotomy (PSO) is commonly used for the correction of sagittal imbalance. The result of PSO might be different according to the flexibility of deformity. The purpose of this study was to compare the result of PSO in fixed versus flexible sagittal imbalance.

Methods: Fifty-four patients who underwent PSO were enrolled with a minimum 2 year follow up. Eighteen patients had fixed imbalance resulting from ankylosing spondylitis and postoperative kyphosis. Thirty-six patients had flexible imbalance from degenerative etiology. We included patients who underwent fusion from thoracolumbar to lumbosacral spine in both groups. The mean age was 65 years in the fixed group and 55.3 years in the flexible group (P<0.01). The osteotomy was performed at one segment, mostly at L2 or L3.

Results: In the fixed group, sagittal C7 plumb was 146mm before surgery, corrected to 30mm after surgery, and changed to 39.8mm at the last visit. In the flexible group, sagittal C7 plumb was 167mm before surgery, 38mm after surgery, and changed to 89.9mm at the last visit. The correction of sagittal C7 plumb was not different in both groups, but loss of correction was more significant in the flexible group (P<0.01). The average improvement of osteotomy angle was 32o in the fixed group and 36o in the flexible group. The loss of correction of osteotomy angle was 1.2o in the fixed group and 4.2o in the flexible group (P=0.05). The average correction of lumbar lordosis was 30.6o in the fixed group and 31.6o in the flexible group. The loss of correction of lumbar lordosis was 2.5o in the fixed group and 11.4o in the flexible group with a significant difference (P=0.03). In the fixed group, there were dural tear in 2 patients and transient neurologic deficit in 2 patients. In the flexible group, pseudarthrosis developed in 3 patients and implant failure in 6 patients.

Conclusion: Pedicle subtraction osteotomy in flexible sagittal imbalance was more likely to cause loss of correction of sagittal balance and osteotomy angle than in fixed sagittal imbalance. Flexible sagittal imbalance demonstrated more complications such as pseudarthrosis and implant failure than fixed sagittal imbalance.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

Paper #43

Interradicular Bone-Disc-Bone Osteotomy (BDBO): An Alternative to Other Osteotomy Types for the Correction of Thoracolumbar and Lumbar Spine Deformities

Cagatay Ozturk, MD; Mehmet Aydogan; Selhan Karadereler; Mehmet Tezer; Ahmet Alanay, MD; Azmi Hamzaoglu, MD Turkey



Summary: Authors have developed a new osteotomy technique preserving the nerve roots and providing an efficient correction and stabilization.

Introduction: Vertebral osteotomies are usually needed for correction of severe and rigid spinal deformities. Pedicle subtraction osteotomy (PSO) or several levels of Smith-Petersen osteotomies (SPO) are usually preferred at the thoracolumbar spine rather than the posterior vertebral column resection (PVCR) as nerve roots can not be sacrificed at this region of spine. Purpose of this study is to introduce and evaluate the results of this osteotomy technique.

Methods: Twelve consecutive patients with thoracolumbar and lumbar deformities managed by BDBO and having more than 2 years of follow-up were evaluated. Preoperative, postoperative and follow-up standing A-P and lateral x-rays were analysed regarding deformity and hospital charts were evaluated for complications. Local kyphosis angle was measured through the upper end plate of the vertebrae above the resection level and lower end plate of the vertebrae below

the resection level. Wide laminectomies were done at the vertebrae above and below the disc space planned to be resected. Then, a wedge osteotomy just below the pedicle of the upper adjacent vertebra and a straight osteotomy through the upper end plate of the lower adjacent vertebra, including the disc tissue were done. Then, the osteotomy side is closed (Figure 1).

Results: Average age of patients (6M, 6F) was 51 (range; 7 to 76) years. Average follow-up was 47 (range; 24 to 89) months. Deformities included kyphosis in 7 and kyphoscoliosis in 5 patients. Preoperative kyphosis of 24 degrees was corrected to -15 degrees of lordosis with an average of 38 degrees of correction. There was 1.5 degrees of correction loss at the final follow-up. Preoperative scoliosis of 21 degrees was corrected to 8 degrees and found to be 10 degrees at the final follow-up. Average number of instrumented vertebrae was 10. Major complications included dural tear in 4 patients. There was no neurological injury.

Conclusion: BDBO is an effective surgery providing an average of 38 degrees of correction in sagittal plane and may be an alternative to PVCR for patients with thoracolumbar and lumbar severe and rigid deformities, particularly if the apex of deformity is a disc level.

Significance: -

Paper #44

Changes in Thoracic Kyphosis Negatively Impact Sagittal Alignment Following Lumbar Pedicle Subtraction Osteotomy

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	Unfavorable	Favorable and neutral	p value
Age	59±11	49±10	*
Pre-op Thoracic Kyphosis	-17±14	-28±30	NS
Pre-op Lumbar Lordosis	11±19	24±21	NS
Pre-op T1 spino-pelvic inclination	7±4	2±5	*
Pre-op SVA	17.5±5.8	10.3±7.2	*
Pre-op Pelvic Incidence	61±10	54±11	*
Pre-op Pelvic Tilt	3.6±.9	2.8±1.2	*
PSO Resection	2.8±1.1	2.3±.6	ns

Comparison of radiographic parameters among the two groups of patients (independent t-test analysis)

Summary: Spinal realignment by lumbar pedicle subtraction osteotomy (PSO) is utilized in the setting of sagittal malalignment. The alignment following PSO in long fusions can be predicted. However, the effect lumbar PSO has upon unfused thoracic levels in shorter fusions (reciprocal change [RC]) is poorly understood. These reciprocal

changes can negatively impact final post-operative alignment. Older patients, and those with larger pelvic incidence and truncal imbalance are more likely to have unfavorable thoracic RC (increased kyphosis).

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

Introduction: Large vertebral resections are frequently utilized in the setting of sagittal malalignment. While the effect of such resection can be anticipated in long fusions, their impact on unfused segments (reciprocal changes; RC) is poorly understood. The objective of this study was to evaluate if RC have a positive or negative impact of spino-pelvic alignment following lumbar PSO in the setting of shorter fusions.

Methods: Consecutive, multicenter retrospective review of 34 adult patients (mean age=54yo; sd=12) who underwent lumbar PSO with upper instrumented vertebra (UIV) below T10. Radiographic analysis included pre and post assessment of Thoracic Kyphosis (TK), Lumbar Lordosis (LL), Sagittal Vertical Axis (SVA), T1 Spino Pelvic Inclination (T1SPI), Pelvic Tilt (PT), and Pelvic Incidence (PI). Final SVA and PT were analyzed to determine successful realignment (SVA < 4 cm, PT < 20 deg). RC in the thoracic spine was designated favorable or unfavorable based upon impact on final SVA and PT.

Results: Mean PSO resection was 26° (SD=9°). LL increased from 20° to 49° (p<0.001). SVA improved from 14 to 4cm (p<0.001) and PT improved from 33° to 25° (p<0.001). Mean increase in TK was 13° (p=0.002). TK was unchanged (<5°) in 11 patients. Five patients had a favorable RC and 18 patients had an unfavorable RC. Unfavorable RC was attributed to junctional failure in 6/18 patients. Significant differences in the unfavorable RC group compared to the other patients included; age and greater pre-operative PT, PI, SVA and T1SPI (Table). There was no difference in preoperative LL or PSO degree of resection between RC groups.

Conclusion: Significant postoperative alignment changes can occur through unfused thoracic spinal segments following lumbar PSO. Unfavorable RC may limit optimal correction (SVA, PT) and can lead to clinical failures. Risk factors for unfavorable thoracic RC include: older patients, larger pre-op PI and PT and worse pre-op T1 spino-pelvic inclination and are not simply due to junctional failure. Care should be taken with selective lumbar fusion and PSO in older patients and those with unfavorable pre-op spino-pelvic parameters.

Paper #45

Clinical and Radiographic Factors that Distinguish Between the Best and Worst Outcomes of Scoliosis Surgery for Adults 46-85 Years Old

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Summary: Older adult scoliosis patients treated surgically with the worst outcomes have higher pre-operative pain, narcotic use, body mass index, and prevalence of depression/anxiety than those having the best outcomes. At follow-up they have poorer coronal and sagittal balance. No other radiographic or surgical parameters distinguished between patients with the best and worst outcomes.

Introduction: It remains unclear why some adults with scoliosis markedly improve with surgery, while others fail to improve. Our objective was to assess for differences between older adult patients with the best and worst outcomes following surgery for scoliosis.

Methods: This is a secondary analysis of a prospective multicenter deformity database. Inclusion criteria included: age 46-85, Cobb angle >20°, no prior instrumentation and outcomes (ODI or SRS-22) at a minimum of 2 years following surgery. The best and worst ~15% for each outcome measure at follow-up were selected for comparison.

Results: For ODI, best (ODI<5) and worst (ODI>40) groups consisted of 28 (15%) and 32 (17%) patients, respectively. For SRS-22, best (SRS-22>4.5) and worst (SRS-22<3) groups consisted of 32 (17%) and 30 (16%) patients, respectively. Factors that were statistically significantly different between the best and worst groups are summarized Table 1. These included higher pre-operative levels of back pain, greater body mass index, and greater proportions of patients on narcotics and reporting depression and anxiety in the worst group compared to the best group. On follow-up the worst group had statistically greater coronal and sagittal imbalance than the best group. There were no statistically significant differences between the two groups in terms of age, comorbidities, idiopathic vs de novo scoliosis, pre-operative or follow-up Cobb angle, pre-operative sagittal or coronal balance, occurrence of minor or major complications, operative time, estimated blood loss, and need for revision surgery.

Conclusion: Older adult scoliosis patients treated surgically with the worst outcomes have higher pre-operative pain, narcotic use, body mass index, and prevalence of depression/anxiety than those having the best outcomes. At follow-up they have poorer coronal and sagittal balance. No other radiographic or surgical parameters distinguished between patients with the best and worst outcomes.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

Paper #46

A Correlation of Radiographic and Functional Measurements in Patients who Underwent Primary Scoliosis Surgery in Adult Age

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Spain

Summary: Prospective radiographic and clinical analysis to correlate radiographic parameters and age with Health Related Quality of Life (HRQOL) measures in patients operated on scoliosis in adult age. Multivariate analysis revealed age and pelvic tilt (PT) significantly influence clinical outcomes.

Introduction: To evaluate if known relationships between radiographic parameters -spinal and spinopelvic- and HRQOL measures are maintained in a cohort of patients operated on scoliosis in adult age.

Methods: 59 patients operated on adult scoliosis at a single centre. Inclusion criteria: > 21 years old, frontal Cobb >40 degrees, > 5 level fusion, >2 year follow-up. Full-length free-standing radiographs including the spine and pelvis, and HRQOL instruments included SRS22 and SF36 were available for all patients.

Thoracic and thoracolumbar kyphosis, maximum kyphosis, lumbar lordosis, sagittal vertical axis (SVA), T1 and T9 spinopelvic inclination, and PT were evaluated. Age, main frontal Cobb and apical vertebra translation and rotation were also considered.

Results: 51 women, 8 men. Median age was 50.2 years; Median final frontal Cobb was 30 degrees; Median postoperative follow-up was 8.5 years. Etiology: Idiopathic 48. Degenerative 11.

Spearman rank order test showed marked significant ($p < 0.001$) correlation between SRS22 activity and SVA ($r = -0.44$), PT ($r = -0.49$) and age ($r = -0.5$). SRS22 total was also significantly ($p < 0.004$) influenced by PT ($r = -0.32$) and age ($r = -0.41$).

There is also a significant relationship ($p < 0.001$) between SF36 physical function and SVA ($r = -0.44$), PT ($r = -0.45$) and age ($r = -0.56$).

No significant correlation was found between frontal parameters and HRQOL measures.

Multivariate analysis revealed age and PT as predictors of worse SRS22 activity scores, so that for each year older the patient is, quality of life decreases in 0,022 points (CI 95% 0.005; 0.038; $p = 0.014$) and for each degree of final pelvic rotation quality of life decreases 0.0021 points (CI 95%, 0.003; 0.039 $P = .026$).

Conclusion: After primary surgery for adult scoliosis, in the long run, frontal radiographic parameters do not correlate with HRQOL measures. Patient age, SVA and PT highly correlate with SRS22 and SF36 physical activity. Age and PT are predictors of SRS activity scores

Paper #47

Comparative Analysis of Clinical Outcome and Perioperative Complications in Primary vs. Revision Adult Scoliosis Surgery

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Comparison of Clinical Outcome Measures between Primary and Revision Adult Scoliosis Surgery

		Function			Self-Image			Mental Health			Pain			Subscore			ODI		
		P	R	p-value	P	R	p-value	P	R	p-value	P	R	p-value	P	R	p-value	P	R	p-value
Total	Preop	3.26	2.87	0.00	2.58	2.46	0.19	3.68	3.49	0.05	2.98	2.61	0.00	3.13	2.86	0.00	32.70	43.36	0.00
	Final	3.58	3.34	0.02	3.86	3.56	0.01	3.99	3.88	0.25	3.81	3.51	0.01	3.81	3.58	0.01	19.23	26.83	0.00
	Change	0.29	0.41	0.23	1.25	1.04	0.11	0.28	0.33	0.64	0.81	0.84	0.80	0.65	0.65	0.97	13.32	16.97	0.16
Age 21-40	Preop	3.64	3.02	0.01	2.76	2.60	0.51	3.59	3.47	0.61	3.21	2.58	0.02	3.30	2.92	0.07	26.85	39.03	0.04
	Final	3.79	3.09	0.01	3.89	3.37	0.03	3.98	3.68	0.13	3.78	3.29	0.11	3.86	3.36	0.02	16.56	29.38	0.02
	Change	0.15	0.07	0.78	1.13	0.77	0.14	0.39	0.21	0.46	0.57	0.71	0.69	0.56	0.44	0.60	10.29	9.65	0.92
Age 40-60	Preop	3.23	2.84	0.00	2.53	2.46	0.22	3.63	3.40	0.01	2.91	2.64	0.00	3.08	2.84	0.00	34.94	44.70	0.00
	Final	3.54	3.40	0.12	3.94	3.62	0.12	3.88	3.87	0.70	3.79	3.53	0.03	3.78	3.60	0.09	19.21	27.14	0.01
	Change	0.31	0.55	0.01	1.41	1.16	0.59	0.25	0.47	0.03	0.88	0.88	0.44	0.70	0.75	0.15	15.07	17.56	0.09
Age >60	Preop	2.76	2.83	0.65	2.41	2.37	0.81	3.68	3.74	0.80	2.49	2.55	0.77	2.85	2.89	0.79	41.21	43.09	0.58
	Final	3.37	3.39	0.95	3.86	3.56	0.15	4.17	4.07	0.60	3.66	3.63	0.90	3.77	3.70	0.68	22.61	23.98	0.74
	Change	0.51	0.32	0.39	1.33	0.94	0.18	0.36	0.05	0.26	1.05	0.83	0.43	0.80	0.56	0.29	19.11	20.76	0.73

ODI=Oswestry disability index, P=Primary, R=Revision, Preop=Preoperative, Final=Final follow-up, Change=Final follow-up - Preoperative

Summary: Analysis of 250 patients (126 primary and 124 revision) who had multilevel fusion surgery for adult scoliosis demonstrated lower rate of complications in primary (32.5%; major 24.6%) than revision (44.4%; major 29.0%) surgical patients. Primary patients reported higher preop and final clinical outcome measures than revision patients, although this difference between 2 cohorts disappeared in older patients. Revision patients seemed to have benefited from surgery just as much as primary patients.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

Introduction: We compared clinical outcome and perioperative complications (Glassman, Spine 2007) in adult patients who underwent primary (P) vs revision (R) scoliosis surgery.

Methods: Clinical and radiographic assessment of 250 consecutive adult patients (mean age 51.4 years) who underwent primary vs revision surgery (>6 levels) for idiopathic or de novo scoliosis between 2002 and 2007 by 2 surgeons at 1 institution with a minimum 2-year f/u (mean 3.6 years) were performed. SRS scores and ODI were used.

Results: There were 126 patients in P group and 124 in R group. Mean age (P=51.2 vs R=51.6 yrs, $p=0.79$), f/u (P=3.6 vs R=3.6 yrs), comorbidities ($p=0.43$), and smoking status ($p=0.98$) were similar between 2 groups. BMI (P=25.5 vs R=27.4 kg/m², $p=0.01$), number of final fusion levels (P=10.5 vs R=12.1 levels, $p=0.00$), fusion to sacrum (P=61.0% vs R=87.1%), osteotomy (P=14.3% vs R=54.9%, $p=0.00$), length of surgery (P=6.5 vs R=8.2 hrs, $p=0.00$), and EBL (P=1072.1 vs R=1401.3 ml, $p=0.05$) were statistically different. Primary patients had lower perioperative (P=17.5% vs R=23.4%; Major P=7.9% vs R=8.1%, Minor P=11.1% vs R=16.1%) and overall (P=32.5% vs R=44.4%; Major P=24.6% vs R=29.0%, Minor P=15.1% vs R=21.9%) complications. Primary patients reported higher preop and final clinical outcome measures in all SRS domains and ODI compared to revision patients. Patients over 60 yrs of age, however, reported similar SRS and ODI scores between 2 groups. The extent of surgical benefit patients received, i.e., final score minus preop score, was similar in all categories between 2 groups.

Conclusion: Adult patients undergoing primary scoliosis surgery had lower perioperative (P=17.5% vs R=23.4%) and overall (P=32.5% vs R=44.4%) complications compared to revision patients. Primary patients reported higher preop and final clinical outcome measures than revision patients, although this difference between 2 groups disappeared in older patients. The benefit of surgery as reflected in the difference between final f/u and preop scores was similar between 2 groups.

Paper #48

Does PSF with Pedicle Screws Control Idiopathic Scoliosis with Open Triradiate Cartilages?

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United States*

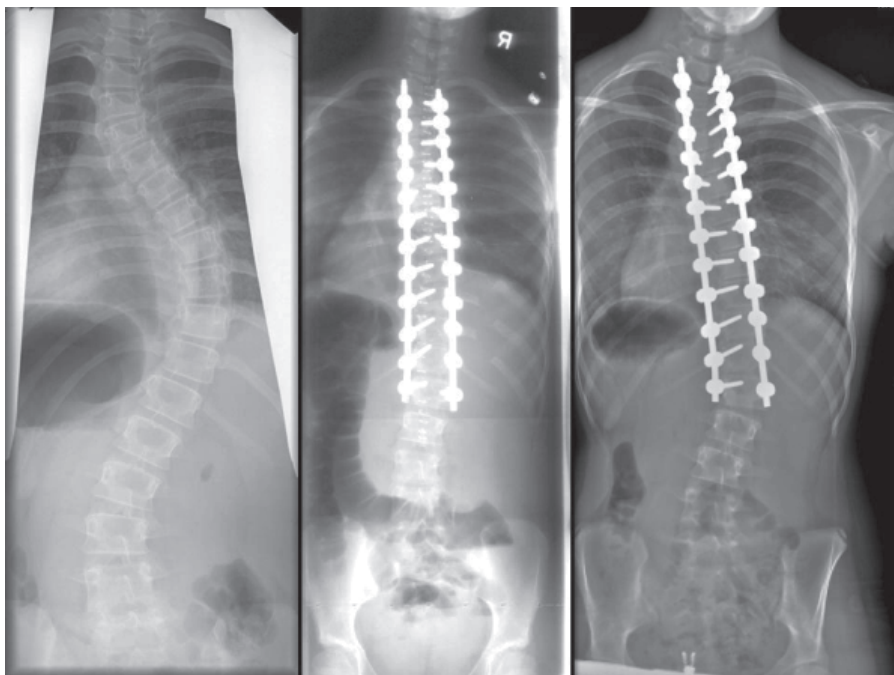


Fig. 1: 15° curve increase by 2 yr follow up after PSF/PS in OTRC

PS (20 pts). All had minimum 2 yr follow up.

Results: Preop curve averaged 58° for (1) & (3) and 54° for (2). Each group was fused a mean of 11 levels. EBL averaged 585 cc for (1) and 1255cc for (2). Hospital stay averaged 5.3 days for (1), 6.6 days for (2) ($p=0.02$), and 5.8 days for (3). Patients in (1) & (2) grew 7 cm between postop and final follow-up, vs 0.5 cm for (3) ($p=0.005$). First postop curves were similar at 12-18°. By 2 year follow up, (1) lost significantly more correction than (2) and (3) (8.8°, 1.6° and 1.3° respectively, $p=0.002$). Progression >10°

Summary: Posterior-only fusion with Pedicle Screws is commonly practiced for patients with open TRC. It lowers OR time, EBL and hospital stay but may lead to modest loss of correction and of kyphosis at 2-yr follow up.

Introduction: Open Triradiate Cartilages (OTRC) indicate significant growth remaining. Patients with significant scoliosis and OTRC had traditionally been treated with anterior and posterior fusion. There is increasing use of posterior-only fusion with pedicle screws (PSF/PS), but no series to compare these outcomes. Clinical outcomes were studied.

Methods: Outcomes of three groups of patients were compared: (1) OTRC, age ≤ 11 having PSF/PS (20 pts), (2) OTRC, age ≤ 11 having APSF (9 pts) and (3) CTRC/Risser 4-5 matched for curve size with group 1 having PSF/

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occurred in 35% of (1), 0% of (2) and 5% of (3) ($p=0.015$)(fig 1). There was no significant difference in lower compensatory curve change between groups. Group 2 gained 8° of kyphosis within the instrumented thoracic curve vs loss of 6° for (1) and (3) ($p=0.01$). There was a significant difference in final clinically-measured rib prominence in (1) vs (2) (10° vs 6° , $p=0.03$) but not in SRS scores. Only one patient has required reoperation (for pseudarthrosis, in group 3).

Conclusion: Patients with OTRC fused posteriorly with PS have less OR time, blood loss and hospital stay but more loss of main curve correction postoperatively than those fused circumferentially and than mature patients. They also have less thoracic kyphosis within the fused region. None have required reoperation at 2 yr F/U.

Significance: Further monitoring of these cohorts and caution in PSF/PS for larger curves may be indicated.

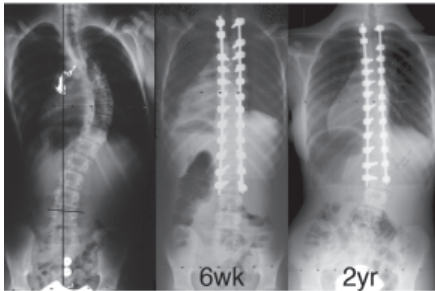
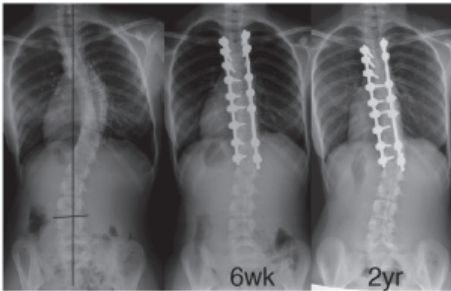
Paper #49

Which Lenke 1A Curves Are at the Greatest Risk for Adding-On...and Why?

Robert H. Cho, MD; Burt Yaszay, MD; Carrie E. Bartley, MA; Tracey Bastrom, MA; Peter O. Newton, MD; Harms Study Group United States

Summary: Lenke 1AL and 1AR have been shown to be two distinct curve patterns with different levels for their lowest instrumented vertebra. This difference places the two patterns at different risks for adding-on with the 1AR group 2.3 times more likely to experience this problem. In the 1AR group fusing patients short of the vertebra above the stable one increases the risk while in the 1AL group younger age and skeletal immaturity place the patient at risk.

Introduction: Previous work (Miyanji et al.) has demonstrated two distinct Lenke 1A curve patterns based on the tilt of L4 (1AL and 1AR). The purpose of this study was to evaluate the incidence of distal "adding on" in these two Lenke 1A curve patterns with the hypothesis that 1AR curves have a higher incidence of adding on than 1AL curves.

"1AR" – L4 tilted to right, LIV:L2	"1AL" – L4 tilted to left, LIV:T12	Methods: A query of prospectively enrolled AIS cases identified 219 patients with surgically corrected Lenke 1A curves followed for >2 years. These patients were grouped based on the pre-op direction of coronal L4 vertebral tilt: 1AL (left) and 1AR (right). The incidence as well as clinical and radiographic risk factors for "adding-on" were identified for each group. Adding-on was strictly defined as an increase Cobb angle of at least 5° with distalization of the lower end vertebra, or a
		

Examples of "Adding on" for both Lenke 1AR and 1AL curves.

change in disc angulation below the lowest instrumented vertebra (LIV) of 5° or greater between the first erect and 2 year f/u xrays. Cases of progression due to implant failure/pseudo were excluded.

Results: Forty-seven (21%) patients met the defined criteria for adding-on. The average increase in Cobb was 10.4° compared with 4° degrees in the non adding-on group. Lenke 1AR curves were 2.3 times more likely to experience adding-on (37/144 Lenke 1AR, 10/75 Lenke 1AL). Of the 1AR curves, the patients who added-on were fused an average 2.0 levels above the stable vertebra, versus an average of 1.3 levels for the patients who did not add-on ($p=0.001$). In contrast, for 1AL curve patients, younger age (12.7 vs. 14.7 years old, $p=0.002$) and lower Risser grade (70% vs. 14% Risser 0, $p=0.004$) were the factors more likely to be associated with adding-on. The selected level of LIV was not a determinant of adding-on in these curves.

Conclusion: In the 1AR curve pattern, there is a greater tendency to choose the LIV too short and in order to prevent adding-on, we recommend fusing distally to 1 level above the stable vertebra. In 1AL curves the risk of adding on appears less, although the most skeletally immature patients deserve special consideration and may benefit from an additional distal level of fusion.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

Paper #50

Selective Thoracic Fusion in Adolescent Idiopathic Scoliosis: Implications of Leveling of the Lowest Instrumented Vertebra on Lumbar Curvature and Coronal Balance

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Summary: The extent to which the lowest instrumented vertebra (LIV) is leveled during selective thoracic fusion is an object of much debate among surgeons, especially in Lenke type 1B, 1C and 3 curves. In this longitudinal study, 205 consecutive patients with correction of AIS formed two cohorts: those who were “leveled” and those who were not. We found that leveling of the LIV gives a smaller lumbar Cobb angle without increasing the risk of coronal imbalance.

Introduction: When performing a thoracic fusion for Lenke 1B, C and Lenke 3 curves, surgeons debate whether the lowest instrumented vertebra (LIV) should be leveled as much as possible, or left with some tilt to create a harmonious transition from fused to unfused spine. Our goal was to study the early effects (min.2 yr f/u) of leveling vs. leaving the tilt in the LIV.

Methods: Prospectively collected data from a multi-center database revealed 205 patients with Lenke type 1B or 1C or 3 curves. We divided these patients into 2 cohorts: 73 with “leveled”(LIV tilt -5° to 5°) and 132 with “non-leveled” LIV. Radiographic data was analyzed before surgery, at first radiographic follow-up and at 2 years after surgery for changes in lumbar curve size, coronal balance and lumbar apical translation.

Results: The average 2 year post-op LIV tilt for the “leveled” group was $5 \pm 4^\circ$ compared to $9.7 \pm 4.6^\circ$ for the “unleveled” group. At 2 years post-op, the lumbar Cobb angle was smaller (17.3° vs. 21.6° , $p < 0.001$) in the leveled group vs. the non-leveled group. Coronal balance was similar between the leveled and non-leveled groups at 2 years after surgery (-1.25 vs. -1.21 , $p = 0.85$) with a slight tendency for trunk shift to the left in both groups. The change in lumbar apical translation was not significantly different between the two groups at 2 year follow-up. There was a weak to moderate association between pre-operative lumbar curve and post-operative LIV tilt. However, 90% of the variation in post-operative LIV tilt was attributable to factors other than pre-operative lumbar curve.

Conclusion: At 2 year follow-up, leveling of the LIV in selective thoracic fusions in AIS results in a smaller absolute lumbar Cobb angle without increasing the risk of coronal imbalance.

Significance: These 2 year follow-up results suggest leveling the thoracic LIV maximizes spontaneous correction of the lumbar curve when a selective thoracic fusion is performed for Lenke 1B, 1C and the rare 3C curves.

Paper #51

Motion of the Spine Pre and Post-Spinal Fusion Compared to Age-Matched

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Summary: Spinal range of motion is limited in all three planes of motion following a spine fusion and instrumentation in adolescents with idiopathic scoliosis.

Introduction: The spinal range of motion (ROM) of adolescents with idiopathic scoliosis (AIS) is affected by instrumentation and fusion. No universally accepted guidelines exist for deciding on the level of instrumentation. This study measures the changes in spinal ROM pre and post instrumentation and fusion and compares them to age-group matched controls.

Methods: This is a prospective study of 26 patients with AIS (18 F, 8M, mean age 14.5 ± 2.2 y; Cobb angle > 50 degrees) who underwent spinal instrumentation and fusion. 16 subjects returned for a post operative assessment. Trunk ROM was assessed with a 3-Dimensional Motion Capture system (VICON; Oxford, UK). While standing the subjects were instructed to move their trunk maximally in all three planes (transverse, coronal and sagittal). The max values were statistically compared within the Scoliosis Group (left side to right side) and to a “Control Group” of age matched typically developing adolescents ($p < 0.05$). Further analysis was done to compare those subjects in the Scoliosis Post-Op Group that had the fusion at L2 or above (L2+) to those that had a fusion at L3 or below (L3-).

Results: Within the Scoliosis Pre-Op Group there was significantly greater rotation and side-bending to the left versus the right. The Scoliosis Group had less trunk rotation and side-bending to the right along with less forward bending flexibility (Table 1) compared to the Control Group. Post operatively the Scoliosis Group lost greater than 46% ROM in the transverse plane, greater than 44% ROM in the coronal plane, 50% ROM bending forward and 15% bending back.

Conclusion: AIS have less ROM in all three planes and move asymmetrically compared to Controls. One year following spinal fusion and instrumentation further loss of ROM was measured in all three planes with the most motion lost in subjects fused at L3 or below.

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Significance: These results provide a comparison for spinal motion prior to surgical instrumentation and fusion and also provide realistic expectations for spinal flexibility.

Paper #52

Meta-Analysis of the Safety and Efficacy of Pedicle Screw Spinal Instrumentation in Pediatric Spinal Deformity: Results of SRS and POSNA Task Force

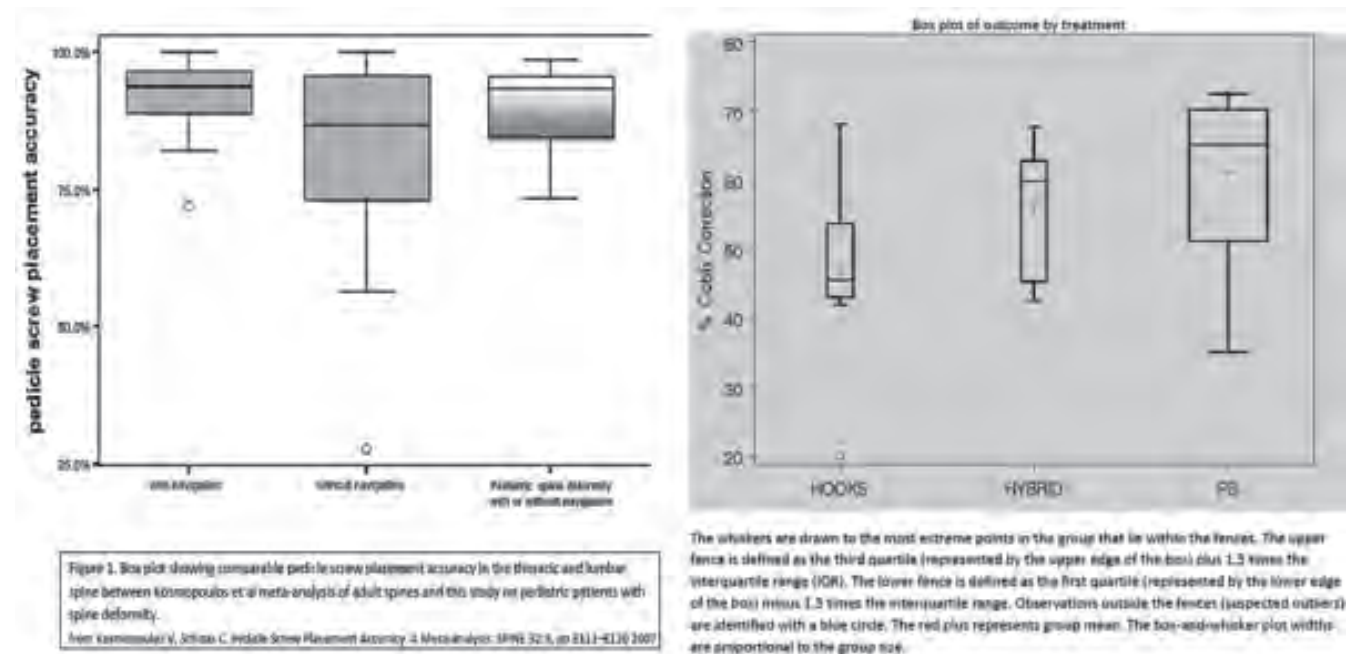
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Summary: Results of a meta-analysis of the published English literature conducted by SRS and POSNA task force revealed that accuracy of pedicle screw placement in the pediatric spine is comparable to accuracy rate reported in adults. PS constructs are significantly more effective in %Cobb correction with a large effect size compared to hook and hybrid constructs

Introduction: Pedicle screws (PS) have revolutionized the surgical treatment of spinal deformity and are extensively used in adults and children. Despite being standard of care for pediatric spinal deformity, pedicle screw systems have not been FDA approved in pediatric populations, and are used as a physician directed application. With support from the Scoliosis Research Society and the Pediatric Orthopaedic Society of North America, a meta-analysis was performed to determine the safety and efficacy of pedicle screw use in pediatric patients

Methods: Pubmed was searched for English language studies of PS use in pediatric patients (<18yrs). Comparison of PS accuracy and effect size comparison for Cobb correction was done

Results: Of 1181 articles, 320 pertinent abstracts were reviewed. 90 full-text articles selected. 35 studies met inclusion criteria for the meta-analysis. 19 studies for PS placement accuracy yielded a total of 13,536 pedicles screws in 1,353 pediatric spine deformity patients. 689 of 13,536 screws were reported misplaced, for an overall accuracy of 95%. The weighted, geometric and 5% trimmed mean accuracy of PS placement were 92%, 88%, and 89% respectively (SD=10%;IQR=10%). 16 comparative studies for the effect size analysis showed PS constructs had significantly larger %Cobb angle correction means compared to hook constructs (Cohen d=1.14; 95%CI=-4.4,10.7) and hybrid constructs (Cohen d=0.49; 95%CI=-5.1,7.3)



Conclusion: Accuracy of pedicle screw placement in the pediatric spine (95%) exceeds the accuracy rate reported in adults (91%). Based on this, the safety of pedicle screw spinal systems in the skeletally immature population should be considered equivalent to that shown in adults. PS constructs are significantly more effective in %Cobb correction with a large effect size compared to hook and hybrid constructs.

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).

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Paper #53

Segmental vs. Non-Segmental Thoracic Pedicle Screws Constructs in Adolescent Idiopathic Scoliosis. Is There any Implant Alloy Effect?

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Italy*

Summary: Thoracic pedicle screws has been proven to be safe and effective in the treatment of AIS. However, the influence of the instrumentation alloy has not yet been investigated. We revised 143 AIS patients surgically treated. Our results showed that when a stainless steel instrumentation is used, non segmental pedicle screw constructs seem to be equally effective as segmental instrumentations in obtaining satisfactory results in patients with main thoracic AIS. When the implant alloy used is Titanium, an implant density of >60 % should be guaranteed so as to achieve similar results.

Introduction: Objective of our study was to compare segmental versus non segmental thoracic pedicle screw instrumentations in posterior fusion for adolescent idiopathic scoliosis (AIS) patients.

Methods: A consecutive series of 143 AIS patients (Lenke 1-4) surgically treated from 1998 through 2005 by means of thoracic pedicle screws only constructs were retrospective reviewed. Considering implant density (number of fixation anchors placed per available anchors sites; segmental>60%, non segmental<40%) and implant alloy used (Ti:titanium vs SS:stainless steel) we divided the aforementioned cohort in four groups: Ti-S=48 cases; Ti-NS=34; SS-S:35; SS-NS=26. Groups were similar for preoperative average age, gender distribution, Risser sign, main thoracic curve and thoracic kyphosis. Pearson correlation coefficient and univariate analysis of variance were used.

Results: At a mean follow-up of 6.2 years (range,3 to 10) the overall final main thoracic curve correction averaged 61.4% (20-89), whereas the implant density within the major curve averaged 71% (15-100). A significant correlation between implant density and percent major curve correction was observed ($r = 0.41$, $p < 0.002$); when the four distinct groups were compared we found that according to percent correction observed the SS-S group showed the greatest average correction (75%), followed by the Ti-S, SS-NS, and Ti-NS. We found no statistically significant differences between SS-S vs Ti-S vs SS-NS ($r = 0.002$, $p > 0.05$; $r = 0.13$, $p > 0.05$; $r = 0.07$, $p > 0.01$), whereas the Ti-NS group showed a statistically significant inferior percent correction when compared to all other groups (average 52%; $p < 0.001$). Nevertheless, no significant difference between groups was found on the SRS-30 assessment showing a postoperative improvement in both self-image and satisfaction.

Conclusion: According to these results, when a SS instrumentation is used, non segmental pedicle screw constructs seem to be equally effective as segmental instrumentations in obtaining satisfactory results in patients with main thoracic AIS. When the implant alloy used is Titanium, an implant density of >60 % should be guaranteed so as to achieve similar results.

Significance: Level 3

Paper #54

Incidence, Distribution, and Surgical Relevance of Abnormal Pedicles in Normal and AIS Spines: A CT Based Study of 6624 Pedicles

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Summary: Significantly higher number of abnormal pedicles is seen in AIS compared to normal. The incidence of screw malpositioning is higher in these pedicles. The curve and patient characteristics have been analyzed for correlation.

Introduction: Understanding of pedicle morphology is critical for accurate screw placement. The Objective of this study is to document abnormal pedicle morphology, its incidence, subtypes, and correlate it with curve & patient characteristics.

Methods: CT scans of 191 Adolescent patients were reviewed for pedicle morphology. Pedicle morphology was classified as Type A: >4mm cancellous channel, Type B: 2-4 mm channel, Type C: cortical channel, and Type D: non-existent pedicle. Group 1 had 96 patients with non-spinal pathology and Group 2 had 95 AIS patients who underwent PSF. The data was analyzed with respect to Age, Weight, and Height, Cobb angle, Kyphosis and Lenke classification. 65 pts in Group II also had post-op CT scans.

Results: 6624 pedicles were studied. In Group I the incidence of abnormal pedicle was 9.8% and in Group II it was 22% ($p < 0.001$). 95.96% of abnormal pedicles in AIS were in the thoracic spine. The incidence of abnormal pedicles in the thoracic spine was 29.6%. Of those, 30.7% were type C or D. In the thoracic spine, three times as many abnormal pedicles were located on the concave side of the curve than on the convex side of the curve (148/197)($p < 0.001$). In 65 patients, who had post-op CT scan (1356 screws) 153 (11.28%) were malpositioned. 76 (21.6%) instrumented abnormal pedicles were malpositioned compared to 77(7.7%) instrumented normal pedicles ($p < 0.001$).

Female and obese patients had significantly higher number.

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Conclusion: Our study found significantly higher incidence rates of abnormal pedicles in AIS patients than non-spinal deformity patients.

Significance: Knowledge of abnormal pedicles preoperatively enables surgeon to anticipate and plan for difficult placement or to skip the pedicle altogether. Of abnormal pedicles found in patients with AIS, most were located within the thoracic curve, with a significant proportion found on the concave side of the curve. Due to the high proportion of dysmorphic pedicles located with the thoracic spine, radiation exposure may be limited by reducing the number of segments scanned for preoperative evaluation in patients with AIS.

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Paper #55

Pedicle Screw Fixation Strategies of the Thoracic Curve in Adolescent Idiopathic Scoliosis

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Summary: The study addressed the radiographic, clinical and cost-analysis of three pedicle screw strategy techniques for the treatment of AIS. The study noted that pedicle screw strategy techniques utilizing non-contiguous multilevel screw fixation (CMSS) maintain an FBCI greater than 100%, are cost-effective, and provide similar clinical outcomes as CMSS.

Introduction: Studies have demonstrated that taking into account curve flexibility based on the fulcrum bending radiograph in patients with adolescent idiopathic scoliosis (AIS) is imperative to best assess curve correction following surgery. We present the prospective radiographic, clinical, and cost comparisons of three pedicle screw fixation strategies in the treatment of thoracic AIS while accounting for curve flexibility.

Methods: Ninety-four AIS patients were prospectively assessed. Seventeen patients had key-vertebral screw strategy (KVSS), 42 had alternate level screw strategy (ALSS), and 35 received contiguous multilevel screw strategy (CMSS). Titanium rods were utilized in the KVSS and ALSS cases, whereas stainless-steel rods were applied in patients with CMSS. Pre- and postoperative postero-anterior and fulcrum bending radiographic Cobb angles were obtained. The fulcrum flexibility and the fulcrum bending correction index (FBCI) were assessed. Final follow-up SRS-22 Questionnaire were assessed. Instrumentation cost analyses was conducted of all three strategies.

Results: The FBCIs of the KVSS, ALSS, and the CMSS were 119%, 122%, and 152%, respectively ($p < 0.001$). There was no statistically significant difference between the overall SRS-22 scores and strategy techniques ($p > 0.05$). In comparison to the CMSS, the KVSS and ALSS were associated with pedicle screw cost reductions of 41.7-73.1% and 33.3-46.2%, respectively.

Conclusion: Although the CMSS may provide an increased amount of FBCI, the KVSS and ALSS utilizing less pedicle screws for the surgical treatment of AIS are safe, cost-effective, and achieve an FBCI greater than 100% in the majority of cases while achieving similar clinical outcomes. In AIS patients with flexible thoracic curves, the KVSS and ALSS are viable alternatives to CMSS. In addition, one should remain cognizant that variation in instrumentation (e.g. stainless steel rods vs. titanium rods) may affect the degree of FBCI.

Significance: In comparison to the CMSS, ALSS and KVSS utilize less pedicle screws while maintaining an FBCI greater than 100%, are cost-effective, and provide similar clinical outcomes. In particular, in AIS patients with flexible thoracic curves, the KVSS and ALSS are viable alternatives to CMSS.

*Paper #56

Morbidity and Mortality of Major Adult Spinal Surgery. A Prospective Cohort Analysis of 942 Consecutive Patients

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Canada*

Summary: Major spinal surgery in the adult is associated with a high incidence of intra- and postoperative complications. We identify a very high rate of previously unrecognized postoperative complications which adversely affect length of stay. Without strict adherence to a prospective data collection system the true complexity of this surgery may be greatly underestimated.

Introduction: The purpose of this study was to determine the mortality and true incidence and severity of morbidity (major and minor, medical and surgical) in adults undergoing complex spinal surgery, and to examine the influence of the introduction of a prospective method of data collection.

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Methods: All patients undergoing surgery over a 12-month period was prospectively collected using a Peri-operative Morbidity Abstraction Tool at weekly dedicated M&M rounds. Prior to the introduction of this system, and utilizing the Hospital Inpatient Database, our documented peri-operative morbidity rate (major and minor, medical and surgical) was 23%. Diagnosis, operative data, hospital data, major and minor complications both medical and surgical, and deaths were recorded.

Results: 100% of all patients discharged from the unit had complete data available for analysis. Nine hundred and forty two patients with an age range of 16 to 90 years (Mean 54 years, Mode 38 years) were identified. There were 552 males and 390 females. 58.5% of patients had undergone elective surgery. 30% of patients were ASIA D or worse on admission. The average Length of Stay was 13.5 days (range 1 - 221 days). 822 (87%) patients had at least 1 documented complication. 39% of these adversely affected hospital length of stay. There were 14 mortalities during the study period. The rate of Intraoperative Surgical complication was 10.5% (4.5% incidental durotomy and 1.9% hardware malposition requiring revision and 2.2% blood loss > 2L). The incidence of postoperative complication was 73.5% (wound complications 13.5%, delirium 8%, pneumonia 7%, neuropathic pain 5%, dysphagia 4.5% and neurological deterioration 3%).

Conclusion: Major spinal surgery in the adult is associated with a high incidence of intra- and postoperative complications. We identify a very high rate of previously unrecognized postoperative complications which adversely affect length of stay. Without strict adherence to a prospective data collection system the true complexity of this surgery may be greatly underestimated.

Paper #57

Preoperative ASA Grading is a Robust Predictor of Complication Rates in Patients Undergoing Surgery for Major Spinal Deformity

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Summary: Providing patients with appropriate counseling regarding operative risk is imperative for obtaining informed consent. In this study we analyzed the multi-center, multi-surgeon Scoliosis Research Society (SRS) Morbidity and Mortality (M&M) database to determine if a patient's American Society of Anesthesiologists (ASA) grade is a predictor of increased morbidity and mortality in adult patients treated operatively for major deformities of the spine. Higher ASA grades correlate with increased perioperative morbidity in the operative treatment of major deformity.

Introduction: Providing patients with appropriate counseling regarding operative risk is imperative for obtaining informed consent. Previous studies have demonstrated the operative risks for populations undergoing corrective spinal surgery. However, a patient's risk assessment should be tailored to their individual circumstances, including preoperative comorbidities. In this study we analyzed the multi-center, multi-surgeon Scoliosis Research Society (SRS) Morbidity and Mortality (M&M) database to determine if a patient's American Society of Anesthesiologists (ASA) grade is a predictor of increased morbidity and mortality in adult patients treated operatively for major deformities of the spine.

Methods: The SRS M&M database was reviewed for the year 2007, the first year in which ASA grade was recorded. Patients without recorded ASA grades were excluded. Inclusion criteria were age over 21 and a primary diagnosis of scoliosis or kyphosis, or a reported osteotomy. Chi-square analysis was used for comparisons between groups with a P value of < 0.05 considered significant.

Results: 1975 patients with a mean age of 53 were included. Patients assigned higher ASA grades were reported to have higher rates of complication (P<0.001) and mortality (P<0.001) as shown in table 1. Patients with higher ASA grades had higher rates of common complications including epidural hematomas (P=0.04), deep wound infections (P<0.001), pulmonary complications (P<0.001), and durotomies (P=0.04).

Conclusion: Higher ASA grades correlate with increased perioperative morbidity in the operative treatment of major deformity. An accurate ASA grading can be useful in counseling patients on the risk/benefit ratio of surgery. These data confirm the increased risk of undergoing corrective surgery on patients with increased risk factors and comorbidities and suggest the utility of the ASA grade in quantifying these risks among adult patients with spinal deformities.

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Paper #58

Major Complications in Revision Adult Deformity Surgery: Risk Factors and Clinical Outcomes with Two to Seven Year Follow-Up

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United States

Comparison of Clinical Outcome Measures between Major Complication Group and No or Minor Complication Group

	Function			Self-Image			Mental Health			Pain			Subscore			ODI		
	Major	No	p-value	Major	No	p-value	Major	No	p-value	Major	No	p-value	Major	No	p-value	Major	No	p-value
Preop	2.60	2.85	0.04	2.37	2.45	0.50	3.45	3.47	0.89	2.31	2.65	0.01	2.69	2.85	0.10	44.44	44.48	0.99
Final	2.97	3.42	0.00	3.28	3.57	0.59	3.81	3.85	0.77	3.18	3.56	0.03	3.31	3.60	0.02	33.28	26.17	0.03
Change	0.36	0.56	0.09	0.91	1.10	0.23	0.37	0.35	0.86	0.86	0.89	0.81	0.60	0.73	0.20	11.06	18.08	0.03

Major = major complication group, No = no or minor complication group, ODI = Oswestry Disability Index

Summary: Analysis of 166 adult patients who underwent multilevel revision fusion surgery for deformity showed 36.7% major complications (15.7% perioperative

and 26.5% late). Associated risk factors were age >60 yrs, EBL >2000 mL, three column osteotomy, comorbidities, and total number of levels fused >10. Although patients with major complications reported lower final outcome scores, they benefited from revision surgery as much as patients who had no complications.

Introduction: We sought to identify risk factors for developing major complications following multilevel revision adult deformity surgery and to compare clinical outcomes between patients who had major complications vs. those who did not.

Methods: Analysis of all consecutive adult patients (age >21 yrs) who underwent multilevel revision fusion surgery for spinal deformity by surgeons at 1 institution with a minimum 2-year f/u was performed. All complications were classified as either major or minor according to Glassman (Spine, 2007). Outcome analysis was conducted with SRS scores and ODI.

Results: 166 patients (141F/25M; mean age 53.8 yrs) were identified with a mean f/u of 3.6 yrs (range 2-7). Primary diagnoses included idiopathic/de novo scoliosis (107), degenerative causes (35), trauma (7), neuromuscular scoliosis (6), congenital causes (5), ankylosing spondylitis (2), Scheurmann's kyphosis (1), tumor (2), and rheumatoid arthritis (1). Most common secondary diagnoses that necessitated revision surgery were adjacent segment disease, fixed sagittal imbalance, and pseudarthrosis. Overall, 36.7% (61/166) and 13.9% (23/166) of patients developed major and minor complications, respectively. Perioperative major complications occurred in 15.7% of patients including 1 death. Late major complications occurred in 26.5% of patients with pseudarthrosis/instrument failure being most common. Significant risk factors were age >60 yrs (p=0.017), EBL >2000 mL (p= 0.019), and three column osteotomy (p=0.04) with a trend toward significance for comorbidities (p=0.064) and total number of levels fused >10 (p=0.098). Patients who experienced major complications reported lower pre- and postop clinical outcome measures. However, the change in outcome scores (final - preop) were similar between 2 groups.

Conclusion: The overall rate of major complications was 36.7% for patients undergoing long revision fusion surgery for adult spinal deformity. Associated risk factors were age >60 yrs, EBL >2000 mL, three column osteotomy, comorbidities, and total number of levels fused >10. The occurrence of a major complication seemed to have a negative impact on ultimate clinical outcome, but patients with complications benefited from revision surgery as much as those without.

Paper #59

Prevalence, Outcomes and Risk Factors for Proximal Junctional Kyphosis following Surgical Correction of Adult Idiopathic Scoliosis

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Summary: Surgical treatment of adult scoliosis patients undergoing long instrumented fusion showed a PJK incidence of 20%. Fusion to sacrum and posterior spinal fusion were identified as risk factors. The incidence of PJK can be minimized by normalization of post operative global sagittal alignment. However, no significant difference was found in SRS outcome scores and ODI for PJK and non PJK patients, with a low revision rate of 12.5 % (4/32 pts).

Introduction: To assess the prevalence, clinical outcomes and risk factors of proximal junctional kyphosis (PJK) in adult idiopathic scoliosis (AIS) patients undergoing long instrumented spinal fusion (>5 vertebrae).

Methods: A retrospective review of the chart and x-ray of 157 consecutive patients with adult scoliosis patients treated with long instrumented spinal fusion. PJK was defined by a proximal junctional angle greater than 10° and at least 10° greater

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than the corresponding preoperative measurement. Radiographic measurements included sagittal plumb line (SVA), thoracic kyphosis (TK), lumbar lordosis (LL) and Pelvic incidence (PI) on preoperative, immediate post op and at follow-up. Bone mineral density (BMD), Body mass index (BMI), age, sex, instrumentation type, surgery type and fusion to sacrum were reviewed. Post-operative SRS outcome scores and Oswestry Disability Index (ODI) were also evaluated. Means were compared with student's t test and chi-square test. P value of <0.05 with confidence Interval 95% was considered significant.

Results: The average age was 46.9 yrs (22-81 yrs) and the avg. f/u was 4.3 yrs (2-12 yrs). PJK occurred in 32 pts (20%). The SRS outcome scores and ODI did not demonstrate significant differences between PJK group and non PJK- group, 4 pts had additional surgeries performed for local pain. Fusion to sacrum and posterior fusion were significant risk for PJK (P=0.03, P<0.01). BMD, BMI, age, sex and instrumentation type indicated no difference. 84% of PJK group was associated with TK+LL+PI>45 degree or pre ope - post ope SVA >50mm vs 6.4% of non PJK group (P<0.01, P<0.01).

Conclusion: Despite the occurrence of PJK in 20% of adult scoliosis patients undergoing long fusion, no significant difference was found in SRS outcome scores and ODI in PJK and non PJK patients. Fusion to sacrum and posterior fusion were identified as risk factors. PJK can be minimized by post operative normalization of global sagittal alignment.

Paper #60

Myelopathic Patients Who Lack Intraoperative Spinal Cord Monitoring Data Have the Highest Rate of Spinal Cord Deficits Following Posterior VCR Surgery

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Summary: The prevalence of unobtainable intraoperative spinal cord monitoring data during adult and pediatric VCR surgery was 17.7% (17/96). Transient postoperative paraplegia occurred exclusively in patients who were unmonitorable due to angular kyphosis with acute, progressive myelopathy. The rate of postoperative spinal cord deficits was significantly higher when there was no intraoperative spinal cord monitoring (3/17 vs. 0/79, p=0.005).

Introduction: Posterior vertebral column resection (VCR) is a powerful technique to correct severe spinal deformities but has the potential to result in major neurologic complications, especially when performed without intraop spinal cord monitoring (SCM).

Methods: The SCM data (DNEPs and SSEPs), operative reports, charts, and radiographs of 96 consecutive adult and pediatric pts (mean age 22.0 yrs, range 4.3-74.0) who underwent VCR were reviewed. All surgical procedures were performed between 2002 and 2009 by 1 surgeon at a single institution.

Patient	Age (yrs)	VCR Level(s)	Dx	Additional Diagnoses	Preop Neuro Status	Postop Neuro Status
1	5.8	T4-6	KS	Cerebral palsy, Dubowitz syndrome	Progressive myelopathy with loss of LE strength for 1.5 wks with improvement after steroids	No change
2	6.4	T6-8	GK	Congenital dislocation T3-4	Progressive myelopathy with loss of LE strength for 2-3 mths	No change
3	12.8	T5-6	KS	Infantile idiopathic scoliosis	Progressive myelopathy with loss of LE strength for 3 mths	Paraplegia
4	14.7	T3-4	AK	Neurofibromatosis	Progressive myelopathy with improvement in LE strength with preoperative traction	No change
5	15.9	T4	KS	Congenital kyphoscoliosis	Severe myelopathy	Paraplegia
6	32.6	T2-3	AK	Cervicothoracic syringomyelia	Severe myelopathy	Paraplegia
7	42.5	T12-L1	AK	Achondroplastic dwarfism	Severe myelopathy	No change
8	10.7	T12	SS	Congenital scoliosis, myelomeningocele	Paraplegia	No change
9	13.3	T6-7	KS	Williams syndrome	Paraplegia	No change
10	14.8	T6-7	KS	Congenital kyphoscoliosis	Paraplegia	No change
11	16.0	T12-L2	GK	Congenital kyphosis	Paraplegia	No change
12	16.2	T10-11	KS	Congenital kyphoscoliosis, myelomeningocele	Paraplegia	No change
13	20.9	T9-10	KS	Myelomeningocele	Paraplegia	No change
14	8.2	T12	KS	Congenital kyphoscoliosis	Global LE weakness	No change
15	20.3	L3	GK	Congenital kyphosis, diastematomyelia	Global LE weakness	No change
16	19.3	L1	KS	Cerebral palsy	Spastic quadraparesis	No change
17	19.6	T8-9	KS	Charcot-Marie-Tooth syndrome	Normal except for bilateral tibialis anterior weakness	No change

KS=kyphoscoliosis, AK=angular kyphosis, GK=global kyphosis, SS=severe scoliosis, Preop=preoperative, Postop=postoperative, Neuro=neurologic

Results: 17 pts (10M/7F; mean age 17.1 yrs) out of 96 (17.7%) did not have detectable SCM data during surgery, while the other 79 had SCM data. The avg pre- and postop scoliosis for these 17 pts were 75.3o (range, 24-132o) and 41.2o (range, 6-100o), respectively. The average pre- and postop kyphosis were +111.3o (range, 31-150o) and

+58.4o (range, 26-110o), respectively. 11 out of 17 were revision cases. Preop neurologic statuses for 17 pts without SCM data were: acute, progressive myelopathy (n=7), no lower ext function (n=6), chronic, weak lower ext (n=2), chronic quadraparesis (n=1), and normal (n=1). 3 pts with acute, progressive myelopathy (3/7) developed transient paraplegia postop. In addition to being myelopathic, all 3 pts were revision cases with angular kyphosis (mean +124.0o). When compared to 79 pts who had intraop SCM data and none of whom developed spinal cord deficits (0/79), the risk of developing postop paraplegia in pts who had no intraop SCM data (3/17; 17.6%) during VCR surgery was statistically much higher (p=0.005).

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Conclusion: The prevalence of unobtainable intraop SCM data during adult and pediatric VCR surgery was 17.7% (17/96), and transient postop paraplegia occurred exclusively in pts who were unmonitorable due to angular kyphosis with acute, progressive myelopathy. The rate of postop spinal cord deficits was significantly higher when there was no intraop SCM (3/17 vs 0/79 with SCM, $p=0.005$).

Significance: This study highlights 1) the importance of using multimodal neurophysiologic monitoring during high risk cases whenever possible and 2) the increased risk of having major neurologic complications in acutely myelopathic pts who undergo VCR surgery without intraop SCM.

Paper #61

Delayed Post-Operative Neurologic Deficits in Spinal Surgery

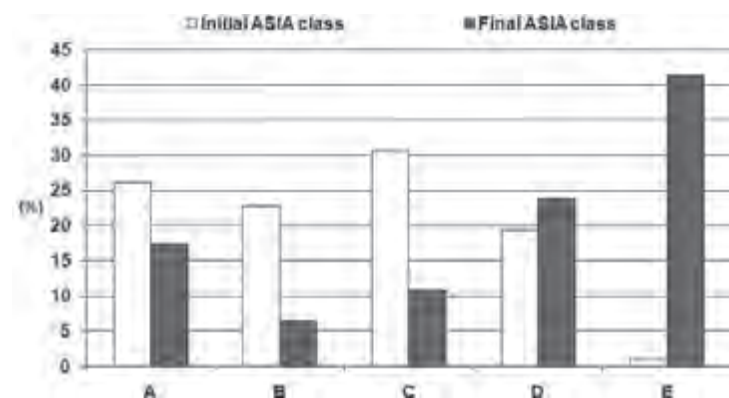
Joshua D. Auerbach, MD; Baron S. Lonner, MD; Kristin E. Kean, BA; Andrew H. Milby, BS; Kenneth J. Paonessa, MD; John P. Dormans, MD; Peter O. Newton, MD; Kit M. Song, MD

United States

Summary: Delayed post-operative neurologic deficit (DPND) is a potentially devastating condition following spinal surgery. DPND occurred in an estimated 1/9910 (0.01%) cases, or 1/4134 (0.024%) deformity cases. 23% of SRS members experienced a case of DPND in the past 10 years, with 63% of cases occurring within 24 hours. 41% ultimately achieved complete neurologic recovery (ASIA E), 26% partial, and 33% experienced no recovery. 22% of patients achieved final neurologic status within 1 week, 38% by 1 month, and 73% by 6 months.

Introduction: The purpose of this study was to characterize the incidence, clinical presentation, diagnostic workup, treatment, and ultimate neurologic outcomes following delayed post-operative neurologic deficit (DPND) in the contemporary era of spinal cord monitoring.

Methods: We developed a survey to comprehensively characterize DPND following spinal surgery. The survey was sent to surgeon members of the SRS through email and standard mail. Three attempts were made to contact potential respondents. The overall response rate was 38% (352/929).



Results: Our results suggest an estimated DPND incidence of 1/9910 (0.01%) cases, or 1/4134 (0.024%) deformity cases. Results from an unpublished survey from 1997 yielded a similar estimated incidence of DPND of 1/3389 (0.03%). 81 surgeons (23%) experienced at least one DPND in the past 10 years (92 total cases). There were no differences in surgeon demographics in those with/without a DPND. Of the cases reported, there were 52 females and 37 males, with 69% <19yrs at presentation. Most common diagnoses were: scoliosis (69%), kyphosis (23%), and spondylolisthesis (14%). 20% were revision surgeries. The number of hours to deficit onset was as follows: 1-12 (36%), 13-24 (27%), 25-48 (27%), >48 (10%). Some form of

spinal cord monitoring was used in 97% of cases, with 47% using transcranial motor potentials. 27% of patients were returned to OR immediately, while 41% had a delayed return to OR. 73% of patients underwent imaging studies prior to treatment (42% MRI; 29% CT/myelogram). The most commonly cited sources of injury included ischemic injury (38%) and cord compression (15%). 41% experienced complete neurologic recovery, 26% partial, and 33% no recovery. 22% of patients achieved final neurologic status within 1 week, 38% by 1 month, and 73% by 6 months (Figure 1).

Conclusion: DPND occurs at an estimated incidence of 0.01%. 63% of DPND cases occurred within the first 24 hours, and 90% within 48 hours. A complete (41%) or partial (26%) neurologic recovery may be expected, emphasizing the need for extreme perioperative vigilance, prompt recognition, and early intervention.

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Paper #62

Does BMP Increase the Incidence of Perioperative Complications in Spinal Fusion? A Comparison of 55,862 Cases of Spinal Fusion with and without BMP.

Brian J. Williams, MD; Justin S. Smith, MD, PhD; Kai-Ming Fu, MD, PhD; D. K. Hamilton, MD; Joseph H. Perra, MD; David W. Polly, MD; Christopher P. Ames, MD; Sigurd H. Berven, MD; Richard E. McCarthy, MD; Steven D. Glassman, MD; Dennis R. Knapp, MD; Christopher I. Shaffrey, MD

United States

Summary: BMP use in anterior cervical fusions was associated with more complications, including wound infections. BMP use for combined ant/post fusions and scoliosis correction procedures was associated with higher complication rates. However, these complication rates are not stratified based on case complexity and do not account for long-term complications, such as psuedarthrosis. For all procedures combined, excluding anterior cervical fusions, the complication profile was similar for fusion with and without BMP.

Introduction: BMP is commonly used to augment spinal fusion; however, there is a dearth of evidence demonstrating associated complications.

Methods: We retrospectively analyzed all fusions submitted to the Scoliosis Research Society Morbidity and Mortality database from 2004-2007 (Level III evidence).

Results: There were 55,862 fusions identified, with BMP used in 21% (Table). BMP was used disproportionately in older patients and revision cases. BMP use in anterior cervical fusions (ACF) was associated with more wound infections and overall complications (Table). There was a trend toward more episodes of dysphagia in the ACF with BMP group (0.2% v. 0.6%, $P=0.088$). For all other cases, there were no differences between the fusion with or without BMP groups for overall complications, wound infections, epidural hematomas, or mortality ($P>0.05$). Among revision procedures there were no differences in the rates of complications based on BMP use. (Table) When stratified by fusion method, BMP use in combined ant/post procedures was associated with more deep wound infections (0.2% v. 1.1%, $P=0.001$), and interlaminar fusions with BMP were associated with more epidural hematomas (0.1% v. 0.5%, $P=0.006$). When stratified by diagnosis, BMP was associated with more epidural hematomas (0.28% v. 0.1%, $P=0.015$) and overall complications (8.5% v. 9.9%, $P=0.031$) in scoliosis correction procedures. However, these rates are not stratified based on case complexity and do not account for long-term complications, such as psuedarthrosis.

Conclusion: BMP was associated with more complications in ACFs, but for all other spinal fusions combined, the complication profile was similar to fusion without BMP.

Paper #63

Surgical Outcome of 72 Cases of Tuberculous Paraplegia. A Retrospective Analysis

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India



Summary: Optimal and direct decompression of the cord in tuberculous paraplegia is essential for a favorable neurological outcome. This retrospective study presents a clinico-radiological classification system which can help in choosing an appropriate surgical approach for achieving this goal.

Introduction: There exists a lack of consensus in selection of a surgical approach based on clinical and radiological criteria. Debate continues regarding superiority of anterior versus posterior approaches. Objective of this study was

- [1] To identify patterns of cord compression in dorsal and lumbar Pott's spine
- [2] To select approach based on clinical and radiological criteria
- [3] To evaluate recovery in paraplegia

Methods: 72 out of 79 surgically treated patients were evaluated retrospectively. Minimum follow up duration was 2 years (2-6 years). Anatomical distribution of lesion was mid-thoracic (42), thoraco-lumbar (27), and lumbar (3). The dural compression was designated as anterior

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(52), posterior (5), circumferential (6), hemispherical (1), extensile (8) and skip (10). Anterior and posterior osseous lesions were classified (Type 1 to 3) according to the severity of destruction. Clinical parameters considered were the age and comorbidities (ASA grade). The surgical approach (anterior versus posterior) was based on type of dural compression and clinical parameters. The instrumentation (anterior, posterior, global) was decided by the anatomical location and the severity of destruction.

Results: Average pre and post operative JOA were 9.36 and 16.36. Average time required for complete recovery was 8.2 weeks. Duration and severity of myelopathy had no correlation with neurological outcome. Age correlated negatively. Average pre and post operative kyphosis was 18.5° and 1.6°. Commonest complication was uninstrumented graft failure (8). Other notable complications were recurrence (2), pulmonary complications (7), intercostalgia (27), wound dehiscence (4), implant failure (1) and death (1). No neurological deterioration was noted.

Conclusion: Significant neurological recovery is expected after optimal decompression irrespective of the duration and severity of myelopathy. The classification system used to differentiate different types of tuberculous destruction may help in choosing a surgical approach.

Paper #64

Perioperative Complications of Pediatric Vertebral Column Resections

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United States

Summary: The rate of perioperative complications following VCR procedures in pediatric patients was 39%. These complications were neurologic in 13% (all except 1 resolved) and non-neurologic in another 26%. The majority of the non-neurologic perioperative complications were respiratory in nature. There were no perioperative deaths or complete neurologic deficits. The non-neurologic complications resolved without long-term sequelae.

Introduction: Vertebral column resections (VCR) are complex operations and treatments of last resort with potential for serious adverse events. The purpose of this study was to define the incidence and type of perioperative complications associated with primary and revision VCR procedures in a pediatric population.

Methods: A retrospective series of 84 primary and 63 revision (1-25 prior surgeries) VCRs was analyzed via detailed chart review for the occurrence of 30 pre-defined complications. The cases were consecutive for each surgeon and gathered from 7 centers. The complications were considered "perioperative" if they were noted within the first 6 weeks of the procedure.

Results: The age of the patients averaged 13.7 years (range: 1-21). These severe (average major coronal or sagittal deformity of 97 + 31 deg) deformities were corrected on average by 56% by excising 1-5 vertebral segments. For 27 patients the VCR was performed in a staged fashion on different days, while the remaining 120 patients were completed under a single anesthetic. A postoperative neurologic deficit was noted in 19 patients (13%) (1 patient improved but incomplete, others recovered). Additional perioperative non-neurological complications occurred in 26% of the cases: 4 patients had blood loss > 2 blood volumes (29 had EBL > 1 BV) and 17 (12%) had respiratory issues (9 primary and 8 revisions) with 4 of these requiring reintubation. There were 5 cases (3%) with early postop wound infection, 2 patients with a deep vein thrombosis (ages 17, 20 yrs) and 3 with misc. GI complications. In 4 patients the procedure was aborted (3 of 4 were revision cases). Importantly, there were no perioperative deaths. The overall non-neurologic complication rates were similar for the primary (24%) and revision (29%) cases.

Conclusion: VCR procedures for severe spinal deformity are major reconstructive operations that are associated with perioperative complications in 39% of cases with the majority being non-neurologic (26% vs. neurologic-13%). Major blood loss should be anticipated with 20% of patients losing more than their blood volume and 3% exceeding 2 blood volumes. Staging procedures as required (planned or unplanned) was performed to address the risks associated with these lengthy procedures.

Paper #65

Comparison of Spinal Deformity Surgery in Patients with Non-Insulin Dependent Diabetes Mellitus (NIDDM) vs. Controls

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United States

Summary: The exact impact of Non-Insulin Dependent Diabetes Mellitus (NIDDM) on operative complications and additional surgeries associated with spinal deformity surgery was quantified with a well matched control study in terms of age at surgery, gender, BMI, number of comorbidities, smoking Hx, current and prior fusion levels, EBL, and the amount of transfusion.

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Contrary to traditional belief, NIDDM was not a significant risk factor for perioperative complications or additional surgeries in adult deformity patients.

		NIDDM	C (Control)	Comparison	
		ME±SD	ME±SD	Test	P value
Matching					
	Age at OR	61.1±9.7435	59.2±9.1580	ttest	0.504
	BMI	30.5±6.9665	28.3±5.2729	ttest	0.230
	No. Comor Present	1.2±0.998	1.0±0.878	MWU	0.330
	Current Fusion Levels	10.5±4.8135	10.3±4.6849	MWU	0.993
	Prior Fusion Levels	3.7±4.3321	4.3±4.1188	MWU	0.459
	EBL	1378.3±770.4524	1843.5±1576.2660	MWU	0.510
	Transfusion	930.4±765.2588	976.1±1173.9473	MWU	0.581
Preop SRS & ODI					
	Preop Activity	2.6±0.7924	2.7±0.6646	ttest	0.629
	Preop Self Image	2.3±0.7597	2.4±0.6552	ttest	0.689
	Preop Mental Health	3.3±0.6820	3.4±1.0134	ttest	0.609
	Preop Pain	2.6±0.6176	2.5±0.8663	MWU	0.744
	Preop Subscore	2.7±0.5332	2.8±0.6789	MWU	0.655
	Preop ODI	43.3±12.3236	41.6±17.1014	ttest	0.713
Postop SRS & ODI					
	Postop Activity	3.1±0.9043	3.2±0.7962	ttest	0.666
	Postop Self Image	3.3±1.0840	3.4±0.7045	ttest	0.782
	Postop Mental Health	3.5±0.9505	3.6±0.6900	MWU	0.227
	Postop Pain	3.2±1.3287	3.3±0.8540	ttest	0.885
	Postop Subscore	3.3±1.3287	3.4±0.6155	ttest	0.610
	Postop Satisfaction	4.0±0.8732	4.0±0.7723	MWU	0.687
	Postop ODI	29.4±17.4247	29.5±18.3483	ttest	0.989

	Major complications		Total	P value	Minor complications			Total	P value
	-	+			-	+	++		
NIDDM	15	8	23	0.331	15	6	2	23	0.074
C	18	5	23		20	3	0	23	
	33	13	46	MWU	35	9	2	46	MWU

	Complications ?		Total	p value	Additional Surgery ?		Total	p value
	-	+			No	Yes		
NIDDM	13	10	23	1	19	4	23	1
C	13	10	23		19	4	23	
	26	20	46	chi square	38	8	46	fischers exact test

Introduction: There are many references supporting diabetes mellitus (DM) as one of the major risk factors for perioperative complications in spinal surgery. However, the results vary depending on the type of DM, suggesting Insulin Dependent DM (IDDM) causes more complications than Non-Insulin Dependent DM (NIDDM), which is far more prevalent in adult spinal deformity surgery. The purpose of this study was to quantify the exact impact of NIDDM on operative complications and additional surgeries associated with spinal deformity surgery.

Methods: Among 5119 adult deformity patients (age>40), 23 NIDDM patients and 23 control (Group C) patients with a minimum 2-year follow-up were selected. Both groups were matched for age at surgery, gender, BMI, number of comorbidities, smoking Hx, current and prior fusion levels, EBL, and the amount of transfusion. Pre- and final SRS scores and ODI, number of perioperative complications and additional surgeries were compared. (Table) Within the NIDDM group, patients with (+) or without (-) complications were compared in terms of postoperative glucose control.

Results: There were no significant differences in the number of major or minor complications, or additional surgeries between the 2 groups. (Table) There was no significant difference in postoperative glucose control with the NIDDM group (+) and (-). Group C reported significantly improved scores at final follow-up in all SRS domains and ODI. Group NIDDM reported improvement in all domains except for the mental health and pain domains, which were not significantly better postop compared to preop. However, there were no significant differences between groups NIDDM and C in terms of SRS and ODI scores preop and postop.

Conclusion: Contrary to traditional thinking, NIDDM was not a significant risk factor for perioperative complications or additional surgeries in adult spinal deformity patients.

Significance: This is the first well-matched control study for adult spinal deformity patients with NIDDM, suggesting that the potential adverse risks associated with NIDDM are minimal when compared to a well matched control group. The ideal preoperative control of glucose should be further studied.

Paper #66

Risks of Chemoprophylaxis for Venous Thromboembolism Following Spinal Fusions: A Retrospective Review of 351 Consecutive Patients

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Summary: We retrospectively reviewed 351 consecutive patients undergoing spinal fusion. All patients were received pneumatic compression stockings and sequential compression devices. 261 patients received chemoprophylaxis and 91 patients did not. We found no difference in post operative hemorrhagic complications between groups.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Introduction: Venous Thromboembolism (VTE) is a major complication following surgical procedures. Rates of VTE vary across studies, and there is no consensus on VTE prophylaxis. Chemoprophylaxis has been shown to significantly reduce the rate of VTE but is rarely used in spinal fusion procedures due to fear of epidural hematoma.

Methods: 351 consecutive patients undergoing spinal fusion were retrospectively reviewed. Surgical procedure, fusion levels, method of VTE prophylaxis, and hemorrhagic complications were recorded.

Results: 351 total patients were evaluated. 260 received chemoprophylaxis for VTE (Group 1). Chemoprophylaxis was started on average of post operative day (POD) 4.5 (range 1-32). 126 patients had chemoprophylaxis started on POD 1-3. All 351 patients were treated with pneumatic compression stockings and sequential compression devices. 91 patients did not receive chemoprophylaxis (Group 2). Demographic data provided in Table 1. A total of 2 hemorrhagic complications occurred in each group. In the chemoprophylaxis group we had a spontaneous adrenal hemorrhage diagnosed by CT scan on POD 5 and one epidural hematoma that occurred prior to starting chemoprophylaxis related to a Jackson-Pratt drain that migrated to the suprafascial space. In group 2 we had once incidence of delayed abdominal wound seroma / hematoma and one epidural hematoma following removal of a retained Jackson-Pratt drain. No patient in either group suffered neurologic injury and no patient had long-term sequelae.

Conclusion: Chemoprophylaxis following spinal fusion can be safely administered. No difference in hemorrhagic complications was noted between groups even with early administration on POD 1-3.

Significance: Chemoprophylaxis may be used safely in patients undergoing spinal fusion without an increase in hemorrhagic complications.

Paper #67

A Comparison of Perioperative and Delayed Major Complications Following 1630 AIS Procedures

*Burt Yaszay, MD; Caitlin Schulte; Michelle C. Marks, PT, MA; Peter O. Newton, MD; Randal R. Betz, MD; Suken A. Shah, MD; Baron S. Lonner, MD; Harry L. Shufflebarger, MD; John M. Flynn, MD; Harms Study Group
United States*

Summary: From 1995 to 2009, there were 8 major neurologic and 72 major non-neurologic complications in 1630 surgically treated AIS patients. The peri-op complication rate was 2.4%. For those patients with 2 yr f/u, the rate was 6.4%. The incidence of intra-operative motor deficits was 0.12%. Seventy patients required re-operation with the majority related to instrumentation and wound complications.

Introduction: In the era of pay for performance, providing a standard for anticipated complications following adolescent idiopathic scoliosis (AIS) surgery will be important. The purpose of this study is to report on the rate of major complications following surgically treated AIS both in the peri-operative period and at >2 yrs follow-up.

Methods: A prospectively collected (1995-2009), multicenter database of patients undergoing surgical correction of AIS was reviewed for all major complications. A secondary review of each patient's medical record was performed to ensure completeness and consistency of the recorded adverse events. 1630 patients with > 6 weeks f/u were utilized in the analysis of perioperative complications, while a subset of 831 pts with > 2 yrs f/u made up the cohort for delayed complication rates. Complications were major if it resulted in re-operation, were considered life-threatening or resulted in spinal cord/nerve root injury.

Results: 1630 patients (1212 post, 341 ant, and 77 ant + post) with an avg age of 14.7 years and avg curve magnitude of 54o (37-123o) were reviewed. The overall complication (major and minor) rate per patient was 25.8%. There were no deaths. There were 8 (0.5%) major neurologic complications that occurred in the peri-op period and included 5 re-operations for radiculopathy from misplaced screws, 1 temporary vision loss, and 2 intra-operative incomplete spinal cord motor deficits (0.12%). There were 72 total major non-neurologic complications of which 30 (1.8%) occurred in the peri-op period (16 wound, 7 pulmonary, 5 instrumentation, and 2 other). The major complication (neurologic and non-neurologic) rate for those with >2 year f/u was 6.4% of which 5.9% required a re-operation. The majority of these major complications were wound (2.2%) and instrumentation (1.8%) related.

Conclusion: Whether counseling patients or dealing with payors, a 6% rate of major complications and re-operation (at >2 years post-op) can be anticipated. The incidence of intra-operative spinal cord level motor deficits was 0.12% (2/1630) with complete and near-complete motor recovery occurring in both patients.

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Paper #68

Morbidity and Mortality Associated with the Operative Treatment of Disorders of the Pediatric Spine: A Report from the SRS M&M Committee

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United States

Summary: Currently, few studies regarding complications and mortality associated with operative treatment of pediatric spinal disorders are available to guide the surgeon. This study provides more detailed complication data. Spinal surgery in children is associated with a range of complications depending on type of operation, but a low mortality rate.

Introduction: Currently, few studies regarding morbidity and mortality associated with operative treatment of pediatric spinal disorders are available to guide the surgeon. This study provides more detailed complication data with an analysis of 23,918 pediatric cases reported in the multicenter, multi-surgeon Scoliosis Research Society (SRS) Morbidity and Mortality (M&M) database.

Methods: The SRS M&M database was queried for the years 2004-2007. Inclusion criterion was age < 18. Cases were categorized by operation type and disease process. Multiple details on the surgical approach, use of neurophysiological monitoring and type of instrumentation were recorded. Major perioperative complications and deaths were evaluated. Statistical analysis was performed with Chi square testing with a P-value of <0.05 considered significant.

Results: 23,918 patients were included. The mean age was 13, with a standard deviation of 3.6 years. Diseases reported were predominantly deformity, including scoliosis (19642), kyphosis (1455), and spondylolisthesis (748). 478 trauma cases were reported. The overall complication rate was 8.5%. Major complications are listed in table 1. Complications by operation type are listed in table 2. Major complications were often due to infection or respiratory concerns. Patients undergoing revision (2034) and osteotomy (2787) operations were more likely to suffer a complication, including new neurological deficits. 31 deaths were reported, for an overall rate of 0.13%. Respiratory complications were the most common etiology of mortality (13). 84% (26) of deaths occurred in children undergoing scoliosis correction.

Conclusion: Spinal surgery in children is associated with a range of complications depending on type of operation, but a low mortality rate. Patients undergoing more aggressive corrective procedures for deformity are more likely to suffer complications.

Paper #69

Factors Associated with Loss of Coronal Deformity Correction in Patients with AIS

Steven W. Hwang, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Peter O. Newton, MD; Randal R. Betz, MD; Patrick J. Cahill, MD
United States

Summary: Loss of coronal correction not attributable to pseudarthrosis, adding-on, or loss of fixation was found in 12% of patients after posterior spinal fusion for AIS and was associated with larger curves, younger age, and hybrid constructs.

Introduction: Increases in post-op coronal curvature are typically attributed to the presence of pseudarthrosis, loss of instrumentation fixation, or adding-on. We evaluated the incidence and factors associated with a loss of coronal correction (LCC) in patients with AIS that was not attributed to these causes.

Methods: A prospective longitudinal study database was retrospectively queried for patients with at least 2 years of follow-up who underwent surgery for AIS. LCC was defined as 1) a greater than 5 degree increase in the inclinometer reading at any time interval following surgery excluding pre-op values, or 2) radiographically, as an increase in 10 degrees or more in the Cobb angle of an instrumented curve as measured on erect post-op radiographs. Patients with pseudarthroses, adding-on, or loss of fixation were excluded.

Results: Ninety-three of 800 (12%) patients had loss of coronal correction. Twenty-one patients had greater than 5 degrees of inclinometer change (2.5%), and 76 patients (9.5%) had greater than 10 degrees of Cobb change with a mean loss of $14.9 \pm 4.2^\circ$ (vs. control group $2.0 \pm 5.1^\circ$, $p < 0.01$). When comparing pedicle screw constructs only, 10% of patients developed LCC as opposed to 20% of the hybrid (combination of hooks and screws) constructs ($p = 0.036$). When comparing all 93 patients against 707 who did not fulfill either criteria, significant differences were found related to the following: age, hybrid construct, magnitude of thoracic curve, thoracic apical translation, and T1 tilt angle.

Conclusion: This study reports a high percentage of LCC (12%) over time. Some of the LCC may be attributable to the development of crankshaft phenomenon; however, skeletal maturity, associated with crankshaft phenomenon, did not significantly contribute to the LCC in our cohort. Larger magnitude thoracic curves with apical deviation and hybrid constructs were associated with an increased likelihood of loss of coronal curve correction.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Significance: Loss of coronal correction is associated with larger curves, younger age, and hybrid constructs.

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).

Paper #70

Development of the Spinal Canal after Transpedicular Instrumentation in One and Two Year Old Children

Michael Ruf, MD; Jurgen Harms, MD

Germany

Summary: Sixty-three transpedicular screws were inserted in 37 vertebrae in one and two year old children. Midsagittal diameter, interpedicular diameter, and the cross-sectional area of the spinal canal were measured at a mean follow-up of 10y 6m. There was no critical iatrogenic stenosis of the spinal canal during further growth. Transpedicular instrumentation for fusion procedures, for growing rods, or for sliding rod systems can be used safely during infancy.

Introduction: Pedicle screws in the immature spine cross the neurocentral synchondrosis, which is responsible for the growth of the posterior elements and the spinal canal. Concerns about iatrogenic stenosis may arise when pedicle screws are used in very young children.

The purpose of this study was to evaluate diameter and cross-sectional area of the spinal canal in a long-term follow-up following transpedicular instrumentation in one or two year old infants.



Instrumentation T12-L1 at the age of 22 months, MRI 7y postop.

Methods: Thirteen operations in 12 one and two year old children were performed between 1991 and 2000. A total of 63 transpedicular screws were inserted in 37 vertebrae; 11 vertebrae underwent unilateral screw implantation and 26 vertebrae were instrumented bilaterally. The average follow-up time was 10y 6m (7+3 to 14+9). MRI or CT scans were performed, and the midsagittal diameter, the interpedicular diameter, and the cross-sectional area of the spinal canal were measured. The values were compared to a neighbouring non-instrumented vertebra of the same patient.

Results: Average midsagittal diameter of the spinal canal of the instrumented vertebrae was slightly increased compared to non-instrumented neighbour vertebrae: 105.7% (88-141). Difference between unilateral instrumented vertebrae and bilateral instrumented vertebrae was minimal: 104.1% (89-141) and 106.3% (88-128). Average overall interpedicular diameter was 99.2% (72-121); 101.8% (77-121) respectively 98.1% (72-118) for the uni and bilateral subgroups. The cross-sectional area of the spinal canal, which represents the space available for the spinal cord, averaged 106.7% (71-171) compared to non-instrumented vertebrae (unilateral 108.5% (71-171), bilateral 106.0% (72-135)).

Conclusion: The results suggest that pedicle screw instrumentation in one and two year old infants does not lead to critical iatrogenic stenosis of the spinal canal

during further growth. From this point of view, transpedicular instrumentation for fusion procedures, for growing rod, as well as sliding rod systems can be applied safely during infancy.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

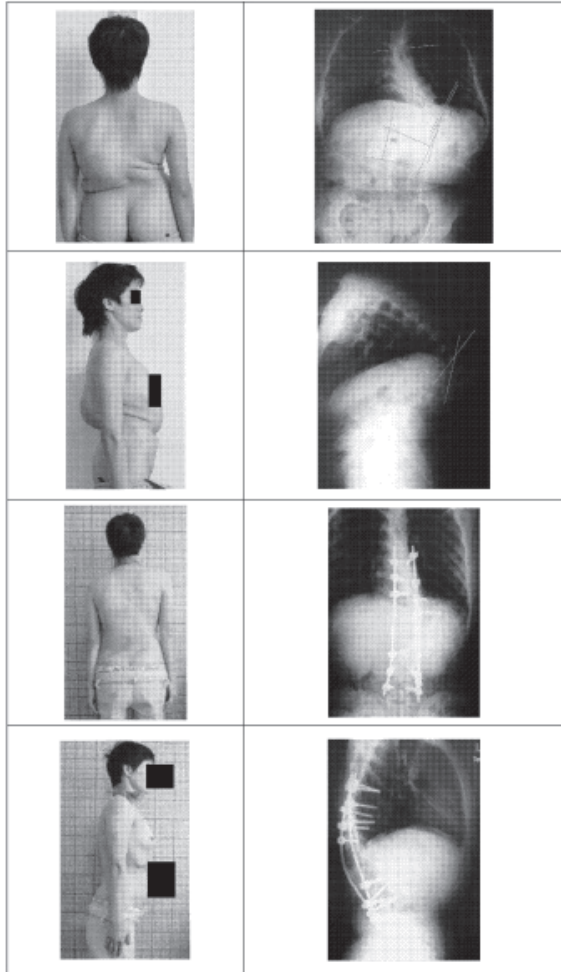
Paper #71

Posterior Vertebral Column Resection for Correction of Severe Rigid Spinal Deformity

Jingming Xie, MD; Yingsong Wang, MD; Ying Zhang, MD; Zhi Zhao, MD

China

Case 1:



A 25-year-old woman with T12 and L1 congenital hemivertebras. The magnitudes of coronal and sagittal Cobb's angle were 170° and 160° respectively. Postoperative standing radiographs showed the coronal and sagittal Cobb's angles were corrected to 43° and 54° respectively. At the follow-up 2 years after operation, the trunk balance was good.

Summary: For severe spinal deformity, the correction efficacy of conventional surgery is limited. However, the application of PVCR has allowed improved correction rates even in severe rigid curves.

Introduction: To evaluate the curative effect of posterior vertebral column resection (PVCR) for correction of severe rigid spinal deformity.

Methods: A consecutive series of 46 patients with severe rigid spinal deformity were surgically treated by PVCR was reviewed, which included 25 males and 21 females with an average age of 20.4 years at the time of operation (11~45 years). Morphological classification included single kyphosis in 8 patients and kyphoscoliosis in 38. The preoperative Cobb's angle of scoliosis was $108.2 \pm 33.6^\circ$ (range $90^\circ \sim 170^\circ$); and the kyphosis was $77.3 \pm 29.4^\circ$ (range $63^\circ \sim 160^\circ$). The flexibility of major curve was less than 10%. The apex of deformity was at T5~L2. In PVCR, entire three-column structure of 1~3 vertebrae at the apical level was/were resected for deformity correction.

Results: The total number of resected vertebrae was 63, including 49 thoracic and 14 lumbar vertebrae. And the highest resected level was at T5. The average operational duration was 387 minutes with an average blood loss of 6470 ml (range 3000~24000ml). The deformity correction rates in coronal and sagittal planes were $63.9 \pm 13.1\%$ (range 47%~94%) and $76.9 \pm 9.7\%$ (range 57%~100%) respectively. Complications were encountered in 14 patients: 3 wound superficial infection, 2 postoperative nerve root irritation, 1 spinal cord ischemic reperfusion injury, 2 hemopneumothoraxes and 2 implant breakage. The period of follow-up was 36.3 months on average (range 24~60 months). The correction loss was less than 5° in the follow-up.

Conclusion: PVCR is effective to correct severe rigid spinal deformity. In the deformity correction process following PVCR, spinal cord is always the center of corrective hinge, and any corrective procedure is at a price of angulation or rotation of spinal cord. However, through the space created by PVCR, any deformity correction forces can be performed under directly visual inspection for keeping the dural tube and spinal cord from any tension. Angulation in coronal or sagittal plane less than 20°, buckling no more than 2cm, torsion less than 10° would not injury spinal cord. But any distraction has to be avoided absolutely. PVCR is complicated and difficult at every turn and route, any operate miss could not be permitted to take place in this surgery.

Paper #72

Surgical Management of Congenital Scoliosis (CS) with Split Cord Malformation (SCM)

Jianxiong Shen, MD; Guixing Qiu

China

Summary: It is recommended all CS patients with SCM should be treated prophylactic prior to any correction surgery. However, SCM patients may remain neurology stable in whole life. 95 neurological intact or stable SCM patients were treated for their CS without any prophylactic neurosurgery. The correction rates were 47.6% at mean follow up 5.3 years. No neurological deficit occurred. Prophylactic neurosurgery prior to scoliosis correction may not necessary in those patients.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Introduction: SCM is a rare congenital disorder. However it is not uncommon in CS. Although the spine surgery has been made a great progress in last 3 decades, the surgical strategy for CS with SCM has not been changed. It is recommended that SCM should be treated prior to any procedure that might cause traction on the spinal cord even if the patients were asymptomatic. Clinically, SCM patients were found neurology stable during their life. Are those patients really needed prophylactic neurosurgery before curve correction?

Methods: This is a prospective study. 95 SCM patients from 500 CS were enrolled from Feb 2001 to Mar 2007. There were 29 male and 66 female. The mean age at operation was 14.1 years. Mean follow up is 5.3 years (2-8years). The inclusion criteria: 1. CS patients with confirmed SCM; 2. neurological is intact or stable during the past 2 years; 3. no neurological deteriorate in traction or fulcrum bending test. Patient with unstable neurological signs or who were planed to have VCR surgery were excluded. They all underwent scoliosis surgery without any prophylactic neurosurgery.

Results: According to Pang's classification, there were 35 SCM I and 60 SCM II patients. The mean involved curve segments was 7.5 and mean SCM around 4 segments. There was no statistic difference between SCM I and SCM II as for age, curve segments and SCM segments. Clinical manifestation included back trichosis 16 patients, diminished pin sensation 10 patients, decreased muscle strength 6 patients. About 83.1% SCM located at T5 - L3. Surgical procedures included posterior 70 patients, anterior 5 and combined A&P 20 patients. All patients had spinal cord monitor and weak up test during the surgery. The mean preoperative curve was 74.1° in SCM I and 65.2° in SCM II, were corrected to 38.3° and 30.2° postoperative, and 41.2° and 32.9° at last follow up respectively. No neurology deteriorated occurred during the operation and at follow up.

Conclusion: CS with SCM patients if their neurological sign is stable, prophylactic neurosurgery prior to scoliosis surgery may not be necessary

Significance: It may change the surgical strategy of management of SCM in CS patients

Paper #73

Impact of Halo-Gravity-Traction (HGT) on Curve Rigidity and Pulmonary Function: Refining Indications for HGT in the Treatment of Rigid Scoliosis & Kyphoscoliosis

Heiko Koller, MD; Vera Gajic; Oliver Meier; Luis Ferraris, MD; Axel Hempfing; Patrick S. Schmitt; Juliane Zenner, MD Germany

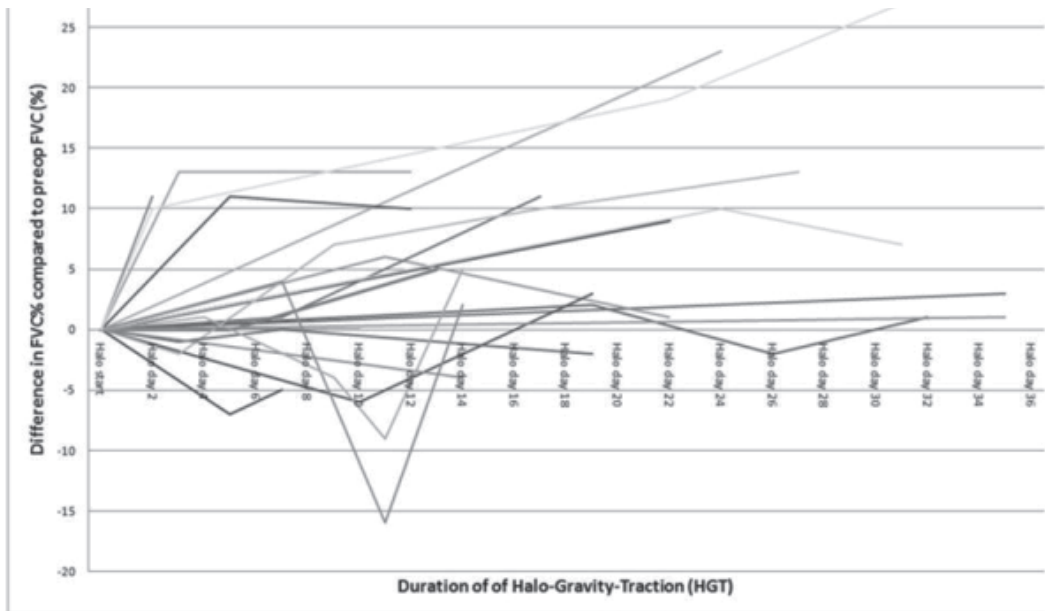


Fig.1 illustrates time dependent interrelations regarding the changes of FVC during HGT compared to the preop FVC% in 24 of 47 patients. Changes in FVC were calculated as difference to the FVC before initiation of HGT. The etiology of the kyphoscoliosis had no impact on early increase or decrease of FVC. Of note, graph illustrates that a few cases had decreased FVC during HGT compared to the preop tests, some cases improved significantly.

Summary: Analysis of 47 patients undergoing Halo-Gravity-Traction (HGT) before surgical correction of severe & rigid kyphoscoliosis and scoliosis. More than 50% of patients had kyphosis >80° and lordosis >100°. Results of repeated radiographic measurements and pulmonary function tests during the HGT showed that in rigid curves increased flexibility and pulmonary function in terms of forced vital capacity was achieved in selected patients only. HGT remains a sound treatment for a subgroup of patients with severe kyphoscoliosis, but indications have to be refined.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Introduction: Presurgical HGT is assumed beneficial concerning a)reduction of neurologic risk by gradual traction on a chronically tethered cord,b)increase of curve flexibility,c)improvement of preop pulmonary function. Little is known on ideal indications, duration & efficacy of HGT. Refinements are indicated.

Methods: Review of 47 pat w/ rigid kypho-scoliosis & pulm. compromise. Analysis focused on impact of HGT on curve flexibility, pulmonary function tests (PFT), complications & surgical outcomes. W/ PFT we assessed the predicted forced vital capacity (FVC%).

Results: 47pat,age was 24±14y, 40 had rigid kyphoscoliosis,5 scoliosis & 2 lordoscoliosis. Apical rotation was 3.4'±1.3(Nash&Moe). Curve apices were mainly thoracic. 4pat were non-ambulatory preop & 2 at follow-up (FU). For 30±14days HGT was used preop in 31 pat(66%) & in 16(34%) preop & after ant.release. Constructs were hybrid or pedicle-screw based. In 18pat(38%) a posterior concave thoracoplasty was added yielding for spinal release & correction of rib cage deformity. At FU of 32±24mo 42pat(89%) were satisfied w/ the result. 13pat had minor & 15 major complications but no neurol deficit. Subsequent surgery was indicated in 12 (incl 7 rib-hump resections). All pat had preop PFT and 24 had ≥3 in HGT: FVC before HGT was 50±21%. Last FVC in HGT was 49±20%. Difference betw/ 1st & last FVC in HGT was 7±8%. FVC at FU(24mo) was 43±14%. 19pat had preop FVC of Ø31% and FVC of Ø35% at FU. No pat had increase of FVC >10% until FU. For time dependent interrelations betw/ FVC & HGT see fig.1: Until 1st FVC-control in HGT (Ø13days) 46% of pat had not improved/changed. Differences betw/ flexibility in HGT compared to traction-&bending-films were insignificant. Cobb angle difference betw/ 1st&last radiograph in HGT was 8±9° for scoliosis, 7±12° for kyphosis. Preop 57% of pat had C7-plumb line >2cm improving to 35% at follow-up. Preop 32% of pat showed decompensated sagittal imbalance improving to 11%.

Conclusion: In severe kyphoscoliosis improvement of pulmonary function, reconstruction of sagittal & coronal balance and reducing risks of neurologic injury are the main goals. HGT is useful in selected pat, our data offer the base for analysis & decision-making while planning treatment strategies that circumvent HGT.

Paper #74

Various Treatment Options of Congenital Scoliosis – Analysis of Long-Term Follow-Up Results

*Martin Repko, PhD; Richard Chaloupka, CSc.; Jan Burda; Jan Pesek
Czech Republic*

Summary: The long-term clinical as well as radiological results and retrospective analysis of various treatment options of congenital scoliosis were compare in our study. The total number of 702 patients treated in our department since 1976 had been evaluated. An average follow up (FU) is 17 years.

Introduction: Congenital scoliosis are dedicated to various possibilities of treatment from observation and conservative treatment, over simple bony fusion to exacting hemivertebrectomies and deformity correction.

Methods: We evaluated security and efficiency of conservative as well various surgical treatment methods using the analysis of radiological and clinical results. Correction grade and complication rate were the main observed outcome measures.

Results: 1.group A (conservative treatment) - 356 pts. (51%). The magnitude of the curves was at time of detection on average 35,7 degrees according to Cobb angle and 39,8 at time of last control.

2.group B (hemiepiphyseodesis) - 112 pts. (16%). Final result of correction was 9,8 degrees (22%).

3.group C (posterior instrumentated fusion) - 147 pts. (21%). Final result of correction was 25,6° (38%).

4.group D1 (anterior strut graft with posterior instrumentated fusion) - 27 pts. Final result of correction was 26° (40%).

5.group D2 (anterior osteotomy with posterior instrumentated fusion) - 33 pts. Final result of correction was 28° (43%).

6.group D3 (combined hemivertebrectomy with posterior instrumentated fusion) - 22 pts. Final result of correction was 31,3° (61%).

7.group D4 (posterior only hemivertebrectomy with instrumentated fusion) - 5 pts. Final result of correction was 30,7° (61%).

Conclusion: The best surgical method for formation failure congenital types seems combined or posterior only instrumentated hemivertebrectomy and early hemiepiphyseodesis for segmentation failure congenital types.

Significance: Early detection, good timing and choosing of adequate surgical treatment type are the main factors of quality treatment results.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

Paper #75

Prevalence and Association of Scoliosis with Syrinx with or without Chiari Malformation

Christian L. Sybrowsky, MD; Walter F. Krenzel, MD

United States

Summary: Between June 2002 and February 2009, 3599 patients were seen for scoliosis. 628(17.4%) had spinal MRI, 115 (18%) of which had a syrinx. The incidence of syrinx in 3183 patients without scoliosis having spinal MRI in the same period was 8%. Of patients with an MRI documented syrinx 31% had scoliosis. Increase in the size of the syrinx on serial MRI was 3/13 (23.1%) in patients without a Chiari malformation and 6/25 (24%) in those with a Chiari Malformation.

Introduction: Syrinx with or without Chiari malformation is one of the most common intraspinal abnormalities noted on MRI scan of patients with scoliosis. In patients without neurological symptoms a repeat MRI scan to document expansion of the syrinx is a standard. We sought to determine the likelihood progression of the syrinx in these patients.

Methods: After IRB approval we identified all patients seen at our institution between June 2002 and February 2009 who received MRI imaging of the spine and/or were seen with a diagnosis of scoliosis and/or syringomyelia. Radiological records were reviewed to identify patients with a syrinx and / or scoliosis.

Results: 3599 patients were seen in our clinic with a diagnosis of scoliosis. Of 3811 patients having Spinal MRI during this period, 628 (16.5%) had scoliosis, 371(9.7%) had a syrinx with 115 having both syrinx and scoliosis. The incidence of syrinx in patients without scoliosis was 8%. The incidence of syrinx in patients with scoliosis was 18%. The incidence of scoliosis in patients with syrinx was 31%. Of the 115 patients with both scoliosis and syrinx 63(54.8%) had a Chiari malformation and 52(45.2%) did not. In the 38 of these that had serial MRI scans 3 of 13(23.1%) without a Chiari malformation and 6 of 25 (24%)with a Chiari malformation had an increase in the size of the syrinx.

Conclusion: Syrinx is more than twice as common in patients undergoing MRI who have scoliosis, than in those without scoliosis. The incidence of scoliosis is 10 times higher in patients with syrinx than the general population. Syrinx size will increase in ~25%, regardless of the presence of a Chiari malformation.

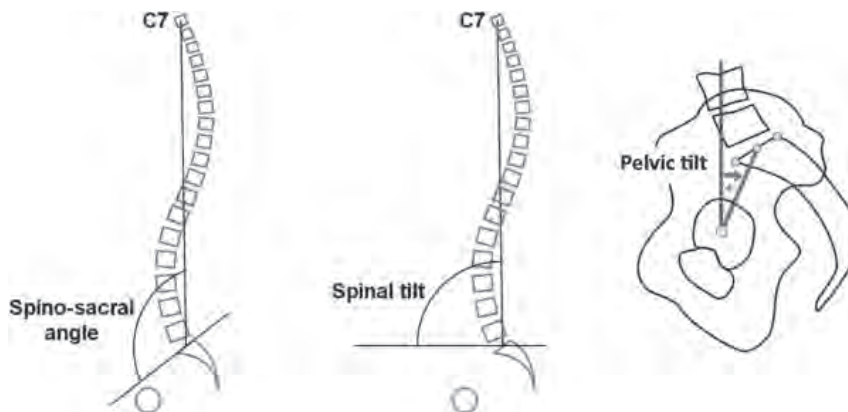
Significance: Syrinx progression will occur in patients with scoliosis, even in the absence of a Chiari malformation. Repeat MRI in these cases is appropriate.

Paper #76

Global Sagittal Spinal Balance: Normative Values from a Prospective Cohort of 715 Asymptomatic Adults and 646 Asymptomatic Children

Jean-Marc Mac-Thiong, MD, PhD; Pierre Roussouly, MD; Eric Berthonnaud, PhD; Pierre Guigui; Hubert Labelle, MD

Canada



Summary: This study presents the largest database in the literature on sagittal global balance in asymptomatic subjects without spinal pathology. Results suggest that asymptomatic children and adults tend to stand with a stable sagittal global balance. Although most asymptomatic subjects stand with C7 plumbline behind the hip axis, about 15% of them had C7 plumbline in front of the hip axis. C7 plumbline in front of the hip axis is not necessarily associated with spinal pathology.

Introduction: Clinically, global spinal balance is an important aspect of the

evaluation of patients with spinal pathology. Previous studies have investigated sagittal spinal balance in the normal population but there is still a need for a large prospective database with normative values in adult and pediatric populations.

Methods: Spino-sacral angle (SSA), spinal tilt (ST) and pelvic tilt (PT) were evaluated in 715 asymptomatic adults and 646 asymptomatic children (Figure). Position of C7 plumbline relative to sacrum and hip axis was also assessed. Comparison between groups were performed using Chi-square tests and correlation analyses were done using Pearson's coefficients. The level of significance was set at 0.05.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Results: Mean SSA and ST were respectively $130.3 \pm 8.1^\circ$ and $90.8 \pm 3.4^\circ$ in adults, and $132.1 \pm 8.3^\circ$ and $93.2 \pm 4.6^\circ$ in children. Mean ± 2 standard deviations for SSA and ST were respectively 114° - 147° and 84° - 98° for adults, and 116° - 149° and 84° - 102° for children. A greater proportion of children presented an anteverted pelvis with negative PT when compared to adults (18.0% vs. 2.5%). C7 plumbline was behind the hip axis in 86% of adults and 83% of children. Correlations with age were respectively 0.10 and 0.08 for SSA and ST, reflecting a slight tendency for SSA and ST to decrease with age.

Conclusion: Asymptomatic subjects tend to stand with a stable global balance and it is expected that about 95% of normal children and adults have an SSA and ST between 115° - 150° and 85° - 100° , respectively. Although most asymptomatic subjects stand with C7 plumbline behind the hip axis, about 15% of them had C7 plumbline in front of the hip axis. C7 plumbline in front of the hip axis is not necessarily associated with spinal pathology.

Significance: The current study reports the largest cohort of asymptomatic subjects in the literature pertaining to the evaluation of sagittal global spinal balance. Results from this study could be used as reference values when evaluating patients with spinal pathology. Progressive anterior displacement of C7 plumbline with respect to sacrum cannot be attributed solely to aging and should raise a suspicion for the risk of developing spinal pathology.

Paper #77

Is radiation-Free Diagnostic Monitoring of Adolescent Idiopathic Scoliosis Feasible using Upright Positional MRI?

Christopher Diefenbach, BS; Baron S. Lonner, MD; Joshua D. Auerbach, MD; Neil Bharucha; Laura E. Dean, BA; Yael Goldstein United States

Summary: Concern about cumulative doses of ionizing radiation during diagnostic evaluation in AIS has led to a search for radiation-free alternatives. We demonstrate equivalent Cobb angle and kyphosis measurements between upright, positional MRI (uMRI) and traditional Xray, while also allowing vertebral rotation evaluation. Radiation-free diagnostic evaluation for AIS with uMRI is performed safely, quickly (<7min), and may serve as an alternative/replacement for traditional ionizing imaging techniques.

Introduction: Concerns about the oncologic potential from cumulative doses of ionizing radiation in children and adolescents being monitored for AIS initiated a search for radiation-free diagnostic imaging modalities, including MRI. We submit that upright, positional MRI (uMRI) produces reliable spinal curvature images compared with traditional X-ray.

Methods: Twenty-five consecutive patients (16F, 9M, average age 14.6yrs, range: 12-18yrs) with a diagnosis of AIS were enrolled. Average major curve magnitude was 30° (range: 6 - 70°). Subjects received anterior-posterior and lateral plain radiographic scoliosis imaging followed within one week by uMRI. MRI data acquisition was performed in <7minutes. Two independent observers performed all Cobb angle, T5-12 kyphosis, and vertebral rotation measurements for comparison. Pearson's correlation was performed to compare X-ray to uMRI measurements, while inter-rater and intra-rater correlations were performed to assess reliability.

Results: We found outstanding correlation between all plain film radiography and uMRI measurements ($p=0.01$); major Cobb angles ($R=0.901$), minor Cobb angles ($R=0.838$), and kyphosis ($R=.943$). Inter-rater reliability for both Xray and MRI measurements of major Cobb angles ($R=0.959$, 0.896 respectively), minor Cobb angles ($R=0.951$, 0.857 respectively), and vertebral rotation ($R=0.945$) were outstanding. Intra-rater reliability for both Xray and MRI measurements of major Cobb angles ($R=0.966$, 0.966 respectively) and minor Cobb angles ($R=0.945$, 0.943 respectively) were also outstanding.

Conclusion: Our results show that uMRI is capable of producing coronal and sagittal plane measurements that highly correlate with traditional plain film radiographic measurements. This, in addition to reliable vertebral rotation measurements, makes uMRI a valuable, radiation-free alternative/substitute for diagnostic evaluation in AIS.

*Paper #78

Growing Rod Graduates: Lessons from 58 Patients who Have Completed their Lengthenings

John M. Flynn, MD; Lauren A. Tomlinson, Bachelor of Science; Jeff Pawelek, BS; George H. Thompson, MD; Richard E. McCarthy, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group United States

Summary: Definitive "final" fusion is the most common endpoint of growing rod treatment in early onset scoliosis (EOS). Most final fusion patients had more levels fused than were spanned by their growing rods with moderate correction of deformity.

Introduction: Over the past decade, spine-based growing rod systems (GRs) have become a valuable tool in managing severe cases of EOS. As more patients advance towards skeletal maturity, little is known about the endpoint of treatment: final fusion, observation without further lengthenings of GRs, or observation after GR removal without final fusion. Our study focuses specifically on this final stage of GR management.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Methods: A multicenter EOS database was queried to capture all skeletally mature patients (defined as ≥ 14 y/o) treated with GRs, and younger patients who had a final fusion. Clinical, radiographic, and operative data were analyzed, with a focus on details and results of the final fusion.

Results: Of the 58 patients who reached skeletal maturity, 53 (91%) had a final fusion, 3 were observed with GRs in place, 1 had implant removal without final fusion, and 1 had a final fusion aborted for neurologic reasons. Most patients (60%) had more levels fused than the number of levels spanned by their GRs (18 patients: +1 level; 11 patients: +2 levels; 2 patients: +3 levels; 1 patients: +5 levels). Correction at final fusion was minimal (<20%) in 25%, moderate (21%-50%) in 53%, and substantial (> 51%) in 15%; there was no correction information on 7% of fused patients. Minimal correction was most common in those with neuromuscular scoliosis; substantial correction was most common in those with idiopathic scoliosis. At final fusion, 5 patients had osteotomies, 7 had a thoracoplasty, and 4 had a concurrent anterior spinal fusion.

Conclusion: At the end of GR management of EOS, most patients had GR removal and final instrumented fusion. For most patients, the final fusion will include more levels than were spanned by the GRs, and will achieve <50% correction of the deformity remaining at the end of GR management.

Significance: This is the first large, multicenter report offering insight into the final step in GR management of EOS.

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).

Paper #79

Outcomes of Growing Rod Techniques in Early Onset Scoliosis: Does the Etiology Matter?

*Behrooz A. Akbarnia, MD; Pooria Salari, MD; George H. Thompson, MD; Paul D. Sponseller, MD; John B. Emans, MD; Growing Spine Study Group
United States*

		Congenital (20)	Idiopathic (43)	Neuromuscular(36)	Syndromic(31)	Others(9)	All(139)
Pre-initial Surgery Main Curve (°)		70 (48-95)	77 (33-147)	82 (45-128)	76 (50-130)	70 (37-98)	76 (33-147)
Initial Curve Correction (%)		^{1a} 33 (-4-80)	^{2a} 50 (0-80)	46 (4-66)	^{3a} 48 (18-73)	45 (8-92)	46 (-4-92)
Final Curve Correction (%)		22 (21-69)	36 (-82-84)	27 (-88-66)	34 (-76-82)	34 (-1564)	31 (-88-84)
Elongation (mm)		^{1b} 22.5 (5-55)	40.5 (3-120)	45 (0-131)	47.5 (0-131)	41 (0-75)	41 (0-131)
T1-S1 Growth (mm/year)		9.6 (0.23-37)	9.9 (0-35)	8.4 (0.31-26)	9 (0-39)	10.2 (2.5-16)	9.4 (0-39)
Complication per procedure (%)		13	21.5	13.8	18	24	17.8
Complication per patient		0.95	^{1c} 1.7	1	1.3	^{1c} 1.66	1.33
Implant Comp /Total Comp (%)		68	68	38	50	60	59
Wound Infection per Patient		0.10	0.28	0.33	0.16	0.22	0.24
Unplanned /Total Surgeries (%)		4.8	6.2	5.6	6.2	4.8	6
Sagittal Balance (deviation from midline)	Pre-Initial Surgery	36 (0-128)	*37 (0-92)	43 (8-82)	38(0-160)	25 (0-75)	†37 (0-160)
	Post-Initial Surgery	31 (0-75)	30 (0-80)	42 (4-128)	29 (0-75)	28 (6.8-60)	†33 (0-128)
	Latest Follow Up	46 (4-114)	*30 (0-253)	40 (0-110)	30 (0-97)	25.8 (8-60)	34 (0-253)
Coronal Balance (deviation from midline)	Pre-Initial Surgery	23 (2-66)	20 (0-124)	*65 (0-192)	37 (0-142)	26 (0-94)	‡36 (0-192)
	Post-Initial Surgery	24 (0-55)	21 (0-207)	*43 (0-200)	19 (0-60)	15 (0-45)	‡26 (0-207)
	Latest Follow Up	14 (0-33)	16.6 (0-129)	65(4-289)	34 (0-176)	19 (0-46)	31 (0-289)

(* , # , † , ‡ P<0.05), 1a is significantly < 2a and 3a. (P<0.05). 1b, 1c = significantly less than other Dx group. (p<0.05) Final curve correction was not significantly different in diagnosis groups when studied in SR and DR groups separately.

Summary: This is the largest multicenter study comparing the results of GR surgery in EOS patients with different etiologies. Growing rods provided acceptable results in all diagnostic groups with respect to curve correction and T1-S1 growth. There are, however, differences in complication rates, sagittal and coronal balance correction. The growing rod technique was found to be a reliable method of treatment in EOS regardless of diagnosis.

Introduction: Growing Rods (GR) are commonly used in treatment of early onset scoliosis (EOS). No study has compared outcomes of GR in EOS patients with different etiologies. The purpose of this study is to compare the outcomes of GR in different diagnostic groups.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Methods: A multi-center retrospective study of 438 EOS patients was performed. 139 patients met the following inclusion criteria: primary GR surgery, major curve >30 deg, age <11 years at initial surgery, min. 3 lengthenings (LEN), max. 24 mos LEN interval and min. two year follow up. Clinical and radiographic data recorded pre-operatively and throughout the treatment period were analyzed.

Results: Mean age at surgery was 5+11 yrs. Mean follow up was 5+2 yrs (2-13). Diagnoses included 20 congenital (CO), 43 idiopathic (ID), 36 neuromuscular (NM), 31 syndromic (SYN) and 9 others. 52 patients had single rod (SR) and 87 patients had dual rod (DR). Mean preop curve was 76 deg (33-147), 41 deg (5-98) postoperatively and 50 deg (10-106) at latest follow up (FU). Mean number of surgeries/patient was 7.8 (4-22). Mean number of LEN was 6 (3-14). Mean LEN interval 10 mos (3-24). T1-S1 growth (post initial surgery to latest FU) in DR was 10.4 vs. 7.2 mm/yr in SR. Initial and final curve correction as well as sagittal and coronal balance improvement was significantly greater in DR patients ($p<0.05$). Implant complications were most common complications. Transient neurologic complications occurred in 4/134 (3%) of patients. Initial curve correction and spine elongation (T1-S1 gain after rod insertion) was significantly less in CO patients. Complication/patient was highest in ID group. In NM and SYN groups, coronal balance improved postop but deteriorated at final follow up (Table 1).

Conclusion: This is the largest report comparing different etiologies of EOS treated with GR. It confirms the results of previous studies that GR provides acceptable results in different etiologies with respect to curve correction and T1-S1 growth. Spinal alignment in NM and SYN patients remain an issue.

Significance: The use of growing rods is a reliable method of treatment in EOS regardless of diagnosis.

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).

Paper #80

Pedicle Screws Have Fewer Complications than Hooks in Children with Growing Rods

David L. Skaggs, MD; Karen S. Myung, MD, PhD; Charles E. Johnston, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group United States

Summary: We examine the rate of complications directly related to pedicle screws versus hooks in children with EOS treated with growing rods. A retrospective multicenter study of 247 patients (896 pedicle screws and 867 hooks) treated at 18 institutions was performed. Pedicle screws in growing rods have significantly less complications than hooks ($p<0.001$). Most complications were loss of fixation. There were no neurological or vascular injuries associated with either implant in 247 children with over 3 years of mean followup.

Introduction: Our purpose was to evaluate the complications of pedicle screws versus hooks in children with early onset scoliosis (EOS) treated with growing rods. As growing rods have a high rate of implant complications compared to spinal fusion, this challenging group of patients is an ideal setting to evaluate the safety of pedicle screws.

Methods: A retrospective multicenter study of 247 patients with growing rods treated at 18 institutions was performed. Inclusion criteria were children < 10 years old who had growing rod surgery between 1998 and 2008 with a complete surgical history. Charts and radiographs were evaluated for complications directly related to a pedicle screw or hook from the index surgery. 896 pedicle screws and 867 hooks were evaluated.

Results: The average age at index surgery was 5.2 years. The average length of follow-up was 40 months. Of the 896 pedicle screws, there were 22 (2.4%) complications directly related to the screw: acute loss of fixation (4), migration (14), breakage (1), skin breakdown (2), and unspecified loss of fixation (1). Of the 867 hooks, there were 60 (6.9%) complications: acute loss of fixation (35), migration (22), and unspecified loss of fixation (3). There were no intraoperative pedicle screw-related issues, but two hooks plowed intra-operatively resulting in bone damage. The average time to loss of fixation was 19 months for both implants. There were no complications involving neurologic or vascular injury directly related to a hook or screw.

Conclusion: Pedicle screws in growing rods have significantly less complications than hooks ($p<0.001$). It is encouraging that there were no neurological or vascular injuries associated with either implant in 247 children with over 3 years of mean followup. The rate of complications directly associated with the use of pedicle screws in this series is comparable to that reported in the adult spine fusion literature (0.4% to 3%).

Significance: As pedicle screws were found to have about one third the complications of hooks in this challenging group of patients perhaps FDA approval of pedicle screws in children should be considered.

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Paper #81

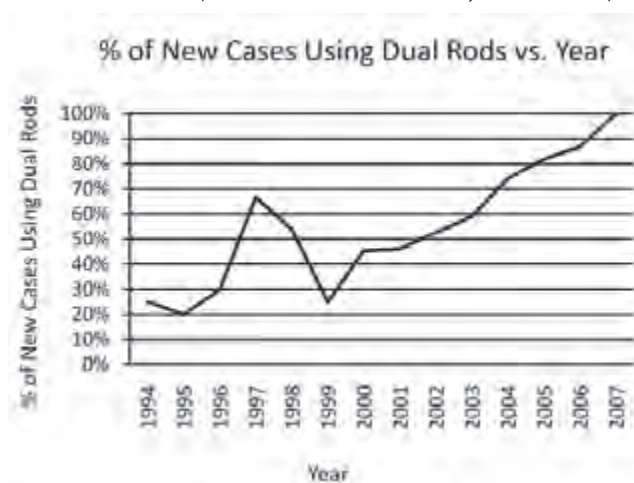
Growing Rods for Pediatric Spinal Deformity: Examining Principles and Practice

Justin S. Yang, MD; Mark McElroy, MS; George H. Thompson, MD; Behrooz A. Akbarnia, MD; Paul D. Sponseller, MD; Growing Spine Study Group
United States

Summary: Consensus exists in maximum age (<10 yrs) and minimum scoliosis (60°) for initiation of growing rods. No diagnosis is uniformly considered a contra-indication. The use of dual rods has increased steadily over time and the mean age at insertion has decreased. Mean lengthening interval is nearly nine months.

Introduction: Growing rods (GR) are a commonly used form of growth guidance for early onset scoliosis (EOS). This study is the first to characterize usage and final treatment among a large and international group of surgeons.

Methods: A survey regarding GR principles and a case-based survey regarding EOS were completed by 19 and 17 surgeons, respectively. 323 GR patients from an EOS multi-center database were analyzed to characterize actual practice and compare it to stated aims. All patients had minimum 2 year follow-up.



Results: In practice, GR were used for most types of early onset spinal deformity. Most surgeons preferred to initiate GR treatment in curves over 50°-60° (11/19) in patients younger than 8-10 years (18/19). In practice, mean curve size at insertion was $73 \pm 20^\circ$ at 6.1 ± 2.5 years of age. Preferred indications for GRs included curve rigidity (9/19) and brace intolerance (8/19). In the case-based survey, there was a correlation ($p=0.04$, $r=0.58$) between increasing curve size and use of GRs over non-operative treatment, rib-based distraction, growth guidance and primary fusion. The most preferred lengthening interval was six months; however, in practice, lengthenings actually occurred every 8.6 ± 5.1 months. In practice, the number of GR insertions per year ($p<0.001$, $r=0.94$) and percentage of dual rods over single rods ($p<0.001$, $r=0.86$) increased over time (Figure). Insertion age ($p=0.02$, $r=-0.61$) and lengthening interval ($p=0.006$, $r=-0.69$) decreased over time. In the survey, the most common indication

for final fusion was skeletal maturity (15/19), and 9/15 surgeons used > Risser 3. Indications to stop lengthening included repeated complications (15/19), curve progression (10/19), and failure for implants to distract during an attempted lengthening (7/19). Of 78 patients who completed GR treatment, 69 had final fusion, 6 had rods removed without fusion and 3 had rods left as an internal brace without fusion. There were 9 complications in 6/78 patients during or after their final treatment.

Conclusion: Practice variation exists in GR treatment, but there is some consensus on indications for surgery (curve size, flexibility, and age), lengthening intervals, and final fusion methods.

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Paper #82

Preoperative Thoracic Kyphosis Can Predict Complications in Growing Rod Surgery for Early Onset Scoliosis

Samuel Schroerlucke, MD; Pooria Salari, MD; Jeff Pawelek, BS; Gregory M. Mundis, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group
United States

Summary: Ninety-four early onset scoliosis patients were categorized into three groups based on the degree of pre-op thoracic kyphosis. Patients with (>40 deg) had significantly more complications than patients with normal kyphosis (10-40 deg) with implant complications being most common.

Introduction: Sagittal plane alignment is one of many important factors in assessing patient outcomes after spinal deformity surgery. However, the restoration of sagittal alignment has not been well documented in EOS. The purpose of this study was to examine the relationship between pre-op thoracic kyphosis and incidence of complications with growing rods.

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	< 10° kyphosis	10-40° kyphosis	>40° kyphosis
n	28	34	31
Age (yrs)	6+9 (2+3-10+4)	5+1 (2+2-10+11)	5+6 (1+3-11+8)
Length of follow up (mos)	48 (24-85)	46 (24-78)	56 (24-110)
Diagnosis			
Syndromic	10	6	8
Congenital	3	11	6
Neuromuscular	4	3	8
Idiopathic	11	16	8
Total Complications			
Implant Failure	6	11	26
Rod breakages	4	6	18
Screw or hook loosening/pullout	4	5	8
General complications			
DWI	0	0	1
DWI	4	0	8
pulm	3	1	2
bleeding	1	0	1
pain	1	1	0
wound closure	0	0	1
death	1	0	0
neurologic	0	0	3
other	8	0	6
Major Cobb's			
Pre op	75 (33-125)	66 (25-94)	80 (43-110)
Latest follow up	41 (2-88)	31 (4-76)	49 (22-78)
T5-T12 Kyphosis			
Pre op	-4 (-11-9)	23 (10-40)	57 (41-115)
Latest follow up	8 (-15-40)	18 (6-34)	39 (9-72)
L1-S1 Lordosis			
Pre op	26 (-74-90)	45 (-13-80)	57 (12-90)
Latest follow up	35 (-20-86)	47 (10-79)	47 (30-83)
T1-S1 Length (mm)			
Pre op	269 (200-349)	261 (215-339)	249 (174-382)
Latest follow up	347 (262-487)	323 (263-402)	310 (229-427)

Methods: Out of 387 patients from a multi-center EOS database, 94 patients had complete data with two year follow up after initial surgery. The patients were categorized into three groups based on degree of pre-op thoracic kyphosis (T5-T12): <10 degrees (K- group), 10-40 degrees (N group) and >40 degrees (K+ group). Diagnosis, demographics, radiographic parameters and complications were analyzed. A multivariate analysis was performed to identify possible confounding effects on complication rates.

Results: Mean age was 5+8 years, mean pre-op Cobb angle was 74 degrees, and mean T5-T12 thoracic kyphosis was 26 degrees. Diagnoses included 20 congenital, 28 idiopathic, 22 neuromuscular, and 24 syndromic patients. 24 had a single rod (SR) and 70 had dual rods (DR). 26 complications occurred in the K- group, 13 occurred in the N group and 49 complications occurred in the K+ group (Table 1). The K+ group had significantly more complications than the N group (p<0.01). The most common complication was implant failure. Multivariate analysis identified diagnosis and proximal kyphosis (T2-T5) as confounding variables. Accounting for these variables the K+ and K- groups were 4.9

and 2.9 times more likely to experience a complication compared to the N group, respectively (p<0.05 for K+ group only). Syndromic children had the highest rate of complications in all groups. No correlation existed between the degree of kyphosis correction and the incidence of complications.

Conclusion: GR patients with thoracic kyphosis out of normal range are more likely to experience complications compared to those with normal kyphosis. The likelihood of complications, particularly implant failure, is highest in patients with kyphosis >40 deg irrespective of diagnosis.

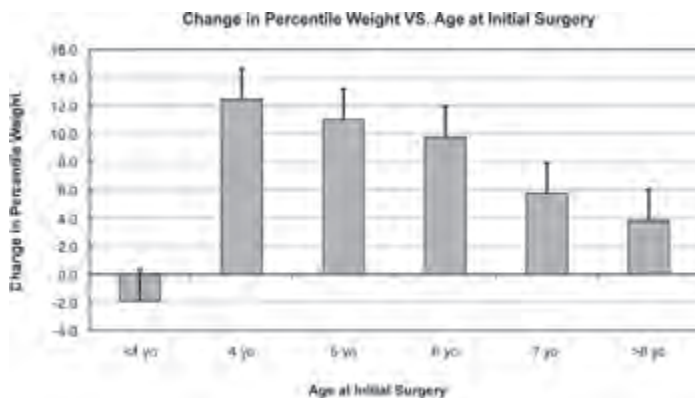
Significance: Thoracic kyphosis in EOS should be closely monitored for complications, particularly implant failure.

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Paper #83

Nutritional Improvement Following Growing Rod Surgery in Children with Early Onset Scoliosis

Karen Myung, MD; David L. Skaggs, MD; George H. Thompson, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group United States



Summary: We examine the preoperative nutritional status, as a marker of pulmonary status, in children with EOS and the effect of growing rod surgery on this status. After surgery, there was a significant improvement in nutritional status in approximately 50% of patients. Yet, children less than 4 years old did not gain weight. Instead, improvement was greatest at age 4 and decreased in a linear fashion as age increased thereafter.

Introduction: Children with severe early onset scoliosis (EOS) often have poor nutritional status as the energy expenditure of breathing approaches the nutritional gain of eating. The use of VEPTR in children with EOS has been shown to improve their weight. The purposes of this study

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are to evaluate the nutritional status of children with EOS and determine the effect of treatment with growing rods.

Methods: Data was retrospectively collected on 88 patients with EOS treated with growing rods at seven different institutions. Mean age at surgery was 5.8 years, and mean Cobb angle was 75 degrees. All patients were followed for a minimum of 2 years (mean follow-up of 4.1 years). Preoperative weights were converted to normative percentiles based on the patients' age and gender.

Results: Preoperatively, 47% (41/88) of our patients were <5 percentile for weight, meeting the criteria for failure to thrive. There is a significant increase in the mean weight percentiles at latest follow-up ($p=0.004$). 49% of the patients gained weight an average of 18 percentile. A significant relationship exists between age at initial surgery and percentile weight gain ($p<0.005$). (Figure) This relationship was not confounded by preoperative weight, preoperative Cobb angle, or years of follow-up ($p>0.05$). The average absolute weight gain at final follow-up was 12.3 kg (range, 0.3-41.3 kg).

Conclusion: Following treatment of EOS with growing rods there was significant improvement in nutritional status in approximately 50% of patients, similar to that reported with VEPTR. These findings support the theory that growing rods improve pulmonary status in children with EOS, as nutritional improvement is one outcome of improved pulmonary status. The relationship between age at initial surgery and nutritional improvement is intriguing.

Significance: Growing rod surgery in children with early onset scoliosis improves nutritional status.

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Paper #84

Early Onset Scoliosis: The Value of Serial Risser Casts

Sean R. Waldron, MD; Connie Poe-Kochert, BSN; Jochen P. Son-Hing, MD, FRCSC; George H. Thompson, MD
United States

Summary: Sixteen consecutive patients with EOS who failed orthotic treatment were successfully stabilized with serial Risser casts until they were older or larger and changed to other methods of treatment (orthoses, growing rod surgery, etc.).

Introduction: The treatment of progressive early-onset scoliosis (EOS) is challenging. In many cases, particularly very young or small patients, orthotic management will not be effective and growing rod surgery may not be appropriate. Serial Risser cast placement may be a safe and effective intermediate method of treatment in these select patients. We conducted a retrospective review of our results of serial Risser casting in the treatment of EOS.

Methods: Sixteen consecutive patients with progressive EOS were treated with serial Risser casting between 1999 and 2008. We analyzed the patient's age, gender, diagnosis, previous treatment, curve magnitude at the initiation of Risser casting, the number of casts, their response to casting, and their transition to treatment methods.

Results: There were 8 patients with idiopathic scoliosis, 5 patients with syndromic scoliosis, and 3 patients with neuromuscular scoliosis. There were 14 females and 2 males. Their mean age at initial cast application was 3.4 years (range, 1 to 8 years). The mean curvature at initial casting was 73° (range, 40 to 118°) and at the last cast application 45° (range, 20 to 95°). The mean length of cast treatment was 18.4 months (range, 8 to 35 months). There were 3 minor complications (skin irritation) associated with cast placement. These healed uneventfully and without scarring. Currently, 4 patients have undergone growing rod surgery, 4 patients are now being braced, 6 patients are still undergoing casting, and one patient each has undergone final fusion and has been lost to follow-up.

Conclusion: Our results support serial Risser casting as a safe, effective intermediate method of treatment for progressive EOS. It can stabilize relatively large curves until the child reaches a more suitable age or size to change to other methods of treatment such as an orthosis or growing rod surgery. Patients who failed bracing at an earlier age may now find it to be effective. Risser casts were well tolerated by the patients and their families and there were minimal minor complications.

Paper #85

Hybrid Growth Rods Using Spinal Implants on Ribs

Karen S. Myung, MD, PhD; David L. Skaggs, MD; Muharrem Yazici, MD; Mohammad Diab, MD; Hilali H. Noordeen, FRCS; Michael G. Vitale, MD, MPH; Charles E. Johnston, MD
United States

Summary: We examine a novel use of spinal hooks on ribs in a study with 2 years of follow-up. Hybrid growing rods where proximal anchors are spinal hooks on ribs may avoid fusion of the thoracic spine, while allowing distractive forces to minimize spinal deformity and encourage growth. This technique compares favorably to traditional growing rods in terms of complica-

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tion rate, T1-S1 growth, and SAL and Cobb angle correction, with the potential pulmonary benefit of avoiding fusion of the thoracic spine.

Introduction: Fusion of the upper thoracic spine in children severely limits pulmonary development. Traditional growing rods typically include a fusion of the upper thoracic spine. Hybrid growing rods in which the proximal anchors are spinal hooks placed on ribs may avoid fusion of the proximal thoracic spine, while allowing distractive forces to minimize spinal deformity and encourage growth. The purpose was to evaluate this novel use of spinal hooks on ribs as proximal anchors.

Methods: A retrospective multi-center study of 28 patients with growing spine instrumentation using spinal hooks on ribs treated at 6 institutions was performed. Mean follow up was 37 months (24-74 mos). Mean age at index surgery was 44 months (5-111 mos). 24 patients have congenital scoliosis.

Results: 23 patients had single rod constructs on the concave side only, and 5 patients had dual rods. Mean primary Cobb angle at the time of index surgery was 69°. Mean Cobb angle correction achieved at the time of the index surgery was 19°, which was maintained through latest follow up. Mean increase in T1-S1 length on the AP radiograph at latest follow up was 49 mm, with a mean increase of 13 mm per lengthening procedure. On average, space available for the lung (SAL) improved by 25 mm on both the concave side and convex side at latest follow up.

Complications occurred in 7 (24%) patients, all with congenital scoliosis. There is a non-significant trend that complications are associated with younger age ($p=0.12$) and larger Cobb angle at index surgery ($p=0.12$). Complications included 2 wound issues, 9 losses of fixation of rib anchors, and 1 rod breakage. There were no neurologic complications. There was no loss of fixation in any construct that had a proximal foundation of at least 4 up-going hooks on ribs, and there were no complications in dual-sided constructs.

Conclusion: We describe a novel technique that compares favorably to traditional growing rods in terms of complication rate, T1-S1 growth, and improvement in SAL and Cobb angle correction, with the potential long-term pulmonary benefit of avoiding fusion or instrumentation of the upper thoracic spine.

Significance: Use of spinal hooks on ribs may be included in our armamentarium for growing spine constructs.

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†Paper #86

Genome-Wide Array Scan Identified Copy Number Variants loci Associated with Adolescent Idiopathic Scoliosis (AIS)

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United States

Summary: Copy number variations (CNVs) are small DNA insertions and deletions that may be ten times more frequent and more likely to cause disease than point mutations. For the first time, we show significant copy number loss or gain in several genomic regions associated with severe AIS. The molecular pathways implicated overlap with the biological functions implicated by genome-wide association data from the same set of individuals.

Introduction: Developmental disorders are often associated with genetic variants. Copy number variations (CNVs) are recently documented micro DNA insertions and deletions that may be ten times more frequent than point mutations. CNVs may be more likely to cause disease than point mutations.

Methods: We performed a genome-wide scan to find CNVs associated with Adolescent Idiopathic Scoliosis (AIS). A total of 879 Caucasian individuals with severe AIS and 1486 Caucasian controls were evaluated for CNVs using the Affymetrix 6.0 HuSNP array. After the implementation of quality filters the data were quantile and normalized. Copy number analysis were determined using Helix Tree (Golden Helix, Bozeman, MT). The copy number segments were determined using the Golden Helix's Univariate Segmentation Algorithm. Statistically different segments were extracted using mean Log₂ ration intensity for that segment to highlight deletions, neutrals and duplications. We then performed association analysis on those segments. A p-value of $<10^{-7}$ was considered evidence of significance.

Results: We found 143 significant segments/regions associated with AIS. Ninety-four of those regions showed gains of copy while 49 had deletions. Sixty-three of these significant regions map to known genes. Biological functions of these genes identified reveal complex groups associated to embryonic development, nervous system development and function, and tissue development.

Conclusion: The molecular pathways implicated overlap with the biological functions using genome-wide association (SNP) data from the same set of individuals. For the first time we show significant copy number loss or gain in several genomic regions associated with severe AIS.

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Significance: The identification of CNVs in severe AIS could not only lead to the enhancement of prognostic testing in AIS, but could also help us identify specific biological pathways that cause AIS or accelerate AIS progression.

†Paper #87

Genome-wide Study Reveals Genetic Loci Associated with Idiopathic Scoliosis

Swarkar Sharma, PhD; Xiaochong Gao; Douglas Londono, PhD; Matthew B. Dobbs, MD; Christina Gurnett, MD PhD; John A. Herring, MD; Derek Gordon, PhD; Carol Wise, PhD
United States

Summary: We ascertained 419 idiopathic scoliosis cases and families in Dallas, Texas and performed a high-density, genome-wide search for genetic susceptibility factors. We obtained strongest results for a region of chromosome 3 near the CHL1 gene encoding a neuronal protein. We replicated these results in two additional white, non-Hispanic cohorts including 576 affected cases and 666 controls. Our findings are a first report of genetic associations with IS susceptibility identified by genome-wide SNP genotyping.

Introduction: Idiopathic scoliosis (IS) is the most common pediatric spinal deformity, yet its etiology is poorly understood. Genetic factors are clearly important in IS susceptibility as revealed by epidemiology studies. We recently initiated a comprehensive search for IS genetic factors via genome-wide association scanning in a large collection of IS cases. This approach will identify common DNA sequences that are relevant to IS susceptibility.

Methods: We ascertained individuals and families with a positive diagnosis of IS in orthopedic clinics in Dallas, Texas and St. Louis, Missouri. Additional cases were ascertained in orthopedic practices in Rhode Island, Massachusetts, Kentucky, Ohio, and Wisconsin. After applying stringent quality control measures we tested evidence of association with IS for >330,000 single nucleotide polymorphisms (SNPs) spanning the human genome in 419 Dallas families. Results were ranked by significance (P-value). We analyzed top SNPs in two follow-up case-control studies restricted to non-Hispanic whites. In the first study we tested SNPs in 379 Dallas cases and 440 healthy controls. In the second follow-up study, we tested the same SNPs in 197 St. Louis and other U.S. cases and 226 additional independent controls.

Results: We obtained strongest evidence for association with IS for SNPs clustering in a region of chromosome 3 and replicated this finding in the two independent follow-up studies (combined $P < 10^{-7}$ for SNP rs10510181). Two overlapping genes, CHL1 and LOC642891, are nearest this region. CHL1 encodes Close Homologue of L1, a neuronal protein that functions in axonal guidance; however, whether LOC642891 encodes a functional protein is unknown.

Conclusion: A region of chromosome 3 is associated with IS. These results implicate two nearby genes in IS pathogenesis.

Significance: Our findings are the first report of genetic associations with IS identified by genome-wide, high-density SNP genotyping. This work suggests potential roles for CHL1 and/or LOC642891 in the etiology of IS.

Paper #88

Scoliosis Surgery in Patients with Adolescent Idiopathic Scoliosis Does Not Alter Lung Volume: A Three Dimensional CT Based Study

Terry Amaral, MD; Etan P. Sugarman, MSIV; Adam L. Wollowick, MD; Beverly Thornhill, MD; Vishal Sarwahi, MD
United States

Summary: CT scans were used to determine pre- and post-operative lung volumes. Significant changes were noted in the posterior hemithoracic asymmetry ratio and the convex to concave lung height ratio. The difference in total lung volume was not significant.

Introduction: CT-based studies of lung volume in AIS patients have previously shown differences in total lung volume and convex-to-concave lung volume ratio compared to normal patients. PFT's in patients with AIS are abnormal before surgery and improve after surgery. The anatomical basis of this is unclear. To date, no study exists that has used CT scans to analyze these parameters following AIS surgery.

Methods: A retrospective chart and image review was conducted to assess changes in lung volume and lung size following AIS surgery. CT scans were performed on either a 64-slice scanner (0.625 mm slice thickness) or a 16-slice scanner (2 mm slice thickness). The raw data obtained was reformatted on the Aquarius Workstation followed by three-dimensional lung volumetric reconstruction using TeraRecon software.

Results: Twelve patients met criteria for inclusion in the study (average age 14.8 years). The mean Cobb angle was 49.4° preoperatively and 9.5° postoperatively ($p = < 0.0001$). The mean number of levels fused was 11.5. The mean lung volume was 1898 cc preoperatively and 1815 cc postoperatively ($p = 0.326$). The left to right lung volume ratio was 0.85 preoperatively and 0.89 postoperatively ($p = 0.084$). The mean posterior hemithoracic asymmetry ratio was 0.60 preoperatively and 0.67 postoperative-

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ly ($p = 0.0001$). The mean concave to convex lung height ratio was 0.93 preoperatively and 0.99 postoperatively ($p = 0.018$). We did not find a significant correlation between change in lung volume and change in Cobb angle, kyphosis, or apical vertebral rotation.

Conclusion: Improvement in pulmonary function following posterior spinal fusion for AIS is likely due to restoration of thoracic and lung symmetry with improvement in the mechanics of respiration as opposed to an improvement in total lung volume or left to right lung volume ratio.

Significance: The reasons for improvement in pulmonary function following AIS surgery are unclear. This study provides a novel, CT-based explanation for this finding which challenges traditional theories.

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Paper #89

Matched Cohort Analysis of Posterior Only Vertebral Column Resection vs. Combined Anterior/Posterior Vertebrectomy for Severe Spinal Deformity

*Joshua M. Pahys, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Samuel K. Cho, MD; Lukas P. Zebala, MD; Matthew M. Kang, MD; Woojin Cho, MD PhD; Linda Koester
United States*

Summary: A matched cohort analysis evaluated posterior only VCR vs. combined A/P vertebrectomy for severe spinal deformity. Compared to a traditional A/P approach, the posterior only VCR had a statistically shorter total operative time and hospital stay, as well as improved sagittal correction and SRS scores at a minimum two year follow up.

Introduction: Posterior only vertebral column resection (VCR) is a potential alternative to combined anterior/posterior vertebrectomy (A/P-V) for the treatment of severe spinal deformity. We examined a matched cohort of patients with severe scoliosis and/or kyphosis, with a minimum two year follow up, treated by posterior only VCR vs. combined A/P vertebrectomy.

Methods: The surgical databases of two spine surgeons at one institution from 1994-2007 were reviewed. Patients were matched based on age at surgery (within ten years), diagnosis, curve pattern, vertebra(e) resected (within one), levels fused (within five), and minimum two year follow up. A total of 34 VCR patients were identified that appropriately matched to 34 A/P-V patients. Comparing VCR vs. A/P-V groups: mean age at surgery: 22.3yrs/23.0yrs($p=0.89$); vertebrae resected: 1.6/1.6; levels fused: 11.6/10.4($p=0.27$); average preop coronal Cobb: 71.9°/65.3°($p=0.52$); average preop sagittal Cobb: 95.5°/75.7° ($p=0.026$).

Results: Final coronal Cobb correction for VCR vs. A/P-V groups were similar: 52.6% vs. 53.9% ($p=0.8$), while VCR final sagittal Cobb correction was superior: 53.0% vs. 40.0% ($p=0.017$). Total estimated blood loss was lower on average in the VCR group, 1237mL vs. 1435mL, although not statistically significant ($p=0.5$). The VCR group had a significantly shorter total OR time: 534min vs. 662min ($p=0.004$) and total length of stay 9.9 vs. 21.0 days ($p=0.004$). Complications for VCR vs. A/P-V groups included: wound infections requiring operative intervention, 2.9% vs. 8.8% ($p=0.31$); required subsequent revision surgery, 2.9% vs. 8.8% ($p=0.31$); and transient motor deficits, 2.9% vs. 5.9% ($p=0.49$), respectively. There were no permanent neurologic deficits in the VCR group, and one permanent foot drop in the A/P-V group ($p=0.5$). Total SRS scores improved from preop to final follow up for VCR, 66.9% to 79.5% ($p=0.007$), compared to A/P-V, 63.1% to 76.7% ($p=0.07$).

Conclusion: Posterior only VCR is a challenging, yet safe and effective means of treating severe scoliosis and/or kyphosis. As compared to an A/P vertebrectomy for severe spinal deformity, a posterior VCR demonstrated shorter operative time and hospital stay, as well as improved sagittal correction and SRS scores at a minimum two year follow up.

Paper #90

Multicenter Analysis of 147 Consecutive Vertebral Column Resections for Severe Pediatric Spinal Deformity

*Lawrence G. Lenke, MD; Peter O. Newton, MD; Daniel J. Sucato, MD, MS; Harry L. Shufflebarger, MD; John B. Emans, MD; Paul D. Sponseller, MD; Suken A. Shah, MD; Brenda Sides, M.A.; Kathy Blanke, RN
United States*

Summary: 147 consecutive pediatric VCRs performed by 7 surgeons demonstrated excellent radiographic correction, improved SRS self-image, satisfaction and total domains, but with a 36% overall complication rate and a 27% incidence of intraoperative neurologic events, thus emphasizing the serious and challenging nature of these complex procedures.

Introduction: Although vertebral column resection (VCR) for severe pediatric spinal deformity is a viable treatment option, the strict definition of the procedure, indications, results, outcomes and complications are unknown or controversial.

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Methods: A retrospective review of 7 surgeons' consecutive experience with VCR was performed independent of industry funding, using a strict definition: "3-column circumferential vertebral osteotomy creating a segmental defect with sufficient instability to require provisional instrumentation." 147 pts (74 females/73 males), avg age 13.7 years, with an avg of 1.6 (1-5) vertebrae resected and avg follow-up of 24 months (3-60) met the inclusion criteria.

Results: Indications for a VCR in the 147 pts were divided into 5 diagnostic categories: kyphoscoliosis (KS, n=52); severe scoliosis (SS, n=37); congenital deformity (CD, n=28); global kyphosis (GK, n=17); angular kyphosis (AK, n=13). There were 84 primary/63 revisions, and 184 total procedures: 127 post-only (17 staged) and 20 combined A/P procedures. The avg preop upright, flexibility and postop Cobb measures (%correction) were: KS: 91°, 65°, 44° (52%-AP), 104°, 81°, 46° (56%-LAT); SS: 104°, 78°, 34° (67%); CD: 47°, 38°, 21° (54%-AP), 56°, 48°, 32° (43%-LAT); GK: 101°, 79°, 47° (54%); AK: 88°, 90°, 41° (54%), respectively. The avg OR time was 457 mins (125-996), avg EBL was 1317 cc (50-6026), for an avg of 51% blood volume loss (6-276%). 53 pts (36%) had a complication, and 39/147 pts (27%) had an intraop neurologic event (spinal cord monitoring change or failed wake-up test), but no pt had complete permanent paraplegia and there were no deaths. SRS scores (n=25 pts) showed sig improvement pre to postop in self-image (2.8 vs 4.1, p<0.0001); satisfaction (3.0 vs 4.3, p=0.0001); and total score (71.4% vs 78.6%, p=0.03).

Conclusion: The use of VCR as a strictly defined procedure for severe pediatric spinal deformity in 147 consecutive pts revealed excellent radiographic correction and improved clinical outcomes in SRS self-image, satisfaction and total scores. However, these complex reconstructions were associated with a 36% overall complication rate and a 27% intraop neurologic event rate, thus emphasizing the challenging nature of these patients and procedures.

Paper #91

Prompt Response to Critical Spinal Cord Monitoring Changes During Vertebral Column Resection Results in a Low Incidence of Permanent Neurologic Deficit

Daniel J. Sucato, MD, MS; Suken A. Shah, MD; Lawrence G. Lenke, MD; Peter O. Newton, MD; John B. Emans, MD; Harry L. Shufflebarger, MD; Paul D. Sponseller, MD
United States

Summary: In a group of 147 consecutive patients undergoing vertebral column resection for severe deformity, 27% had intraoperative neurologic events, however, only 13% had immediate postoperative neurologic deficits and only 1 (0.7) patient had a permanent decline in neurologic status. The acute response to intraoperative changes (decreasing correction, resecting more bone, shortening the spine and raising blood pressure) were critical to preserving neurologic function.

Introduction: Vertebral Column Resection (VCR) is a powerful procedure used to treat severe spinal deformity that carries potentially high neurologic risk. There are no studies analyzing risk factors and incidence of intraoperative neuromonitoring (IONM) changes comparing them to postoperative neurologic deficit.

Methods: A multi-institution retrospective database of consecutive VCR procedures was analyzed. The risk factors for the development of intraoperative IONM changes were identified and strategies to prevent permanent neurologic deficit were reviewed.

Results: Of the 147 patients, 39 (27%) had an intraoperative neurologic event (critical neuromonitoring change or failed wake up test). All deficits except one (radiculopathy) were detected intraoperatively by a change in monitoring and/or an abnormal wake-up test. The risk factors included: younger age (11.5 vs 14.3 years, p<0.01), smaller weight (32.0 vs 43.6 kg, p<0.01), longer operative time (516 vs 453 min, p<0.05), type of preoperative deformity (angular kyphosis had greatest risk) thoracic or thoracolumbar level VCR (T-31% vs TL-33% vs L-5%, p<0.05) and the # vertebrae resected (≤ 2 : 24% vs > 2 : 64%, p<0.01). The intraop events occurred during: resection-43%, correction-43%, implant placement- 3%. The primary intraoperative response was: decrease correction 32%, resect more bone 27%, shorten the spine 13%, raise blood pressure 16%. Immediately postoperatively 19 (13%) had some change in neurologic status; 15 were spinal cord deficits and 4 were nerve root injuries. 18 of these deficits resolved over an average of 3.5 months (1 day to 12 months). Only 1 patient (0.7%) had a permanent decrease in neurologic function. Six patients with abnormal preoperative neurologic exams (myelopathy or LE weakness) improved after the VCR.

Conclusion: Despite a high incidence of intraoperative neurologic events during a VCR, the likelihood of permanent neurologic deficits is very low with the use of multimodality spinal cord monitoring and prompt responses to critical changes. Surgeons should consider less correction, more bone resection, shortening the spine and raising blood pressure when monitoring changes are noted to avoid neurologic deficits.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

Paper #92

Comparison Between PSO and Anterior Corpectomy and Plating for Treating Post-Traumatic Kyphosis. A Multi-center Study

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Egypt*

Summary: When compared to anterior corpectomy and plating, PSO is suggested by this multicenter study to be equally safe but more effective in correcting post-traumatic deformity.

Introduction: Kyphosis is a common sequel of neglected or poorly managed thoracolumbar fractures. The aim of this work was to compare between pedicle subtraction osteotomy (PSO) and anterior corpectomy, grafting and plating (ACP) for correcting post-traumatic kyphosis of the thoracolumbar spine.

Methods: Forty three patients with symptomatic post-traumatic kyphosis of the thoracolumbar spine were treated with PSO and were prospectively followed for a minimum of 2 years duration. Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI) were used to judge for the clinical improvement. Radiographs were obtained at 2, 6, 12 and 24 months. The recorded clinical and radiological outcomes were compared to a historical group of 37 patients, who were treated earlier by the same authors with ACP.

Results: The mean correction of the kyphotic angle was $30.3^{\circ} \pm 5.0^{\circ}$ for the PSO group and $19.7^{\circ} \pm 7^{\circ}$ for the ACP group ($P=0.001$). The mean estimated blood loss was slightly more and the mean operative time was slightly shorter in the PSO group. The PSO group showed significantly better clinical outcome as reflected by the improvement in the VAS score and the ODI. Patients reported very good satisfaction (91% in PSO vs 84% in ACP) and good function (88% in PSO vs 76% in ACP) at ultimate follow-up. Complications in the PSO group included pulling out of screws (1) and recurrence of deformity requiring revision and longer fixation, and transient lower limb paraesthesia (2). Recorded complications in the ACP group included aortic injury (1) that was successfully repaired, pseudarthrosis (1), persistent graft donor site morbidity (3), and incisional hernia (1).

Conclusion: PSO seems to be an equally safe technique but more effective than ACP for correcting post-traumatic kyphosis with faster rehabilitation and significantly better patients' satisfaction.

Paper #93

Loss of Correction in Treatment of Thoracolumbar Kyphosis Secondary to Ankylosing Spondylitis: A Comparison Between Smith-Petersen Osteotomies and Pedicle Subtraction Osteotomy

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China*

Summary: Loss of correction of thoracolumbar kyphosis secondary to ankylosing spondylitis (AS) was compared between Smith-Petersen osteotomies (SPOs) and pedicle subtraction osteotomy (PSO). There was no significant difference between the two groups in terms of immediate post-operative correction, but higher loss of correction was found in the SPOs group than in PSO group.

Introduction: The thoracolumbar kyphosis secondary to AS could be corrected by two types of posterior osteotomy techniques, SPOs and PSO. The aim of this study was to evaluate the difference of immediate post-operative correction and loss of correction between SPOs group and PSO group.

Methods: Fifty patients were divided into two groups. 19 cases in Group 1 underwent SPOs, including 16 males and 3 females with an age range from 21 to 40 years. The average global kyphosis (GK) was $64.6^{\circ} \pm 25.6^{\circ}$. Thirty-one cases (26 male, 5 female) with an age range from 22 to 54 years old in Group 2 were corrected by mono-segmental PSO. The average GK was $73.7^{\circ} \pm 23.6^{\circ}$. Radiographic parameters including sagittal vertical axis, T5-T12 kyphosis, T12-S1 lordosis, GK and Cobb angle of instrumented region were measured.

Results: Both groups showed similar pre- and post-operative thoracic kyphosis and lumbar lordosis and sagittal vertical axis. The average GK was corrected to 25.5° and 31.4° in Group 1 and 2, respectively. All cases were followed-up with a minimum two years. At the last follow-up, mean loss of correction in the fusion area were 6.1° in Group 1 and 1.3° in Group 2, respectively. The difference was statistically significant ($p < 0.05$). Loss of correction more than 5° happened in 4 cases (21.1%) for Group 1, and in 5 cases (16.1%) for Group 2 (Chi-square test, $p < 0.05$).

Conclusion: SPOs and PSO showed similar immediate post-operative correction of the thoracolumbar kyphosis secondary to AS. However, patients with the SPOs technique showed more loss of correction in the instrumented region.

Significance: The patients treated with SPOs should be carefully and closely followed-up because of high risk of loss of correction.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Paper #94

Sterility of Posterior Elements of Spine in Posterior Correction Surgery

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Japan*

Summary: Bacterial contamination of the posterior elements of spine during posterior correction surgery was investigated to know the feasibility of laminae as local bone graft in terms of sterility. The culture was positive in 32.5% of the specimen obtained immediately before closure of the wound, suggesting that bacterial contamination in the operative field develops during surgery.

Introduction: The sterility of local bones used for graft may be one of the key factors for prevention of postoperative infection. The purpose of this study was to investigate the sterility of the posterior elements of the spine during posterior correction surgery.

Methods: 80 consecutive patients (15 males, 65 females, mean age 19.5 years) who underwent posterior correction surgery for spinal deformities were included in the study. The surgical field was prepared routinely by brushing of the skin using povidone-iodine scrub solution, followed by dissection by 10% povidon-iodine field solution. During surgery, specimens for bacterial culture were obtained by swabs from 1) the skin after brushing but before dressing, 2) laminae immediately after exposure, 3) immediately after screw placement, 4) immediately before wound closure, 5) a small piece of bone obtained from the spinous process immediately after exposure and place on the sterile dish during surgery as control. The culture was conducted both on blood agar and GAM agar plates.

Results: No patient developed clinically apparent postoperative infection by at least 6 months after surgery. The culture was positive in 25 (31.3%) in Specimen(S) 1, 19(23.8%) in S2, 25(31.3%) in S3, 26 (32.5%) in S4, 6 (7.5%) in S5. Bacterial species included *P. Acne* in 15 specimens, *Propioni sp* in 9, and others in 5. 22 (88%) of 25 patients with positive culture in Specimen 1 and 17 (30.9%) of 55 patients without demonstrated positive culture in the specimens obtained during surgery. A mean surgical time were 265 ± 94.9 min in patients with positive culture and 214 ± 107.3 with negative culture ($p = 0.107$).

Conclusion: The culture was more frequently positive in a specimen obtained immediately before wound closure than in a specimen harvested immediately after exposure and isolated from the surgical field. The detected bacterial species were mostly indigenous bacteria of the skin. This result suggests that bacterial contamination in the operative field possibly from the skins of the patients develops during surgery especially with longer duration.

Significance: Local bone harvested at the later stage of surgery may be more subject to bacterial contamination leading to an increased risk of postoperative infection.

Paper #95

A Prospective, Randomized, Double-Blind, Placebo-Controlled Study on Efficacy of Intraoperative Ketamine in Reduction of Postoperative Pain in Opiate-Dependent Chronic Back Pain Patients Undergoing Spinal Surgery

*Randy W. Loftus, MD; Dilip K. Sengupta, MD
United States*

Summary: In a prospective, randomized, double-blind, placebo-controlled study on 102 opiate-dependent patients undergoing spinal surgery, intraoperative use of Ketamin was found to reduce post-operative pain and need for opiate medication.

Introduction: Ketamine has been shown to be useful in the reduction of acute postoperative pain and analgesic consumption in a variety of surgical interventions. Little is known regarding its efficacy in opiate-dependent patients with a history of chronic back pain undergoing spinal surgery.

Methods: 102 patients were enrolled over a two-year period (February 2007 to April 2009) with IRB approval and after informed consent. Patients in the treatment group were administered 0.5mg/kg of intravenous Ketamine prior to the surgical incision followed by an infusion at 10mcg/kg/min started prior to incision and terminated at wound closure. Patients in the placebo group received saline of equivalent volume. The anesthetic was controlled in both groups. Patients were monitored for post-operative pain and opiate medication need for 48 hours post-operatively and at 6 weeks follow-up. The primary outcomes were pain intensity as reported by the patients in visual analogue scale, and morphine consumption. Secondary outcomes included hemodynamic changes, duration of stay in post-anesthesia care unit and hospital stay, and any side effect.

Results: Total morphine consumption (morphine equivalents) was significantly reduced in the treatment group at 24 and 48 hours and at 6 weeks. The mean pain intensity was significantly less in the treatment group in the post-anesthesia care unit and at 6 weeks follow-up, but was not different at 24 and 48 hours. There were no differences in known Ketamine or opiate-related side-effects between the groups.

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Conclusion: Intraoperative use of low-dose Ketamine reduces intensity of post-operative pain, and need for opiate consumption in immediate postoperative period and also at 6 weeks after spinal surgery in chronic opiate-dependent patients. There was no apparent side effect noted with such use of Ketamin.

Significance: This study clearly establishes the safety and efficacy of intraoperative use of low-dose Ketamin in reduction of post-operative pain after spinal surgery in opiate dependent patients

Paper #96

Antifibrinolytic Agents Substantially Reduce Blood Loss During Vertebral Column Resection Procedures

Peter O. Newton, MD; Tracey Bastrom, MA; John B. Emans, MD; Suken A. Shah, MD; Harry L. Shufflebarger, MD; Paul D. Sponseller, MD; Daniel J. Sucato, MD, MS; Lawrence G. Lenke, MD
United States

Summary: A multicenter review of 147 pediatric spinal deformity patients who underwent a vertebral column resection procedure was performed. When normalized to patient size and number of levels excised, antifibrinolytic agents resulted in ~40% decrease in blood loss during vertebral column resection procedures.

Introduction: Vertebral column resection (VCR) procedures may be associated with substantial intraoperative blood loss. The purpose of this study was to evaluate the effect of antifibrinolytic agents used during surgery on blood loss during VCR procedures for pediatric patients.

Methods: A multi-center retrospective review of 147 patients (age <21 yrs) who underwent VCR as part of their spinal deformity correction was conducted. Estimated blood loss was calculated as a % of blood volume (EBL/BV), which was then normalized to the number of vertebral levels removed (%BV/level). The use of antifibrinolytic (AF) agents was noted (tranexamic acid, aminocaproic acid, aprotinin, none) and based on the surgeons choice. Blood loss in these groups was compared utilizing analysis of covariance (controlling for deformity magnitude) with Bonferroni post hoc comparisons ($p < 0.05$).

Results: The average preop major deformity (kyphosis or scoliosis) was $97 \pm 31^\circ$. The average number of vertebral levels excised was 1.6 (range 1-5). The total EBL averaged 1317 ml (range 50-6026 ml). 11 patients were excluded from the AF sub-analysis: 7 with incomplete data and 4 that received aminocaproic acid (too few to compare); yielding a total of 136. 64 patients received no AF, 42 received tranexamic acid, and 30 received aprotinin. Half of the patients (68) had a congenital deformity and these were evenly distributed among the 3 AF groups ($p = 0.7$). Overall % blood volume loss/vertebral level excised was $41 \pm 39\%$, yet varied widely (range 6-162%). Normalized blood loss (%BV/level) in the group that did not receive an AF agent was significantly higher ($52 \pm 37\%$) than in the tranexamic acid ($30 \pm 34\%$, $p < 0.01$) and aprotinin ($32 \pm 24\%$, $p < 0.05$) groups. No difference was found between the 2 AF groups ($p = 0.9$).

Conclusion: Blood loss associated with VCR procedures was found to be highly variable and in many cases exceeded the blood volume. The use of AF agents was not routinely utilized, and aprotinin has since been removed for the market. We had insufficient data to assess the efficacy of aminocaproic acid; however, when normalized to patient size and number of levels excised, the use of tranexamic acid resulted in a 42% reduction in normalized intraoperative EBL associated with VCR procedures.

Paper #97

The Natural History of Dural Ectasia in Marfan Syndrome

Addisu Mesfin, MD; Nicholas Ahn, MD; John Carrino, MD; Paul D. Sponseller, MD
United States

Summary: Dural ectasia is a common feature of the Marfan syndrome and is one of the major criteria used to diagnose Marfan syndrome. The natural history of dural ectasia is not known. We present a 10 year follow up of symptoms and imaging characteristics of dural ectasia in Marfan syndrome. Our results indicate the symptoms and imaging characteristics associated with dural ectasia do not worsen over time.

Introduction: Dural ectasia, or widening of the dural sac, in the lumbosacral spine is a common feature of Marfan syndrome. Dural ectasia has been associated with low back pain as well as increased surgical complications in Marfan syndrome. The natural history of dural ectasia in Marfan syndrome is not known.

Methods: Twenty Marfan patients with dural ectasia who underwent MRI and CT of the lumbosacral spine and completed the Oswestry Disability Index (ODI) in 1998-1999 were prospectively followed. In 2009 repeat imaging with CT and/or MRI of the lumbosacral spine was obtained as well as new ODI questionnaires. Our exclusion criteria were patients who underwent surgery of the lumbosacral spine or were lost to follow up. Based on MRI we evaluated the dural sac ratio (dural sac diameter/vertebral body diameter) of L4-S2 as well volumetric measurements (GE Advantage Workstation) of the dura from L5-S2 to determine if the dural ectasia size increased over time.

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Results: Fifteen (75%) out of the original twenty patients were available for follow up. All fifteen completed the ODI questionnaire. The mean age was 49.6 (41.1-61.2). The mean follow up was 10.5 yrs (9.8-11). The mean ODI score in 1998-99 was 25.8, SD 19.7 (0-46.67) and the mean ODI score in 2009 was 22.2, SD: 21.3 (0 - 62.2). No statistical significance was noted ($p = 0.76$). MRI dural volumetric measurements were available for 10 patients from 2009 and 7 from 1998-99. The mean dural volume in 1998-99 was 73.4, SD 38.1 (22-138.9) and in 2009 was 79.6, SD 43.7 (16.7-140.3). No statistically significant difference was noted between the two groups ($p = 0.76$). The dural sac ratio (DSR) of L4-S2 was available for 10 patients from 2009 and 8 from 1998-99. The mean L4-S2 DSR for the 1998-98 group was (L4: 0.66, L5: 0.8, S1: 2.23, S2: 66.5) and for the 2009 group (L4: 0.7, L5: 0.76, S1: 2.11, S2: 65). No statistical significance was noted in DSR at L4-S2 (L4: $p=0.81$, L5: $p=0.67$, S1: $p = 0.8473$, S2: $p=0.9834$).

Conclusion: The natural history of dural ectasia in marfan syndrome does not demonstrate an increase in ODI scores and does not demonstrate a significant increase in dural ectasia size.

Significance: This is the first study detailing the natural history of dural ectasia in Marfan syndrome.

Paper #98

Analysis of Preexistent Vertebral Rotation in the Normal, Non-Scoliotic Infantile, Juvenile and Adolescent Spine

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Netherlands

Mean vertebral rotation for each age group and gender

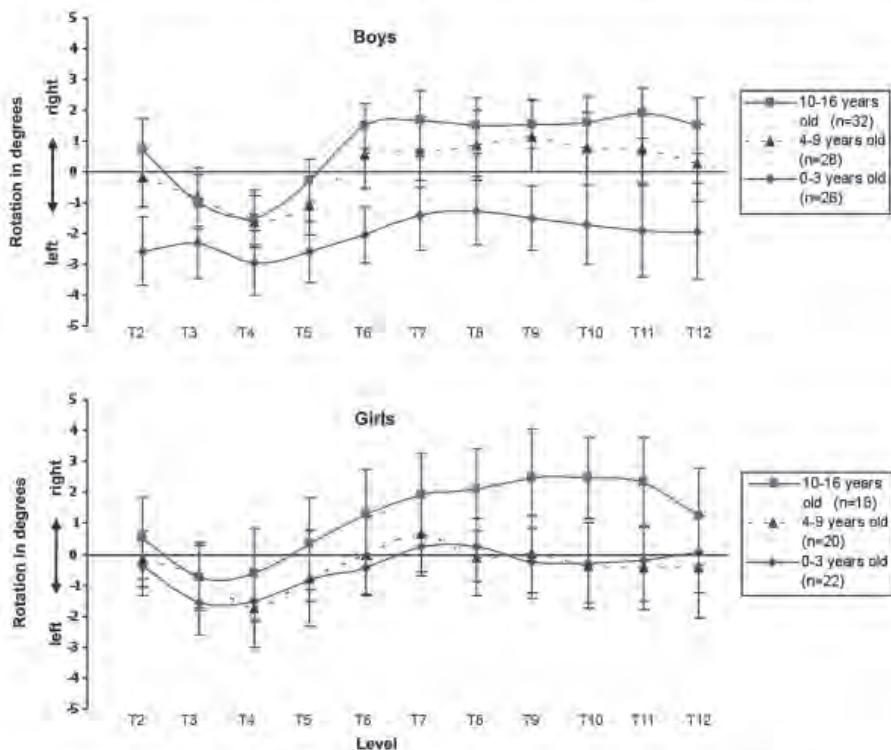


Figure 1 Vertebral rotation in the transverse plane (mean and 95% confidence interval) of T2-T12 in the infantile (0-3 years old), juvenile (3-10 years old) and adolescent (10-16 years old) non-scoliotic boys and girls. All measurements are in degrees.

Summary: Vertebral rotation was systematically analyzed in the normal, non-scoliotic infantile, juvenile and adolescent thoracic spine. The well-known predominance of right-sided thoracic curves in adolescent idiopathic scoliosis (IS) and left-sided curves in infantile IS are explained by the observed patterns of vertebral rotation that preexist at the corresponding age.

Introduction: Distribution of gender as well as distribution of left and right-sided curves is different in infantile, juvenile and adolescent IS. In infantile IS, boys are affected more often than girls and the curve is typically left-sided. Whereas in adolescent IS, predominantly girls are affected and the thoracic curve is typically right-sided. It has been hypothesized that the direction of the curve is determined by an already built-in rotational tendency of the spine, which is present at the time a spine starts to develop a scoliosis. Recently such a preexisting rotational pattern was identified in the normal, non-scoliotic adult spine. A systematic analysis of possible preexisting vertebral

rotation in the normal, non-scoliotic infantile, juvenile and adolescent spine was performed to test this hypothesis.

Methods: Vertebral rotation of T2-T12 was measured with semi-automated software in 142 children (0-16 years old) that had undergone CT examination of the thorax for reasons such as pulmonary disease or malignancies. A repeated measures ANOVA was performed to analyze differences in vertebral rotation patterns between the infantile (0-3 years old), juvenile (4-9 years old) and adolescent (10-16 years old) boys and girls.

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Results: Mean vertebral rotation for each age group and gender is shown in Fig. 1. In the adolescent spine, T3-T4 were significantly rotated to the left and T6-T12 to the right. In the infantile spine, most thoracic vertebrae were significantly more rotated to the left. In the juvenile spine, direction of vertebral rotation was equally distributed. Rotation to the left was more pronounced in infantile boys, however no statistical differences were found between the genders.

Conclusion: Although considerably less in magnitude, the preexistent rotational patterns at the infantile and adolescent age groups, are comparable to the most prevalent types of IS occurring at that age group. These data support the hypothesis that once the spine starts to decompensate, for still unknown reasons, this built-in rotational pattern determines the direction of the spinal curve.

Significance: This is the first systematic analysis of preexistent vertebral rotation in the growing spine. Results explain the predominant direction of curvature in IS.

Paper #99

Is Iliac Crest Bone Graft Still the Gold Standard in Spinal Fusion Surgery? A Survey of Spine Surgeons

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United States

Summary: We surveyed spine surgeons at SRS-2009 and CSRS-2009 regarding opinions of iliac crest bone graft (ICBG) versus bone graft substitute (BGS) in spinal fusion surgeries. 452 surveys were returned with similar results at each conference. Donor site morbidity is a significant concern in graft selection; the majority did not feel that ICBG should remain the gold standard in anterior cervical fusions and half felt that it should not remain the gold standard in lumbar fusion surgeries.

Introduction: Numerous studies show BGS may be comparable to ICBG, without the additional morbidity, but current literature suggests that ICBG remains the gold standard. This survey queries spine surgeons regarding current opinions and uses of ICBG and BGS in spinal fusion surgery.

Methods: A survey was distributed at SRS-2009 and CSRS-2009 containing multiple-choice and short answer questions evaluating demographics, uses and opinions of ICBG and BGS.

Results: Surveys returned: SRS 250 (41%), CSRS 202 (48%), total 452.

The demographics for the conferences were as follows:

Orthopaedic trained surgeons: SRS 95%, CSRS 77%,

Academic: SRS 45%, CSRS 78%,

In Practice >10yrs: SRS 66%, CSRS 55%,

Perform >100 spine surgeries annually: SRS 73%, CSRS 85%,

Practice within the US: SRS 74%, CSRS 78%,

Believe they achieve the best fusion rates with:

ICBG alone: SRS 25%, CSRS 34%,

ICBG + bone graft substitutes: SRS 11%, CSRS 20%,

Local bone + bone graft substitutes-SRS 49%, CSRS 30%,

Bone graft substitutes alone-SRS 3%, CSRS 0%,

Rate unaffected by graft choice-SRS 12%, CSRS 16%,

Expect use of ICBG to remain same or decrease: SRS 92%, CSRS 80%,

Report problems with ICBG donor site morbidity: SRS 81%, CSRS 77%; this was also the most commonly listed reason for avoiding ICBG use at SRS and CSRS.

Believe ICBG should no longer be the gold standard in anterior cervical fusions: SRS 58%, CSRS 56% (p=0.67, no significant difference between conferences).

Believe ICBG should no longer be the gold standard in lumbar fusions: SRS 48%, CSRS 50% (p=0.60, no significant difference between conferences).

Conclusion: These findings indicate that donor site morbidity strongly influences graft selection. Finally, it appears that the majority of spine surgeons may no longer consider ICBG to be the gold standard in spinal fusion surgery.

Significance: This survey indicates that for the majority of spine surgeons, donor site morbidity strongly influences graft selection and that BGS is considered an acceptable alternative to ICBG. It also indicates that ICBG may no longer be considered the gold standard in spinal fusion surgery.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Paper #100

Does Preoperative Bowel Preparation Reduce Post-Operative Bowel Morbidity and Length of Stay After Scoliosis Surgery?

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United States

Summary: This is a single surgeon randomized prospective series of patients with AIS to determine whether a preoperative bowel prep reduces postoperative bowel morbidity and length of stay.

Introduction: Constipation is common following scoliosis surgery due to the need for narcotics, dietary changes, and immobilization. Crawford(2005) reported 78 percent of patients undergoing spinal surgery developed GI morbidity postoperatively, resulting in prolonged hospital stays. The purpose of this study is to determine if a pre-op bowel preparation decreased the incidence of post-op GI morbidity and length of hospital stay for children undergoing surgery for AIS. We hypothesized that patients having a pre-operative bowel prep would have reduced bowel morbidity and a shorter length of stay following scoliosis surgery.

Methods: We conducted an IRB-approved, randomized, prospective study of 60 patients who underwent PSIF for AIS at our institution between June 2007 and July 2009. After informed consent, patients were randomized into two groups: Group A received a pre-op bowel prep using NuLytley®, and Group B received no pre-op bowel prep. Post-op data collection included time of last bowel movement pre-operatively, abdominal girth, bowel sounds, nausea, emesis, ambulation, weight, pain management (Epidural/PCA), medication (pain), medication (constipation), abdominal pain, date transitioned to oral medication, oral intake and stool output, and length of stay. All patients followed a standardized post-operative bowel protocol and dietary regimen.

Results: 60 patients were consecutively enrolled and randomized into the two groups. The groups were evenly matched for age and gender. In Group A, 5 patients did not tolerate the bowel prep, leaving 25 patients in Group A and 30 in Group B. Group A had significantly less weight gain ($p<0.09$), fewer post-op bowel medications ($p<0.023$) and a shorter time to 1st bowel movement ($p<0.03$) than the controls. However, there was no difference in length of stay between the two groups ($p=0.222$).

Conclusion: These data show a modest reduction in some aspects of bowel morbidity by pre-op bowel prep before scoliosis surgery. There is no evidence that a pre-operative bowel prep reduces length of stay or other parameters of bowel morbidity.

Significance: Post-operative bowel morbidity remains a relevant problem after scoliosis surgery. Pre-op bowel prep does not significantly reduce post-op bowel morbidity or length of stay.

Paper #101

Long Term Results from Steroid (Deflazacort) Treatment in the Development of Scoliosis in Duchenne Muscular Dystrophy

Benjamin Alman, MD; Doug Biggar

Canada

Summary: Long term steroid treatment dramatically reduces the need for spinal surgery in boys with Duchenne muscular dystrophy into patient's third decade of life. Steroid treatment also results in improved survival in afflicted boys.

Introduction: Boys with Duchenne muscular dystrophy develop progressive muscle weakness causing a progressive decline in ambulatory ability, pulmonary function, and cardiac function. This is associated with the development of progressive scoliosis. Prolonged steroid treatment results in a substantial slowing in the rate of decline in muscle weakness, resulting in improved pulmonary and cardiac function and a substantially reduced chance of developing scoliosis in the medium term. The long effect of steroid treatment on the development of scoliosis is unknown.

Methods: 54 ambulatory boys with Duchenne muscular dystrophy were enrolled in a comparative study using the steroid, deflazacort. The boys were offered deflazacort on a high dose daily oral regimen. 30 elected to use steroid treatment, and 24 did not. The boys were matched for important baseline characteristics, and treatment started at an average age of 8. They were followed for 14 years, and none of the boys was lost to follow-up. They were examined every four to six months for the development of a scoliosis (defined as a Cobb angle greater than 20 degrees), back symptoms, or the need for spinal surgery.

Results: Four boys in the no-steroid group and one in the steroid died in the past four years. At latest follow-up six boys in the steroid treatment group developed at least 20 degrees of scoliosis and all underwent spinal surgery. One of these boys also had pain likely secondary to osteoporosis related compression fractures, but the rest did not have long term symptoms. All of the boys in the no steroid group developed at least a 20 degree curve or underwent surgery. There was a very significant ($p<0.0005$) difference in the change of developing scoliosis.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

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Conclusion: This data shows that long-term steroid use results in a decreased need for spinal surgery. It also results in a survival advantage. 75% of boys in the steroid treatment group have not developed curves into their third decade of life, while all of the boys in the no treatment group did.

Significance: Long term steroid treatment can avoid the need for scoliosis surgery, as well as improve survival, in Duchenne muscular dystrophy.

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).

Paper #102

Is Pre-operative Pulmonary Function Test Valuable in Surgery for Flaccid Neuromuscular Scoliosis?

Hak-Sun Kim, MD; Eun-Su Moon, PhD; Hwan-Mo Lee; Seong-Hwan Moon, PhD, MD; Hyon-su Chong, MD; Do-Hyun Kim; Dong-Eun Shin, PhD
Korea, Republic of

Forced vital capacity \ Complications	Pneumonia	Pneumothorax	Atelectasis	> 48 hours mechanical ventilation	Total
Less than 30% group A (n=18)	0	5	1	5	11 (61%)
30-50% group B (n=20)	4	1	4	0	9 (45%)
More than 50% group C (n=36)	5	4	0	9	18 (50%)
Total	9	10	5	14	38 (51%)

There is no statistic difference among 3 groups.

Summary: 74 patients with flaccid NM scoliosis were operated. Compare to complication rate, we divided the patients in to 3 groups. Group A 18 patients FVC <30%, Group B 20 patients FVC (30% -50%), Group C had 36 patients FVC >50%. Complications were defined as pneumonia, pneumothorax, atelectasis, and prolonged mechanical ventilation. Since there was no statistically significant difference among the three groups, FVC under 30% was not a contraindication for surgery and preoperative PFT could not predict postoperative pulmonary complications.

Introduction: One paper has reported that less than 30% FVC can be safely operated upon in NM scoliosis. However, the paper covered only 8 patients, so statistic evaluation was not possible.

The purpose of this paper is to address the relationship between PFT and postop pulmonary complication to make a statistic evaluation whether 1) FVC over 30% is a reliable criterion for surgery and 2) a correlation between the preop PFT and postop pulmonary complication exists.

Methods: Seventy-four patients with flaccid NM scoliosis were operated upon with preoperative PFT. We divided the patients in to 3 groups. Group A had 18 pts with FVC < 30%, regarded a contraindication of surgery. Group B had 20 pts with FVC of 30% -50%, Group C had 36 pts with FVC > 50%. Complications were defined as pneumonia, pneumothorax, atelectasis, and cases that need over 48 hours of mechanical ventilation.

Results: Of the 74 patients, there were 49 males and 25 females. The average age was 14.2(5-32), and the average preoperative Cobb angle 70.6(16.7-135) degrees. There were 43 cases of progressive MD, 20 cases of spinal muscular atrophy, 6 cases of congenital myopathy, and 5 other cases. Group A(FVC < 30%) had 5 cases of pneumothorax, 5 cases that need over 48 hours of mechanical ventilation, and 1 case of atelectasis, a total of 11 cases(61%). Group B (FVC 30% - 50%) had 4 cases of pneumonia, 4 cases that need over 48 hours of mechanical ventilation, and 1 case of pneumothorax, a total of 9 cases(45%). Group C(FVC > 50%) had 9 cases that need over 48 hours of mechanical ventilation, 5 cases of pneumonia, and 4 cases of pneumothorax, a total of 18 cases(50%). Among the three groups, although there were some arithmetic differences, there were no statistically significant difference(p=0.12).

Conclusion: Because of no statistic significance among the three groups, FVC under 30% was not a contraindication for surgery and preoperative PFT could not predict postoperative pulmonary complications.

Significance: We documented that less than 30% FVC is not contraindication for surgery in NM scoliosis.

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Paper #103

Growing Rods for Scoliosis in Spinal Muscular Atrophy

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United States*

Summary: Significant scoliosis develops early in many children with Spinal Muscular Atrophy (SMA). Growing rods (GR) are effective in controlling the scoliosis.

Introduction: Control of early onset scoliosis (EOS) in SMA may be important to minimize restrictive pulmonary disease.

Methods: 15 SMA patients with EOS treated with GR were studied. Trunk growth and curve control were assessed. Burden of care and complications were contrasted with GR in idiopathic scoliosis (IS).

Results: 15 patients with SMA underwent GR surgery at a mean age of 7.8 ± 1.9 years. Follow-up was 42 ± 31 months. Mean curve was $90 \pm 19^\circ$ preop, $45 \pm 12^\circ$ at first postop, and $52 \pm 17^\circ$ at latest follow-up. 6 had single rods, and 9 had dual rods. Mean 15.9 ± 1.7 levels were instrumented, and 9 extended to pelvis. Mean # lengthenings (LN) were 3.7 ± 2.8 at mean 9.0 ± 4.9 month interval. Hospital stay for initial insertion was 7.5 ± 6.5 days for SMA versus 4.6 ± 2.7 days for IS and for LN was 1.6 ± 3.2 days for SMA versus 0.4 ± 0.8 days for IS ($P=0.02$). 40% of SMA LN were outpatient procedures versus 71% of idiopathic LN. In SMA, coronal imbalance was 6.8 ± 8.1 cm preop, 3.3 ± 3.9 cm at first postop, and 5.5 ± 3.9 cm at latest follow-up. Mean gain in T1-S1 length from preop to latest was 5.9 ± 6.1 cm. Space available for lung ratio increased from 0.85 ± 0.19 preop to 0.95 ± 0.28 at latest follow-up. Lung height on concave side increased from 11.3 ± 2.5 cm preop to 13.6 ± 4.5 cm at latest follow-up, and lung height on convex side increased from 13.7 ± 4.1 cm preop to 14.6 ± 3.9 cm at latest follow-up. Significant complications included 3 infections, 3 anchor dislodgements, 2 laminar fractures, 1 cardiac arrest, 1 implant prominence, 1 rod dislodgement from connector, and 1 tracheostomy. There were no rod fractures or neurologic complications. SMA patients had 0.8 significant complications per patient, and IS had 0.9. Five patients underwent final fusion at age 13.1 ± 2.5 years and final pre-fusion curve $64 \pm 11^\circ$.

Conclusion: GRs improve trunk and lung height for SMA patients who develop severe scoliosis at a young age. Burden of care due to serial lengthenings is greater than IS but complications are similar. GR deserves comparison with other options.

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Paper #104

The Patient with Myelomeningocele: Is Untethering Necessary Prior to Deformity Correction?

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Summary: All patients with myelomeningocele (MM) have a radiographically tethered spinal cord. No guidelines exist as to when and if to untether these patients prior to spine deformity correction. We identified 19 patients with MM with 2-year follow-up who had not undergone an untethering procedure in the one year prior to their spine deformity correction. Significant correction (59%) was obtained, and no patient experienced a new cranial nerve palsy, shunt malfunction, or upper extremity weakness. One patient experienced transient lower extremity weakness which returned to baseline within one month of surgery. Our results suggest that in select patients with MM (i.e. those not presenting with symptoms typically associated with a tethered cord), it may not be necessary to untether the spinal cord prior to correcting their spine deformity.

Introduction: Tethering of the spinal cord is thought to increase the chance of neurologic injury when spinal deformity correction is undertaken. All patients with MM are radiographically tethered, and untethering procedures carry significant morbidity including worsening neurologic function and wound complications. No guidelines exist concerning untethering patients with MM prior to deformity correction.

Methods: We retrospectively identified 19 patients with MM who 1) had no evidence of a clinically symptomatic tethered cord, 2) had undergone a spinal fusion for deformity correction, and 3) had not been untethered for at least one year prior to surgery. Minimum follow up was 2 years. Charts and radiographs were reviewed for neurologic or shunt complications.

Results: Mean age of the MM patients was 12.2 years with 3.9 yrs follow-up and with the following neurologic levels: $\geq T12=8$, $L1=4$, $L2=3$, $L3=2$, $L4=2$. All were radiographically tethered as confirmed by MRI. 14 of the patients (74%) had a ventriculoperitoneal shunt. The mean Cobb angle was corrected from 81 ± 28 to 33 ± 13 degrees postoperatively, for a 59% correction. All patients underwent neuromonitoring of their upper extremities, with some having obtainable lower extremity monitoring.

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Postoperatively, no patient experienced new cranial nerve palsy, shunt malfunction, or upper extremity weakness/sensory loss. One patient had transient lower extremity weakness which returned to baseline within one month of surgery.

Conclusion: All patients with MM have a tethered spinal cord. Our results suggest that untethering may not be necessary in these patients prior to deformity surgery, as long as they do not present with signs/symptoms typical for a tethered cord.

Significance: Patients with MM do not necessarily need their spinal cords untethered prior to deformity correction surgery.

Paper #105

Combined Anterior-Posterior vs. Posterior Only Fusion for Severe Non-Spastic Neuromuscular Deformity

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Summary: Severe neuromuscular (NM) deformity has traditionally been treated with circumferential release and fusion. Posterior-only fusion offers lower morbidity, but whether results are comparable is unclear. We compared 36 non-spastic NM patients with severe curves treated via A/PSF vs. 25 matched patients treated with posterior-only surgery. The posterior-only group had significantly lower blood loss and operative times and trended towards lower revision and complication rates. Cobb angles, correction, sitting balance, and pelvic tilt were similar between the two groups at 2 years.

Introduction: While posterior-only fusion (PSF) could potentially result in less morbidity, no studies to date have demonstrated that it has efficacy comparable to circumferential release and fusion (A/PSF) in the non-spastic neuromuscular (NM) population with significant deformity. We examined the 2-year outcomes of patients that had received a PSF and compared them with a similar population that underwent A/PSF to determine if PSF could replace A/PSF as the procedure of choice.

Methods: 61 non-spastic NM patients with severe scoliosis ($101.9^\circ \pm 15.0$) or kyphosis ($108.0^\circ \pm 16.6$) underwent either a primary A/PSF (n=36) or PSF alone (n=25). Patients in both groups were followed for a minimum of 2 years. Diagnoses include myelomeningocele (n=30), SMA (n=8), Duchenne's (n=5), and other myopathies (n=18). There were no significant differences in age at surgery, preoperative average coronal and sagittal plane Cobb angles, sitting coronal balance, and pelvic tilt between the two groups.

Results: Blood loss was 1251 ± 779 cc for A/PSF and 620 ± 285 cc for PSF ($p < 0.0001$). The mean operative time for A/PSF was 703 ± 260 min vs. 382 ± 103 min for PSF ($p < 0.0001$). 9/36 (25.0%) A/PSF required revision within 2 years vs. 2/25 (8.0%) PSF patients ($p = 0.106$). 12/36 (33.3%) had significant complications in the A/PSF group vs. 3/25 (12.0%) in the PSF group ($p = 0.166$). There were no differences in terms of % correction of deformity, coronal and sagittal plane Cobb angles, sitting coronal balance, and pelvic tilt between the two groups at 2-year follow-up.

Conclusion: Posterior-only spinal fusion demonstrates equivalent radiographic outcomes to combined anterior/posterior release and fusion in non-spastic neuromuscular patients with significant sagittal and coronal plane deformities. The PSF only group also had significantly lower EBL and operative times as well as an obvious trend towards lower complications and revision rates. This study supports the use of PSF in lieu of A/PSF for deformity correction in non-spastic NM patients.

Paper #106

Subsequent, Unplanned Spine Surgery and Life Survival of Patients Operated for Neuropathic Spine Deformity

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Summary: One hundred eight (93%) consecutive patients were followed 10.45 ± 5.04 years. Survival from subsequent spine surgery was 91.4% at 5, 90.1% at 10 & 15, and 60.1% at 20 years. Life survival was 97.9% at 5, 89.4% at 10, 79.9% at 15, 50.4% at 20, and 37.5% at 20.1 years. Ninety seven percent were satisfied or very satisfied with the outcome. Even after successful spine deformity surgery, this population's health status is often precarious.

Introduction: Survival analysis is widely used to study the natural history of diseases and treatments for them. Our purposes were to characterize the survival from subsequent spine surgery and death of patients treated surgically for severe spinal deformity due to neurological diseases.

Methods: One hundred sixteen consecutive patients were treated with primary posterior hybrid instrumentation and arthrodesis. There were no perioperative deaths, spinal cord injuries or acute deep wound infections. One hundred eight (93%; 60F, 48M), operated at 13.98 ± 3.36 years were followed 10.45 ± 5.04 , (2 to 20.67) years. Eighty-five had upper motor (e.g. cerebral palsy 43) and 23 lower motor neuron (e.g. myelomeningocele 18) diseases. The largest deformities; number, and degrees pre and post operative were scoliosis (87, 80° , 24°), hyperkyphosis (15, 100° , 38°), and hyperlordosis (6, 113° , 55°). Pelvic obliquity of $\geq 10^\circ$ was present in 74; 27° pre and 6° postoperative.

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Results: Eleven (10%) had subsequent spine surgery 4.07 ± 5.66 years postoperative. Indications were delayed deep wound infection 2, pseudarthrosis 2, implant problems 5 and other 2. Survival was 91.4% at 5, 90.1% at 10 & 15 and 60.1% at 20 years. Nineteen (18%) died 11.71 ± 5.60 years postoperative. Causes were sleep apnea 4, pulmonary problems 4 and other 11. Life survival was 97.9% at 5, 89.4% at 10, 79.9% at 15, 50.4% at 20 and 37.5% at 20.1 years. (Figure 1) At 9.08 ± 5.36 years follow-up, 97% (99/102) of patients, parents and/or caregivers were satisfied or very satisfied with the outcome.

Conclusion: Following successful surgery for neuropathic spine deformity, survival from subsequent spine surgery is comparable to that reported in the few series of idiopathic scoliosis studied in the same manner. However, life survival after 5 years is a steady decline, reaching 37.5% and 20.1 years, underscoring the often precarious health status of these patients.

Paper #107

Surgical Treatment of Scoliosis in Non-Ambulatory Spastic Quadriplegic Cerebral Palsy Patients: A Matched Cohort Comparison of Luque-Galveston Technique and All-Pedicle Screw Constructs

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United States

Summary: 28 patients with non-ambulatory spastic quadriplegic cerebral palsy underwent surgery for correction of their scoliosis with Luque-Galveston (n=14) or all-pedicle screw constructs (n=14) in a matched cohort analysis. All-pedicle screw construct group had shorter hospital stays, lower blood loss and better correction of coronal Cobb. Correction of PO, complications and reoperations were not different between the groups.

Introduction: The purpose of this study is to compare Luque-Galveston (LG) technique to all-pedicle screw (PS) constructs in the surgical care of scoliosis in GCFS IV non-ambulatory spastic quadriplegic cerebral palsy patients.

Methods: A matched cohort study was performed between two tertiary-care pediatric centers; one utilizing LG technique and the other PS constructs. Minimum follow-up was 2 years postoperative (PS 2.5y, LG 4.6y, NS). 14 patients were matched from each center based on age (PS mean age 15.4y, LG 15.5 y), preoperative pelvic obliquity (PS mean 33.8o, LG 29.1o) and major coronal Cobb (PS mean 100.9o, LG 100.1o).

Results: There was posterior only surgery in 14/14 PS and 11/14 LG surgeries. Overall there were 20 females and 8 males (PS 9 female, 5 male; LG 11 female, 3 male). Mean blood loss was 1003 cc in the PS group and 2750 in the LG group ($p=0.0016$). Final f/u Cobb was lower in the PS group (13.5o vs. 34.3o, $p<0.05$) with 86.5% correction in the PS group and 65.7% in the LG group. Postoperatively ICU days were similar (PS 3.6 days vs. LG 3.8 days, NS) but days in the hospital was greater in the LG group (PS 11.1 days vs. LG 14.9, $p=0.0475$). Final f/u pelvic obliquity was similar (PS 8.5o vs LG 3.3o, NS). There were no major complications in the PS group. In the LG group there was one deep infection and 1 reoperation for removal of a prominent sublaminar wire.

Conclusion: This is the first study to directly compare LG to PS constructs utilizing matched patient cohorts in this patient population. PS had better correction of coronal Cobb, lower blood loss and shorter hospital stays. There was no difference in the correction of PO, complications or reoperations.

Significance: Luque-Galveston and all-pedicle screw constructs are effective in treating scoliosis in non-ambulatory quadriplegic cerebral palsy patients with PS constructs having better coronal Cobb correction.

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).

Paper #108

The Importance of Sagittal Spino-Pelvic Alignment in Low-Grade Spondylolisthesis

Jean-Marc Mac-Thiong, MD, PhD; Pierre Roussouly, MD; Michael T. Hresko, MD; Hubert Labelle, MD

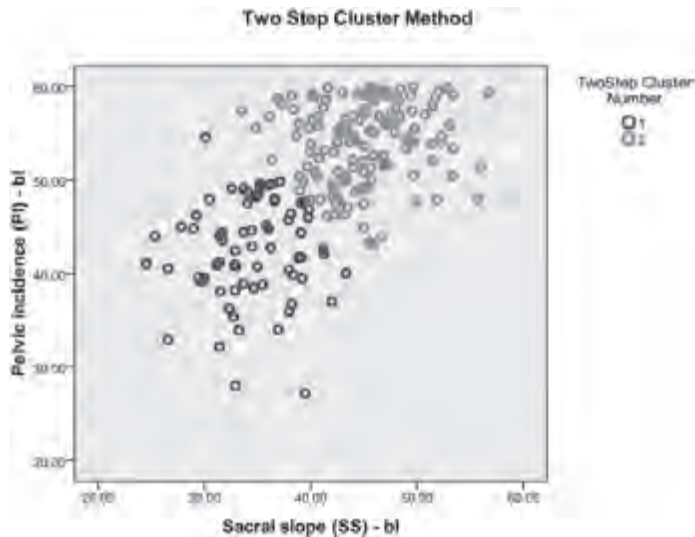
Canada

Summary: This study on 210 patients with low-grade spondylolisthesis found that there are two distinct subtypes with respect to pelvic incidence (PI) and sacral slope (SS). There is a specific subtype with low PI and SS (nutcracker subtype), and another with near normal PI and SS, which are associated with distinct pelvic, lumbosacral and lumbar alignment. Clinically, these subtypes are similar with respect to clinical evaluation and health-related quality of life (HRQOL), although hamstring tightness may be more prevalent in the nutcracker subtype.

Introduction: Previous studies suggest that there may be specific subtypes of patients in low-grade spondylolisthesis. This study determines if there are specific subtypes in low-grade spondylolisthesis with respect to sagittal spino-pelvic alignment, clinical evaluation and HRQOL.

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Methods: A cohort of 210 unoperated patients seen with low-grade lumbosacral spondylolisthesis aged between 10 and 20 years with a PI smaller than 60° were reviewed. An unsupervised TwoStep clustering method was used to identify natural groupings (clusters) based on parameters of spino-pelvic alignment evaluating the pelvis, lumbosacral spine, thoracic spine, and global balance. All parameters of spino-pelvic alignment, as well as age, clinical evaluation and HRQOL (SF12 and SRS) were compared between the clusters using Fisher's exact and Student t tests for continuous variables, and Pearson Chi-square tests for proportions.

Results: Two clusters with characteristic PI and SS were found (Figure). Mean PI and SS were respectively 42.5±5.4° and 34.6±4.1° for cluster 1, and 54.0±4.2° and 45.0±4.5° for cluster 2. Age, clinical evaluation and HRQOL were similar, except that there were more patients with hamstring tightness in cluster 1. Comparisons of spino-pelvic alignment showed significant differences in PI, SS, lumbar

lordosis, lumbar tilt and length of lordosis. On the opposite, parameters describing the thoracic spine and global balance were similar.

Conclusion: This study confirms that there are two distinct subtypes of patients with low-grade spondylolisthesis with respect to PI and SS. There is a specific subtype with low PI and SS (nutcracker subtype), and another with near normal PI and SS, which are associated with distinct pelvic, lumbosacral and lumbar alignment. Clinically, these subtypes are similar with respect to clinical evaluation and HRQOL, although hamstring tightness may be more prevalent in the nutcracker subtype.

Significance: It is important to differentiate between these two subtypes because it may have an important influence on the the natural history and management of low-grade spondylolisthesis.

Paper #109

Relationship Between HRQL Measures and Spino-Pelvic Alignment in Adolescent Spondylolisthesis Compared to a Control Population

Hubert Labelle, MD; Pierre Roussouly, MD; Jean-Marc Mac-Thiong, MD, PhD; Stefan Parent, MD, PhD; Michael T. Hresko, MD Canada

Summary: A cohort of 397 adolescents with L5-S1 spondylolisthesis was compared to an aged-matched control population. HRQL was measured with the SRS-22 questionnaire and correlated to spino-pelvic alignment measured on standing radiographs and divided into types according to the SDSG classification. Except for Mental Health, all SRS-22 domains are clearly abnormal in spondylolisthesis and there are significant differences according to various types of spino-pelvic alignment, thus supporting the value of a classification based on spino-pelvic alignment.

Introduction: Spondylolisthesis is a prevalent disease, but its effect on health-related quality of life (HRQL) is poorly documented. Our goal was to understand how the disease interferes with an adolescent's day-to-day life and document its relationship with spino-pelvic alignment.

Methods: A prospective, multi-center study of 397 consecutive adolescents with L5-S1 spondylolisthesis with a mean age of 14±3 y.o. was compared to an age and BMI-matched control population of 63 normal adolescents. HRQL was measured with the SRS-22 questionnaire at baseline evaluation, before any surgery. A dedicated software was used to measure grade (I to IV), pelvic incidence, sacral slope, pelvic tilt and C7-plumbline on lateral standing radiographs. Subjects were divided in 6 types of spino-pelvic alignment according to the SDSG classification. Statistical analysis was performed using Student tests and ANOVA with post hoc analyses (Games-Howell).

Results: There were significant differences overall between the 2 populations in all SRS domains, patients with spondylolisthesis scoring lower on all domains except Mental Health. There were also significant differences in scores among grades for spondylolisthesis, with the exception of Mental Health : total score was significantly higher in grade 1 vs 3, and in grade 2 vs 3 and 4. Pain was less severe in grade 2 vs 3 and 4, while appearance was better in grades 1 and 2 vs 3 and 4, and level of activity was higher in grade 2 vs 3 and 4. Finally, there were also significant differences in scores among the spondy types, with the exception of Mental Health : total score was significantly higher in types 1, 2 and 3 vs 4, and in type 1 vs 5. Pain was less severe

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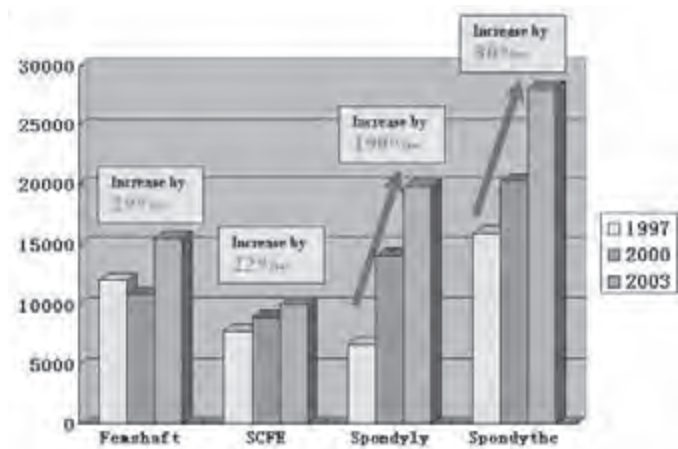
in types 1, 2, and 3 vs 5, while appearance was better in types 1, 2 and 3 vs 4, and in type 1 vs 5, and level of activity was higher in type 2 vs 4 and 5.

Conclusion: This study documents baseline HRQL values in a large cohort of adolescents with spondylolisthesis compared to a control population. Except for Mental Health, all SRS-22 domains are clearly abnormal in spondylolisthesis, with significant differences according to grade and types of spino-pelvic alignment, thus supporting the value of a classification based on spino-pelvic alignment.

Paper #110

Trends in Lumbar Spine Surgery Rates and Hospital Costs for Pediatric Patients with Spondylolysis and Spondylolisthesis

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United States



Summary: U.S. trends in lumbar spine surgery for pediatric SPONDY are analyzed.

Introduction: The average rate of lumbar fusion in the United States (U.S.) has increased 3 folds from 1992 to 2003 and the total spending for lumbar fusion has increased more than 500% during the same period. The purpose of this study was to examine if pediatric patients with spondylolysis/spondylolisthesis (SPONDY) have the same trends in lumbar spine surgery rates and hospital costs.

Methods: National survey Data from the Healthcare Cost and Utilization Kid's Inpatient Database (KID) were used in the study. Inflation adjusted average hospital costs, surgery rates and surgical procedures were assessed of trend and regional variations during a 10-year period using multiple regression models.

Results: A total of 1,616 spondylolisthesis and 369 spondylolysis cases were identified in KID database from 1997 to 2006. The surgery rates of treating spondylolysis increased from 0.7% in 1997 to 1.8% in 2006 and the average costs increased by 3.1 folds ($p < 0.001$). The surgery rates of treating spondylolisthesis did not increase significantly from 1997 to 2006, however, the average costs increased by 2.4 folds ($p < 0.001$). The costs of SPONDY in the west region were over 1.1 fold higher than other regions ($p < 0.05$). The rates of the use of posterior lumbar fusion in treating spondylolisthesis remained stable from 69% in 1997 to 70% in 2006; however, the rates of the use of posterior lumbar fusion in treating spondylolysis significantly increased from 21% in 1997 to 62% in 2006. Average costs for SPONDY had a significantly greater increase compared to other common pediatric orthopedic disorders.

Conclusion: The costs for SPONDY in pediatric patients had significant increases from 1997 to 2006. The costs in west region were highest compared to other regions of the U.S. The rates of posterior lumbar fusion increased significantly in treating spondylolysis.

Significance: This is the first study to describe trends in lumbar spine surgery rates and costs for pediatric patients with SPONDY. Further investigations on patient-level outcomes and additional cost-effectiveness analysis are warranted.

Paper #111

Correlation Between Lumbar Lordosis and Isthmic Spondylolisthesis in Young Patients. A Radiographic Study in 1667 Spine Patients

Schlenzka Dietrich, MD, PhD; Mauno Ylikoski, MD; Timo A. Yrjonen; Leena Ristolainen, MSc, PT; Jyrki Kettunen
Finland

Summary: The relationship between lumbar lordosis and isthmic spondylolisthesis was investigated from standing radiographs of 1667 young spine clinics outpatients, mean age 13.8 ± 1.9 (9-19)y. Of them, 151 (9.1%) had isthmic spondylolisthesis. Spondylolisthesis was significantly more common (13.9%) in patients with lumbar lordosis >40 drs, as compared to patients a lordosis ≤ 40 drs (4.6%) ($p = 0.001$).

A significant positive correlation between lumbar lordosis and isthmic spondylolisthesis could be proven. It is unclear whether this is a primary or secondary phenomenon.

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Introduction: Biomechanical investigations and clinical studies on limited numbers of adult patients have shown a relation between lumbar lordosis and isthmic spondylolisthesis.

Aim of the study was to investigate this relationship in a substantial number of children and adolescents.

Methods: Overall, 1734 children and adolescents referred because of suspected spinal pathology had standing p.a. and lateral x-rays of the whole spine. Seventy-seven patients with other diagnoses were excluded. Thus, 1667 form the basis of this investigation. There were 1422 females and 245 males, mean age 13.8 ± 1.9 (9-19)y.

All measurements were performed by one experienced radiologist using Cobb's method utilising the Rippstein pluriometer. Scoliotic curves, thoracic kyphosis, and lumbar lordosis were measured from all patients. Sacral inclination was measured only in the more recent 797 consecutive cases.

Results: The mean coronal Cobb angle was 27.4 ± 12.7 (0-83)drs, mean thoracic kyphosis 32.5 ± 12.5 (-11-85)drs, mean lumbar lordosis 40.7 ± 11.7 (-7-105)drs, mean sacral inclination 52 ± 8 (15-76)drs. Out of 1667 patients, 151 (9.1%) had isthmic spondylolisthesis. The mean degree of slip was 18.1 ± 17.7 (1-100)%. Spondylolisthesis was present in males in 11.8% and in females in (9.7%)(n.s.). There was no significant difference in the incidence of spondylolisthesis between age groups <13.8 years (n=783) versus >13.8 years (n=884).

Of the 798 patients with a lumbar lordosis >40drs, 13.9% had a spondylolisthesis, but only 4.6% of 869 patients with a lumbar lordosis ≤ 40 drs ($p=0.001$). Sacral inclination was significantly greater ($p=0.03$) in patients with spondylolisthesis.

In this patient group, the incidence of isthmic spondylolisthesis was about double in comparison to values given in the literature for the normal population. This can be explained by the fact that this was a selected group of patients with spinal pathology.

Conclusion: In conclusion, a significant positive correlation between degree of lumbar lordosis and presence of isthmic spondylolisthesis could be shown. It remains, however, unclear whether this is a primary or secondary phenomenon.

Significance: The result adds to our knowledge on the aetiology of isthmic spondylolisthesis and indicates the need of further research

Paper #112

Introducing a New Health Related Quality of Life Outcome Tool for Metastatic Disease of the Spine. Content Validation using the International Classification of Functioning, Disability and Health

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Canada*

Summary: Literature on metastatic tumors of the spine and clinical outcomes is limited and generally of poor quality. We present and validate a new questionnaire that has superior content capacity to measure disease burden of patients with metastatic disease of the spine than any instruments previously identified in the literature

Introduction: Literature on metastatic tumors of the spine and clinical outcomes is limited and generally of poor quality. The SOSG has developed a 'quality of life' outcome tool specific for patients with metastatic of the spine. The ICF is a universal framework allowing content exploration, comparison and validation of all questionnaires relating to HRQOL.

Methods: A systematic review of Health Related Quality of Life Outcomes (HRQOL) in metastatic disease of the spine and content validation of a new Spine Oncology Study Group Outcomes Questionnaire (SOSGOQ). A systematic review identified 141 studies. Reported outcome tools were enumerated. The most commonly utilized (ESAS, Karnofsky Scale and ODI) and the SOSGOQ were linked to the ICF. Descriptive statistics examined the frequency and specificity of the ICF linkage. Linkage reliability was evaluated by inter-investigator percentage agreement.

Results: The SOSGOQ contains 56 concepts, with all 4 domains of the ICF represented. 4 concepts could not be linked. There was 100% inter-observer agreement (IOA) for total number of concepts and for those 'not covered'. 100% of concepts had 'First and Second' level linkage. 100% IOA exists at both 'Component' and "First Level" linkage. There was 96.1% IOA at 'Second' Level. 33 concepts linked to Third Level with 96.9% IOA. 10 concepts linked at the Fourth Level with 100% IOA.

Conclusion: The SOSGOQ includes all domains relevant for measurement of function and disability and it's content validity is confirmed by linkage with the ICF. This new questionnaire has superior content capacity to measure disease burden of patients with metastatic disease of the spine than any instruments previously identified in the literature

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

Paper #113

The Effect of Surgery on Health Related Quality of Life and Functional Outcome in Patients with Metastatic Epidural Spinal Cord Compression-Initial Results of the AOSpine North America Prospective Multicenter Study

Michael G. Fehlings, MD, PhD; Branko Kopjar; Alexander R. Vaccaro, MD, PhD; Paul Arnold; Charles G. Fisher, MD, MHSc; Ziya L. Gokaslan, MD; James Schuster; Mark B. Dekutoski, MD
United States

Summary: Prospective multi-center controlled, cohort study involving sites in North America with independent evaluation of outcomes.

Introduction: Metastatic epidural spinal cord compression (MESCC) is common and recent studies have provided evidence that in selected patients combined surgery and radiotherapy (XRT) provides the optimal neurological recovery. However, patients with MESCC have relatively short life-expectancy and face numerous challenges. Hence, the impact of surgery on improving quality of life outcomes in the setting of MESCC is less clear.

Methods: We compared changes in outcomes at 3 months in surviving patients using t-test for paired observations.

Results: The study included 34% females with an average age of 59 yrs (SD 12). Sites of the primary lungs (33%), prostate (20%), breast (11%), and kidney (11%). Twenty subjects (36%) died prior to reaching 3 mon follow-up. In surviving subjects, VAS pain levels improved by 3 points, from 6.0 (SD 2.0) to 2.9 (SD 2.4). No stat. sig. changes in ASIA grades. The EQ-5D improved for .19 from .50 (SD .29) at the baseline to .69 (SD .27) at 3 months ($P < .01$). SF36-v2 PCS and MCS scores did not improve with treatment. However, ODI improved by 26 points, from 53.60 (21.88) at baseline to 27.46 (SD 19.17) at 3 months ($P < .01$)

Conclusion: The initial results from this prospective clinical study show that surgically treated patients with MESCC have poor survival. The patients who survive three months have less pain, improved spine-specific functional outcomes and significant gains in health utility scores. However, this does not translate into significant gains in overall health related quality of life. This could be due to overall poor health status of patients. Individuals with less than three month survival may be less than ideal candidates for surgical intervention. Further follow-up and a larger sample size in this ongoing study will help determine whether the short-term gains in health utilities are sustained and to identify subgroups of patients who may benefit from the surgical intervention. There is also a need to develop outcome measures more suitable to assess the effects of surgical treatment in patients with metastatic spinal disease.

Significance: To assess quality of life outcomes in patients receiving surgical treatment for metastatic epidural spinal cord compression (MESCC)

Paper #114

Clinical and Radiographic Examinations of Vertebral Arch Reconstruction Based on 90 Degree Rotational Laminoplasty After Removal of Spinal Cord and Cauda Equina Tumors

Takashi Asazuma, MD; Yoshiyuki Yato; Hideaki Imabayashi, MD; Yohei Iguchi; Koichi Nemoto, MD
Japan

Summary: Ninety degree rotational laminoplasty was developed as a technique for vertebral arch reconstruction following resection of spinal cord and cauda equina tumors. The clinical and radiographic results were reported. Rotational laminoplasty affords a satisfactory operative exposure for the resection of large, complex lesions. It creates a widely patent, stable spinal canal easily.

Introduction: A variety of procedures for reconstructing the spine following the removal of spinal cord and cauda equina tumors have been developed to prevent postoperative spinal deformities and nerve entrapment. The purpose of this study is to introduce a new reconstructive procedure based on 90 degree rotational laminoplasty and to report clinical and radiological results.

Methods: Data on 15 patients (4 men and 11 women) who underwent rotational laminoplasty were reviewed. The patients' age at the time of operation ranged from 29 to 68 years (mean age: 54.3 years). Postoperative follow-up period was 2 years to 9 years and 4 months (average: 4 years 3 months). The level of invasion was from 10th thoracic vertebra to fifth lumbar vertebra. The number of invaded laminae ranged from 1 to 6 (average: 2.6 laminae). The final pathologic diagnosis was neurinoma in thirteen cases, and meningioma and neurofibroma in one case each. Clinical outcome was assessed using the Japanese Orthopaedic Association (JOA) score and its recovery rate. Changes in the average intervertebral range of motion, including adjacent vertebrae, and the change in lordosis in cases of lumbar spine invasion were noted. Computed tomography (CT) was used to determine whether there was complete bony union or not between rotated laminae and the facet joint, and whether the reconstructed laminae had retained their integrity and preserved the size of the spinal canal.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

Podium Presentation Abstracts

Results: The tumor was removed totally in all cases. The JOA score improved from 16.7 to 100% (average: 77.8%). The change in the postoperative intervertebral range of motion was a 5.0-degree decrease to a 10.0-degree increase (average: 1.0 degree increase). The change in lordosis varied from a 13-degree decrease to a 11 degree increase (average: 3.8 degree decrease). Bony union was confirmed in situ in 13 cases. And the rotated laminae remained in situ in all fifteen cases.

Conclusion: Rotational laminoplasty affords a satisfactory operative exposure for the resection of large, complex lesions. It creates a widely patent, stable spinal canal easily.

Significance: Rotational laminoplasty was developed as a vertebral arch reconstruction procedure to facilitate resection spinal cord and cauda equina tumours.

Paper #115

Combined En Bloc Chest Wall Resection and Vertebrectomy of Primary Malignant Spine Tumors

Claudia Druschel; Alexander C. Disch; Ingo Melcher; Norbert Haas; Klaus-Dieter Schaser

Germany

Summary: Description of oncological and surgical results of combined en bloc vertebral and chest wall resection for spinal sarcoma involving the thoracic wall.

Introduction: Description of oncological and surgical results of combined en bloc vertebral and chest wall resection for spinal sarcoma involving the thoracic wall.

Methods: From 06/2007 to 12/2009 16 patients (female/male:7/9; range of age: 27-83yrs) underwent a combined en bloc resection of chest wall and vertebrectomy for solitary primary spinal sarcoma and metastatic lesions. The median follow-up was 21,4(3-84) months. Histological analysis revealed 3 metastases, 2 lyomyosarcomas, 6 osteosarcomas, 4 chondrosarcomas and 1 neurofibrosarcoma. All patients underwent a chestwall resection en bloc with multilevel (2/3/4 segments: n=4/3/2) hemi (n=9) or total vertebrectomy (n=7) with subsequent defect reconstruction. Reconstruction of the spinal defect following total resections was accomplished by combined dorsal stabilization and carbon cage interposition. In two patients an additional angular stable plate was fixed for anterolateral support. The chest wall defects were closed with a goretex®-patch. One patient also received a musculocutaneous latissimus dorsi flap .

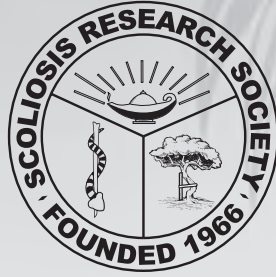
Results: The surgical margins were R0 in 15 (wide in 12, marginal in 3) and R1 in 1 patient(s). Marginal/ R1 resections were due to extracompartmental sarcoma invasion (spinal canal) and dural involvement. In these patients postoperative radiotherapy was performed. Surgical complications requiring revision occurred in 1 patient due to injury of the ductus thoracicus and persisting chylothorax. Temporary subileus or mild pneumonia appeared in 3 patients. No superficial/deep infection or neurological deficits (except those related to oncologically required dissection of thoracic nerve roots) were observed. At follow up 3 patients died due to the disease after 10,5 months. Local recurrences were seen in 3 patients at median 21,4 months (3-84). Pulmonary metastases necessitating polychemotherapy were seen in 3 patients after median 15 months.

Conclusion: Despite the only midterm follow up, the combined en bloc resection of chest wall and multilevel en bloc spondylectomy /hemivertebrectomy is a challenging but safe and effective technique in order to achieve adequate margins and local control in selected with spinal sarcomas extending to the dorsolateral chest wall.

* Russell A. Hibbs Award Nominee for Best Clinical Presentation † Russell A. Hibbs Award Nominee for Best Basic Science Presentation

The background features a traditional Japanese ink wash style illustration. It depicts bamboo stalks with long, slender leaves and clusters of cherry blossoms on thin branches. The composition is layered, with some elements appearing as faint outlines and others as more solid white shapes. A vertical dark grey band runs down the right side of the page, containing a more prominent white illustration of bamboo leaves and stems.

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E-Poster #201

Beyond the Learning Curve: Does the Accuracy of Pedicle Screw Placement Improve with Experience in AIS Patients: A CT-Based Analysis of 1356 Pedicle Screws

Etan P. Sugarman, MSIV; Vishal Sarwahi, MD; Adam L. Wollowick, MD; Melanie Gambassi, NP; Terry Amaral, MD
United States

Summary: Accuracy of pedicle screw (PS) placement over time was analyzed in 67 AIS patients. There was a plateau effect that was noticed with PS placement initially. However, with increasing surgeon's confidence a decrease in accuracy was seen.

Introduction: PS placement in Adolescent Idiopathic Scoliosis (AIS) is challenging. Few studies have described the learning curve, which vary from 80-120 PS. The objective of this study was to document improvement in PS placement after a surgeon has already placed over 400 screws.

Methods: 104 patients with AIS were evaluated for screw placement between 2005-2009. 67 patients with postop CT-scans were included. Criteria by Kim et al. was utilized. Mislplaced screws were divided into anterior, medial and lateral. Charts and X-rays were reviewed to calculate Cobb angle, kyphosis, levels fused, estimated blood loss (EBL), operative time, and complications. Preoperative CT-scans were reviewed for evaluation of pedicle morphology. Linear regression analysis was performed to calculate improvement in PS placement over time.

Results: A total of 1356 PS were placed in 67 patients. 1203 were properly placed. 153 were malpositioned. There were 47 PS found to be anterior, 15 medial, and 91 lateral. There was improvement in the incidence of lateral PS ($p < 0.001$), while the incidence of medial PS was unchanged ($p = 0.374$). The incidence of anterior breach increased over time ($p < 0.001$). The EBL per fixation point decreased with time ($p = 0.013$), as did the avg. time for PS insertion ($p < 0.001$). The avg. number of PS placed per fusion did not increase over time ($p = 0.194$). There were no vascular or neurological complications. No PS required revision. We found no correlation between increasing kyphosis and malposition rate ($p = 0.46$). Overall, the PS malposition rate was 11.3%.

Conclusion: While improvements continue in the surgical time, PS insertion time, and the EBL per fixation point, the PS accuracy, even after considerable experience, does not improve significantly.

Significance: After the initial learning curve, a plateau effect seems to appear. However, with increasing surgeon confidence, and placement of larger and longer screws (6-0x40mm) in the upper thoracic spine, an increase in anterior violations were seen. While operative time, PS insertion time, and blood loss continues to improve, additional strategies need to be identified to improve accuracy of PS placement. Availability of portable, intraoperative CT-scanner (O-arm) may be a step in this direction.

E-Poster #202 - WITHDRAWN

E-Poster #203

Common Mathematical Formulas Fail to Predict Postoperative Sagittal Alignment: Confirmation of a Need for More Advanced Equations

Justin S. Smith, MD, PhD; Shay Bess, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Richard Hostin, MD;
International Spine Study Group
United States

Equation	Correct prediction (%)	Correct prediction of poor SVA (%)	Correct prediction of good SVA (%)	Spearman	Mean error SVA prediction
(1) $LL \geq TK + 20$	63	87	51	0.37	NA
(2) $PSO \text{ angle} = \text{atan}(y/z)$	72	98	59	0.54	111mm
(3) $LL + PI + TK \leq 45$	74	28	97	0.37	NA
(4) $LL \geq PI - 10^\circ$	78	79	78	0.55	NA
(5) $SVA = -52.87 + 5.90*PI - 5.13*LL_{\text{max}} - 4.45*PT - 2.09*TK_{\text{max}} + 5.13*age$	89*	70	98	0.75	30mm

LL=lumbar lordosis, TK=thoracic kyphosis, PI=pelvic incidence, LL_{max}=max lumbar lordosis, TK_{max}=max thoracic kyphosis, *P<0.05

Summary: Preoperative planning is essential to optimize postoperative spinal alignment. The accuracy of 5 mathematical models to predict postoperative spinal alignment following pedicle subtraction osteotomy was assessed. Mathematical models that did not account for compensatory changes in the spine and pelvis poorly predicted optimal postoperative alignment and may predispose to poor clinical outcome.

Introduction: Failure to achieve optimal sagittal alignment after spinal fusion correlates strongly with poor clinical outcomes. Mathematical models have been proposed to predict optimal postoperative sagittal vertical axis (SVA) following pedicle subtraction osteotomy (PSO). Most formulas fail to evaluate pelvic tilt and the compensatory interplay between the spine and

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pelvis in response to regional alignment changes. Purpose: comparative evaluation of mathematical formulas in predicting good/bad postoperative spino-pelvic alignment following PSO surgery.

Methods: Multicenter, radiographic evaluation of a large consecutive series of PSO procedures. The ability of 5 mathematical models to predict postoperative SVA category (poor / good, cutoff=5cm) following PSO was evaluated by comparing predicted categories to post-operative radiographic measurements.

Results: 147 patients, mean age 52 yrs (SD, 15 yrs) received 147 PSO (42 thoracic, 105 lumbar). Mean number of levels fused was 12.6 (SD, 3.8 levels). Mean pre and postoperative SVA were 108 mm (SD 95 mm) and 30 mm (SD 60 mm; $p < 0.001$). 47 patients had postoperative SVA > 5cm. Each mathematical formula provided unique prediction for postoperative spinal alignment (Pearson R-square < 0.15). Formulas that neglected pelvic parameters (1,2) poorly predicted final SVA and poorly correlated with post-operative SVA (Table). The formulas that included pelvic incidence (3,4) had improved SVA prediction. Formula 5 incorporated pelvic incidence, pelvic tilt and regional parameters had substantially improved SVA prediction ($p < 0.05$) and correlation with optimal SVA ($R = 0.75$).

Conclusion: Preoperative planning is essential to optimize postoperative spinal alignment. Mathematical models that do not account for pelvic geometry and orientation poorly predict postoperative alignment and may predispose to poor clinical outcome. Formula 5 incorporated spinopelvic parameters and adjusted for the interplay between spine and pelvis based upon regional alignment changes leading to optimal prediction of post-operative SVA.

E-Poster #204

Respiratory Function in AIS Patients Undergoing Surgery: - Is There A Correlation With Percentage Correction? (Minimum 10 Year Follow-Up)

*Bruce F. Hodgson, FRACS; James T. Bourne, MBChB, MRCS Ed; Virginia M. Martin, RN PG Dip Nurs
New Zealand*

Summary: Percent correction (surgical) of AIS does not correlate with long term respiratory function. There is an improvement in FEV1 and FVC at 10 years despite chest wall violation

Introduction: AIS surgery is undertaken for cosmesis, progression and preventing delayed cardio respiratory complications. A surgical correction of greater than 60 percent Cobb angle deformity is generally thought to be a satisfactory outcome. It is not known if the extent of correction has an influence upon respiratory function in the long term.

We present our 10 year respiratory function follow up data for patients with AIS who underwent surgery with analysis based upon percentage correction obtained.

Methods: Respiratory function data obtained prospectively was reviewed retrospectively for 22 of 26 patients with AIS. FEV1 and FVC pre-operative values were compared with minimum 10 year post-operative values.

Patients were analysed by percentage correction of the original deformity $\leq 60\%$ (Group 1) or $> 60\%$ (Group 2) and by chest wall violation (Group A) or not (Group B). In our unit we undertake a rib release not a formal thoracoplasty.

Cobb angles were measured from plain radiographs (pre and post operative) by an independent observer (JTB).

Results: In percentage correction (Group 1 and 2) 9 of 22 patients had a clinically significant improvement ($> 12\%$) in FEV1 at 10 years. None of the 22 had a clinically worsened FEV1.

11 of 22 patients had a clinically significant improvement in FVC and only 1 had clinically significant worsening.

Conclusion: Only 1 of 22 patients (posterior fusion) had a clinically significant decrease in 1 of the 2 respiratory function parameters at 10 years.

There appears to be no correlation between percentage of scoliosis correction obtained and FEV1. There is an improvement in FEV1 and FVC at 10 years in those patients despite chest wall violation. Long term respiratory function is not clinically significantly worsened by our current operative techniques.

E-Poster #205

Three-Dimensional Spine Parameters can Differentiate Between Evolutive and Non-Evolutive Patients with AIS at the Initial Visit

*Marie-Lyne Nault, MD, MSc; Stefan Parent, MD, PhD; Marjolaine Roy-Beaudry, MSc; Jacques de Guise, PhD; Jean-Marc Mac-Thiong, MD, PhD; Hubert Labelle, MD
Canada*

Summary: Prediction of curve progression remains challenging in adolescent idiopathic scoliosis (AIS) at the first visit. The objective of this study was to compare 3D morphologic parameters of the spine at the first visit between a non evolutive (NE) and in an evolutive (E) group of immature AIS. Differences were found for 5 parameters: Mean 3D apical disks wedging, lower

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junctional vertebrae axial rotation, torsion, T6 slenderness, T1-L5 slenderness.

Introduction: Prediction of curve progression remains challenging in adolescent idiopathic scoliosis (AIS) at the first visit. The objective of this study was to compare 3D morphologic parameters of the spine at the first visit between a non evolutive (NE) and in an evolutive (E) group of immature AIS.

Methods: A retrospective case-control study was done with all patients presenting the following inclusion criteria at their initial visit: (1) Risser sign 0 or 1 (2) Cobb angle between 11 and 40 degrees (3) anteroposterior (AP) and lateral radiograph available. Exclusion criteria were (1) limb length discrepancy (2) syndromic, neuromuscular or congenital scoliosis. The first group was made of surgically corrected AIS (E) (n=19) and the second group was composed of NE patients that reached skeletal maturity (n=18). Computerized measurements were done on reconstructed 3D spines. There were 5 categories of measurements: Cobb angles (kyphosis, lordosis), 3D wedging (apical vertebra, mean 2 apical disks), rotation (upper and lower junctional vertebra, apical vertebra and disk), torsion and slenderness (height/width ratio of T6, L4, and T1-L5). Non parametric Mann-Whitney test were done.

Results: There was no statistical difference between the two groups for age, 3D Cobb angle, lordosis and kyphosis.

Differences were found for 5 parameters presented in the table.

Conclusion: This study confirms for the first time the theory of Perdriolle stating that wedging begins in the disks and then in the vertebral body and identifies 3D morphologic parameters that could be used in the prediction of AIS evolution.

Significance: With the rapid evolution of reconstruction software, 3D parameters will become more readily available and could help determine which patients are at higher risk of progression. Those results have to be confirm with a prospective study and could represent strong basis for the development of a progression prediction model.

E-Poster #206

Sagittal Plane Alignment after Posterior Fusion in Adolescent Idiopathic Scoliosis at a Minimum 5 Years Follow-Up: Pedicle Screws Only vs. Thoracic Hooks in Hybrid Constructs

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Italy

Summary: Controversy exists regarding loss of thoracic kyphosis seen after thoracic pedicle screws construct for posterior fusion in AIS. We revised 88 consecutive AIS patients with a Lenke type 1 curve treated by posterior instrumentation. At a minimum 5 years follow-up, sagittal contour in the thoracic spine was not found less kyphotic when pedicle screws only instrumentation were compared to thoracic hooks in hybrid constructs ($r=0.002$; $p>0.05$).

Introduction: Controversy exists regarding loss of thoracic kyphosis seen after thoracic pedicle screws construct for posterior fusion in AIS. Aim of our study was to determine whether thoracic pedicle screws have advantages with concern to sagittal plane alignment when compared to thoracic hooks in hybrid instrumentations in the treatment of thoracic adolescent idiopathic scoliosis (AIS).

Methods: Eighty-eight consecutive AIS patients with a Lenke type 1 curve treated by posterior instrumentation between 1998 and 2003 were analyzed. In 45 patients (Group Hy) thoracic hooks (in hybrid constructs) and in 43 patients (Group TPS) thoracic screws only were used. Preoperative average age (Hy 15.3 ys vs TPS 16 ys), gender (Hy 38 f/7m vs TPS 37 f/6m), Risser sign (Hy 2.9 vs 2.9 TPS), main thoracic curve (Hy 64° vs TPS 65.5°) and thoracic kyphosis (Hy 22.6° vs TPS 21.4°) were similar in both groups. Pearson correlation coefficient and univariate analysis of variance were used.

Results: At a mean follow-up of 7.3 years (5-10), the TPS group achieved a greater final main thoracic curve correction (Hy 46.4% vs TPS 58.4%; $p<0.001$), with inferior loss of initial correction (Hy -11.1° vs TPS -1.3° ; $p<0.0005$). Absolute final thoracic kyphosis resulted similar (Hy 31.4° vs TPS 25.4° ; $r=0.002$; $p>0.05$), with both groups showing an equally statistical significant amelioration of the sagittal contour [(Hy 49.2%; $p<0.001$) vs (TPS 43.4%; $p<0.001$)] ($p>0.05$). A significant correlation between absolute kyphosis correction (final-preop) and % main thoracic curve initial correction loss was observed in the Hy Group ($r=0.35$, $p<0.001$). The SRS-30 assessment showed an improvement in self-image and satisfaction, without significant differences between groups.

Conclusion: According to the present series results, at a minimum 5 years follow-up, sagittal contour in the thoracic spine was not found less kyphotic when pedicle screws only instrumentation were compared to thoracic hooks in hybrid constructs ($r=0.002$; $p>0.05$). The higher was the loss of initial correction of main thoracic curve, seen in the Hybrid Group, the greater was the postoperative absolute kyphosis at T5-T12 level ($r=0.35$, $p<0.001$).

Significance: Level 3

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E-Poster #207

Effect of Multi Rib Osteotomy on Pulmonary Functions after Correction of Adolescent Scoliosis

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Egypt

Summary: Rib osteotomy technique is used for giving more flexibility of the spine during correction. However, it leads to chest cage disruption and affection of pulmonary functions

Introduction: Rib osteotomy technique is used for giving more flexibility of the spine during correction especially in severe and rigid curves. However, rib osteotomy leads to a type of chest cage disruption and affection of pulmonary functions

Methods: A prospective study of 50 patients who underwent posterior spinal fusion for correction of adolescent scoliosis. Patients were divided according to number of ribs osteotomy into two groups. Group 1 (n=16) who underwent posterior fusion in addition to rib osteotomy from 1-3 ribs, while group 2 (n=34) who had rib osteotomy from 4-6 ribs. All patients were evaluated regarding pulmonary functions and Cobb's angle preoperatively, post operatively, one year and two years post operatively. All patients received pulmonary rehabilitation program from one week postoperative till one year post operative

Results: Curve correction: The mean Cobb's angle at the preoperative and final follow up for group 1 was 72.9 ± 22.9 degree and 11.2 ± 3.9 degree respectively (85% correction). In group 2 it was 75.7 ± 21.7 degree preoperatively and 18.3 ± 10.9 degrees at final follow up (76% correction). Pulmonary functions: Pre operatively there was no significant difference between 2 groups. Immediately postoperative there was significant reduction regarding FVC by about 39% in group 1 and 69% in group 2. Another significant reduction was observed in MVV by about 60% in both groups. One year post operative FVC showed significant improvement in group 1 by 57% while in group 2 it was 28%. MVV showed another significant improvement by about 72% and 54% in group 1 and 2 respectively. Two years post operative showed no mean improvement in both groups which not exceeded 6% improvement

Conclusion: Multi rib osteotomy more than 3 ribs has a negative effect on pulmonary function extended till one year postoperative even with application of pulmonary rehabilitation program. However, rib osteotomy from 1-3 ribs has a negative effect just immediately postoperatively which converted at 1 and 2 years post operative

Significance: Rib osteotomy technique has a positive significant effect on curve correction however it has severe negative effect on pulmonary functions especially with osteotomy for more than 3 ribs. Pulmonary rehabilitation program has positive significant effect on improving pulmonary functions

E-Poster #208

Disease Severity and Treatment in Adolescent Idiopathic Scoliosis: The Impact of Race and Socioeconomic Status

Neil Bharucha; Per D. Trobisch, MD; Kristin E. Kean, BA; Sandra Richard, MA; Yolanda Bucello, BA; Baron S. Lonner, MD

United States

Summary: Race and socioeconomic status have been shown to affect disease severity and access to care in the recent orthopaedic literature. We analyzed how these parameters affected disease severity and initial treatment in patients with adolescent idiopathic scoliosis. Major curve magnitude and percentage of patients with curves in the surgical range were greater in black patients than white patients.

Introduction: Although studies have been conducted on the prevalence of AIS by race, no studies have described disease severity at presentation. This study aimed to assess the association between race and socioeconomic status (SES) with disease severity at presentation in AIS patients.

Methods: A retrospective chart review of 403 AIS patients in a single practitioner's office between 2004-2009 was performed. Race, age, family income, major curve magnitude, and prescribed initial treatment (observation, brace, or surgery) were assessed. Independent sample t-tests were used to detect group differences in curve magnitude. Pearson Chi2 analysis was used to detect group differences for curves in the surgical range ($>40^\circ$) and the initial treatment.

Results: Racial identification was: Asian (n=37), Black (n=86), Hispanic (n=44), White (n=219), and Other (n=17). Mean major curve magnitude was greater in black (33°) than in white patients (28° , $p < 0.05$). Black patients were more likely to present with curves in the surgical range (34% v 24%, $p < 0.05$) and were more likely to have surgery as their initial treatment than white patients (34% vs. 19%) ($p < 0.05$). There was no difference in age of presentation. None of the parameters were impacted by SES.

Conclusion: Major curve magnitude and percentage of patients with curves in the surgical range were greater in black than white patients. SES had no impact on disease severity in a single surgeon's practice. Further study of these issues across multiple clinics may be instructive in this era of healthcare reform.

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E-Poster #209

Segmental Correction of Adolescent Idiopathic Scoliosis by All-Screw Fixation Method in Adolescents and Young Adults Minimum 5 Years Follow-Up with SF-36 Questionnaire

Ching-Hsiao Yu, MD; Po-Quang Chen, MD, PhD

Taiwan

Summary: Forty-nine AIS patients, treated with posterior fusion using all-screw method showed a satisfactory radiographic and clinical results without major complications with more than 5-year-followup. Functional outcome assessed by the SF-36 questionnaire showed some physical limitation compared to normal populations. The author suggest all-screw method is a effective and safe method. Besides, the study also revealed a similar deformity correction results between adolescents and young adults.

Introduction: In last decade, pedicle screws have become the mainstream of the fixation method for spinal deformity correction. All-screw method has also been proved to be a effective and safe procedure in recent years.

Methods: Forty-nine consecutive patients were included with minimum of 5- year follow-up (mean, 6.1; range, 5.1-7.3 years). The average age of surgery was 18.5 ± 5.0 years. We assessed radiographic measurements at preoperative (Preop), postoperative (PO) and final follow-up (FFU) period. Curve correction rate, correction loss rate, complications, accuracy of pedicle screws and SF-36 scores were analyzed. Two age groups was divided depending on age of surgery and their results were also compared: the adolescent (AIS) group (≤ 20 years, $n=34$) and the young adult (ADIS) group (> 20 years, $n=15$)

Results: The average major curve was corrected from $58.0 \pm 13.0^\circ$ Preop to $16.0 \pm 9.0^\circ$ PO, and increased to $18.4 \pm 8.6^\circ$ ($p>0.05$) FFU. This revealed a 72.7% correction rate and a correction loss of 2.4° (3.92%). The thoracic kyphosis decreased little at FFU ($22 \pm 12^\circ$ to $20 \pm 6^\circ$, $p>0.05$). Apical vertebral rotation decreased from 2.1 ± 0.8 PreOP to 0.8 ± 0.8 at FFU (Nash-Moe grading, $p<0.01$). Among total 831 pedicle screws, 56 (6.7%) were found to be malpositioned. Compared with 2069 age-matched Taiwanese, SF-36 scores showed inferior result in 2 variables: physical function (81.94 versus 96.82) and role physical (61.29 versus 89.63). No fatal or neurological complications were noted except one postoperative hemothorax. The deformity correction was similar between AIS and ADIS group.

Conclusion: Follow-up more than 5 years, the authors suggest that all-screw method is an efficient and safe method. The results between adolescents and young adults was comparable.

E-Poster #210

Cross-Ethnicity Comparisons of the Scoliosis Research Society Outcomes Instrument in Adolescent Idiopathic Scoliosis

Lee J. Morse, MD; Noriaki Kawakami, MD; Lawrence G. Lenke, MD; Daniel J. Sucato, MD MS; James O. Sanders, MD; Mohammad Diab, MD
United States

Summary: We evaluate differences in the pre-operative Scoliosis Research Society Outcomes Instrument (SRS-30) between US Caucasian, Black, Hispanic, and Asian, as well as Japanese ethnicities in adolescent idiopathic scoliosis.

Introduction: The SRS-30 was developed using a US cohort of patients with adolescent idiopathic scoliosis. There are no comparative studies of SRS-30 outcomes between multiple US ethnicities, and between US and non-US cohorts.

Methods: Pre-operative SRS-30 outcomes data were collected from 2371 patients with adolescent idiopathic scoliosis from 5 different ethnic groups: US Caucasian (1534), Black (306), Hispanic (104), and Asian (218), as well as a Japanese cohort from Nogoya, Japan (209). Outcomes from the 5 domains of the SRS-30 were analyzed and compared between groups. Pair-wise comparisons in the SRS-30 domains were adjusted for multiple comparisons using Bonferroni correction.

Results: Statistically significant differences ($p < 0.05$) are reported. Japanese and US Asians had higher Pain scores (Japanese 4.47, US Asian 4.47, Hispanic 4.10, Black 4.19, Caucasian 4.05) but lower Appearance scores than other groups (Japanese 2.79, US Asian 2.98, Hispanic 3.13, Caucasian 3.30, Black 3.45). Japanese had the highest Activity scores, while US Asians had the lowest (Japanese 4.30, Caucasian 4.16, Black 4.04, Hispanic 3.98, US Asian 3.83). Japanese had the highest Mental scores, while Hispanics had the lowest (Japanese 4.17, Black 4.01, Caucasian 3.94, US Asian 3.87, Hispanic 3.77). Japanese and Blacks had the highest Total scores (Japanese 3.90, Black 3.90, US Asian 3.76, Hispanic 3.75, Caucasian 3.84).

Conclusion: Among several significant differences, Japanese patients had the highest Pain, Activity, Mental and Total scores but the lowest Appearance scores. US Asians resembled Japanese patients in having high Pain scores and low Appearance scores, but differed in having lower Activity scores.

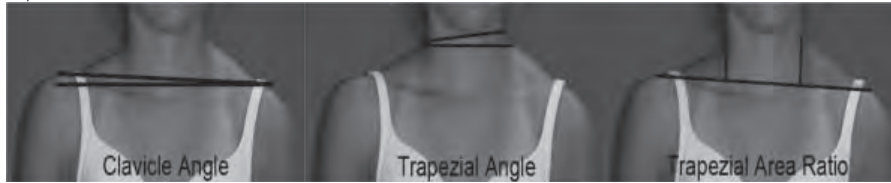
Significance: Ethnic and geographic variations in the SRS-30 must be taken into account when counseling patients about operative treatment for adolescent idiopathic scoliosis, and when interpreting outcome studies.

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E-Poster #211

Defining Two Components of Shoulder Imbalance: Clavicle Tilt and Trapezial Prominence

*Takashi Ono, MD; Tracey Bastrom, MA; Peter O. Newton, MD; Harms Study Group
Japan*



Measures of shoulder imbalance on clinical photos

hypothesize that there are 2 distinct features of shoulder asymmetry (Clavicle Tilt and Trapezial Prominence) that correspond to different underlying radiographic parameters.

Methods: A consecutive series of 113 pre-operative patients with right main thoracic Lenke 1 and 2 AIS curves were investigated to evaluate the correlations between clinical and radiographic findings of shoulder imbalance. The following parameters were defined and evaluated from pre-op clinical photographs: clavicle angle (tilt), trapezial angle, ratio of left to right trapezial area (Figure). These were compared to radiographic measures of T1 tilt, first rib angle, magnitudes of curves, and thoracic and lumbar apical translation to C7 plumb line and CSVL.

Results: The average age of patients was 14.1 yrs. There were 82 Lenke 1 and 31 Lenke 2 curves with an average thoracic Cobb of 52.1 degrees. The clinical clavicle angle ranged from -10.7 to +6.0 degrees (+ = high on left) and had the modest correlation with the proximal thoracic curve size, T1 tilt, coronal balance, and thoracic apical deviation (r value, 0.43, 0.42, 0.41 and 0.41, respectively). In contrast, medial shoulder trapezial prominence as measured clinically by both the trapezial angle (range: -12.7 to +6.6) and trapezial area ratio (natural log of ratio range; -1.15 to +0.80) correlated well with the radiographic measures of T1 tilt and the 1st rib angle (trap angle: 0.70 and 0.68; trap area ratio: 0.58 and 0.60, respectively).

Conclusion: Shoulder imbalance is often reported as differences in the "height" of the shoulders. Our analysis suggests there are 2 distinct regions (lateral and medial) of shoulder height asymmetry. Medial differences reflected in trapezial prominence relate principally to deformity created by upward tilted proximal ribs and thus T1 tilt. While, lateral differences in shoulder symmetry as reflected in the clavicle angle correlate only weakly with radiographic measures of spinal deformity. This suggests correction of trapezial prominence may be more predictable compared to clavicle angulation following scoliosis surgery.

Summary: While most studies describe shoulder asymmetry as difference in height of shoulders, these findings suggest there are 2 distinct regions (lateral and medial) of shoulder height asymmetry.

Introduction: Shoulder balance is often described as "level" shoulders. We

Measures of shoulder imbalance on clinical photos

E-Poster #212

Posterior Spinal Fusion from T2 to the Sacrum for the Management of Major Deformities in Patients with Parkinson's Disease. A Retrospective Review with Analysis of Complications

*Anouar Bourghli, MD; Ibrahim Obeid; Nicolas Aurouer, MD; Olivier Gille; Vincent Pointillart, MD, PhD; Jean M. Vital
France*

Summary: T2-sacrum fusion is an option for the management of major deformities in patients with Parkinson's disease. Despite several complications, clinical and radiological results were acceptable with improvement of sagittal and coronal alignment after surgery. These results were maintained even in patients who required revision surgery

Introduction: Spine deformity surgery in Parkinson disease is challenging and complicated. The aim of the study is to evaluate the efficiency of the long posterior construct and the incidence and types of perioperative complications, and also to assess patient satisfaction following surgery

Methods: A retrospective review was performed on 12 consecutive Parkinson's disease patients undergoing a posterior spinal fusion from T2 to the sacrum for major deformities in a 2 year span at a single institution. 6 were first surgeries and 6 revision surgeries. The aim of the surgery was to correct the coronal and sagittal imbalance, pedicle subtraction osteotomy was used in 6 cases. All patients had a circumferential fusion at L5S1 using TLIF. Pre-operative, 3 months post-operative and latest follow-up full spine EOS low dose radiographs were evaluated by an independent spine surgeon, complications were analyzed. Assessment of the functional outcome was made using the SRS-30 questionnaire

Results: The mean age at index procedure was 68 years. The mean duration of Parkinson disease was 10 years. Mean follow up was 32.8 months. Sagittal and coronal alignments were improved after surgery with statistical significance, the SVA improved from

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15.2 cm to 0.5 cm at the latest follow-up. 5 patients were revised 1 time, 3 for instrumentation failure, 1 for an adjacent level instability at T1T2 and 1 for an epidural hematoma. 1 patient was revised 3 times after adjacent level instability at T1T2. Patients were pleased with their clinical outcome based on the SRS-30 questionnaire and most of them would have the same procedure again

Conclusion: This is the first series of Parkinson's disease patients undergoing posterior spinal fusion from T2 to the sacrum for management of major deformities. This study indicates that good correction of sagittal and frontal balance enables good clinical and radiological results that remain stable over time even when complications occur

Significance: T2-sacrum fusion is a good option for the treatment of spine deformities in Parkinson disease. The instrumentation failures occurred during the first 6 months postoperatively in patients without sagittal imbalance, and were probably due to rod weakness (5.5 mm rod) and overbending

E-Poster #213

Pre-Op Psychiatric Diagnosis Predicts Occurrence of PTSD Following Elective Lumbar Fusion Better than Extent of Procedure or Complications

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United States*

Summary: Post-Traumatic Stress Disorder (PTSD) is common following lumbar spine fusion. Pre-operative psychiatric disturbance was a stronger predictor of PTSD than spinal diagnosis, extent of surgery, and development of complications. Occurrence of PTSD negatively impacted self-reported clinical outcome scores.

Introduction: PTSD has been demonstrated in surgical patients following trauma, cancer, and organ transplant. No assessments of PTSD among lumbar spine fusion patients have been performed. We sought to evaluate the impact of pre-operative demographic and peri-operative variable on incidence of post-operative PTSD in patients undergoing lumbar spine fusion.

Methods: A prospective analysis of lumbar spine fusion patients was performed using the PTSD Checklist (PCL-C) at pre-operatively, and at 3-, 6-, 9-, and 12-months following surgery. Variables recorded included age, gender, marital and job status, education, psychiatric history, complications, ICU stay, EBL, staging of surgery, and post-op ventilation. Univariate analysis was performed for statistical significance of predictive variables. Clinical outcomes were assessed using ODI and SF-36 scores.

Results: 74 patients were enrolled; 26 underwent extended lumbar fusion for spinal deformity. 100% follow-up was obtained at 1 year; because of the short term effect sought, 2 year follow-up was not sought. PTSD occurred in 22% (16/74) of patients at at least one time point. The only variables statistically associated with PTSD were prior psychiatric history ($p = 0.02$), and positive pre-operative PTSD score on the PCL ($p=0.01$). Occurrence of PTSD post-operatively significantly reduced surgical benefit as measured by ODI ($p < .0001$) and SF-36 summary scores ($p < .003$ and $p < .0001$).

Conclusion: Post-traumatic stress disorder is frequent after lumbar spine fusion surgery. These symptoms appear to be more strongly related to patients' pre-operative psychiatric state than to the extent of surgery or occurrence of complications. Occurrence of PTSD negatively impacted self-reported clinical outcome scores.

E-Poster #214

The Effect of Spinal Instrumentation on Kinematics at the Cervicothoracic Junction: Emphasis on Soft Tissue Response Using an In-Vitro Human Cadaveric Model

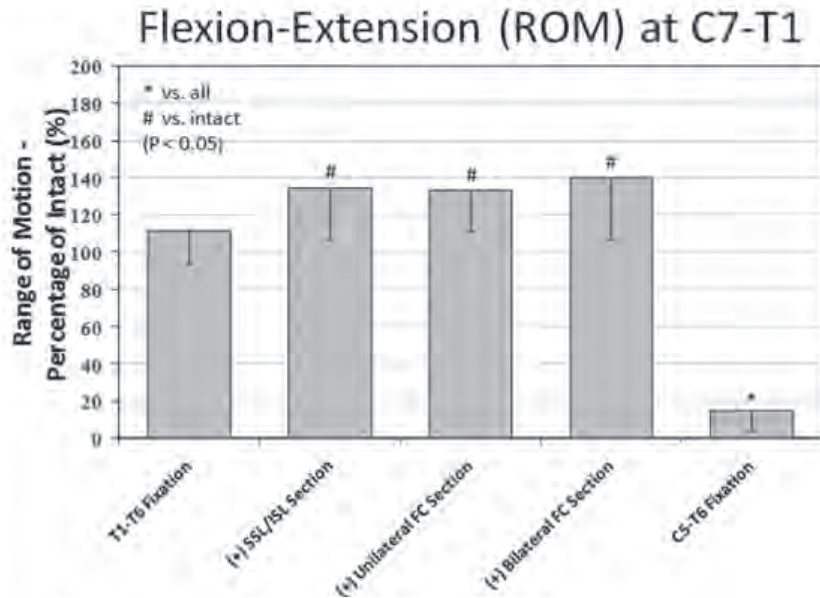
*Ryan M. Kretzer, MD; Nianbin Hu, MD; Hidemasa Umekoji, MD; Daniel M. Sciubba, MD; George I. Jallo; Paul C. McAfee, MD; P. Justin Tortolani, MD; Bryan W. Cunningham, MSc
United States*

Summary: A cadaveric biomechanical experiment was performed to assess the role of instrumentation and soft tissue structures at the cervicothoracic junction (CTJ). While a long construct moment arm in the thoracic spine was not shown to significantly increase ROM at the supra-adjacent segment, the supraspinous/interspinous ligament (SSL/ISL) complex was found to play a significant role in flexion-extension stability and should be preserved if stopping thoracic constructs at T1.

Introduction: Thoracic pedicle screw (PS) instrumentation is often indicated in the treatment of complex spinal pathology. The goal of this study was to determine the role of ligamentous and facet capsule structures at the CTJ as they relate to stability above thoracic PS constructs.

Methods: A 6-degree of freedom spine simulator was used to test multidirectional range of motion (ROM) at C7-T1 in 8 human cadaveric specimens. Flexion-extension (FE), lateral bending (LB), and axial rotation (AR) at the CTJ were tested in the intact condition, followed by T1-T6 PS fixation. Flexibility testing of the T1-T6 PS construct was then performed after sectioning the C7-T1 SSL/ISL complex, followed by unilateral and bilateral facet capsule (FC) disruption. Finally, each specimen was reconstructed using C5-T6 instrumented fixation.

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ROM at C7-T1 as the percentage of the intact condition. Bar height equals mean value and error bars one standard deviation. Symbols above bars denote statistical significance ($p < 0.05$).

junction kyphosis. If a T1 laminectomy is required for neural decompression or surgical access, instrumentation should be extended into the cervical spine. Facet capsule disruption may not be an acutely destabilizing event due to the interaction of the C7-T1 facet joints with T1 instrumentation.

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).

Results: While the application of a long segment thoracic construct stopping at T1 did not significantly increase FE peak ROM at the supra-adjacent level, sectioning the SSL/ISL significantly increased flexibility, producing 35% more motion than the intact condition ($p < 0.05$). Subsequent FC sectioning had little additional effect on ROM in FE. Alternatively, the application of thoracic PSs had a stabilizing affect on the supra-adjacent C7-T1 segment in AR, leading to a decrease in peak ROM to 83% of intact ($p < 0.05$) presumably due to the interaction between T1 instrumentation and the supra-adjacent C7-T1 facet joints. In LB, each treatment group demonstrated trends towards increased supra-adjacent ROM, however these trends did not reach statistical significance ($p > 0.05$).

Conclusion: When stopping thoracic constructs at T1, care should be taken to preserve the SSL/ISL complex to avoid destabilization of the supra-adjacent CTJ, which may manifest clinically as proximal

E-Poster #215

Progression in Patients with Combined Congenital Scoliosis and Rib Anomalies

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Japan

Summary: This study was designed to evaluate scoliosis progression in patients with congenital scoliosis (CS) and rib anomalies (RA). 64 patients matched the inclusion criteria: younger than 10 years of age, minimum F/U 2 years, no treatment procedures, plain X-ray films at the first visit and final F/U. Risk factors were determined to be: severe curve at younger age, unilateral involvement of RA, mixed type of CS with unilateral unsegmented bar and contralateral hemivertebrae, and wider range of RA.

Introduction: The goals of this study were to evaluate progression in patients with combined congenital scoliosis (CS) and rib cage anomalies (RA), and to determine risk factors for progression.

Methods: Based on a survey of patients with combined CS and RA that was conducted via questionnaires (response rate 50.5%), 64 patients matched the inclusion criteria: younger than 10 years of age at the first visit, minimum F/U 2 years, no treatment procedures, plain X-ray films at their first visit and final F/U. Plain X-ray images were evaluated in terms of range & type of RA, severity & type of CS, thoracic height, and associated anomalies.

Results: Of the 64 patients, there were 25 males and 39 females with an average age of 2.4 years at the first visit and 10.8 years at the final F/U. Average F/U time was 8.3 years. 43 of the 64 patients had unilateral RA. RA included rib fusion in 45, mixed rib fusion and defect in 11, rib proximity w/o any rib fusion in 5, and rib defect in 3. Vertebral anomalies included failure of formation in 5, failure of segmentation in 17 and mixed type in 40. The magnitude of scoliosis was 41.6° at the first visit and 60.9° at the final F/U. Scoliosis progression per year was 2.7°/y in 64 patients, 2.0°/y in bilateral involvement and 3.1°/y in unilateral, although 5 patients did not show any progression. One third of the rib cage was involved in 28 patients, two thirds in 25,

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and almost all in 11. Progression rate in patients with almost all involvement (3.1°/y) was statistically higher than those with one third involvement (2.2°/y). Cases with unilateral unsegmented bar with contralateral hemivertebrae demonstrated much higher progression rates (4.1/y) than any other types of vertebral anomalies. 5 patients were treated with some respiratory support (home oxygen therapy in 2, BIPAP in 2 and assisted ventilation in 1).

Conclusion: Risk factors in patients with combined CS and RA were determined to be: severe curve at younger age, unilateral involvement of RA, mixed type of CS with unilateral unsegmented bar and contralateral hemivertebrae, and wider range of RA.

Significance: By evaluating progression in patients with combined CS and RA, we could determine risk factors for progression in primary thoracic insufficiency syndrome.

E-Poster #216

Safety and Accuracy of Pedicle Screw Placement in Young Children with Scoliosis

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China

Summary: An analysis of 242 pedicle screws inserted in young children with scoliosis showed good safety and accuracy. There were 18 screws in malposition but only two were supposed to be related to neurologic complications.

Introduction: Neurovascular complication remains one of the great concerns when placing pedicle screws especially when applied to unmaturing spine. We reported the results of a retrospective study on the safety and accuracy of pedicle screw insertion in the patients younger than 10 years old with spinal deformities.

Methods: A total of 37 consecutive cases subjected to posterior pedicle-based instrumentation for scoliosis were analyzed in terms of the accuracy of pedicle insertion. The patients included 19 girls and 18 boys, with a mean age of 5.4 years at surgery (range 2-10 years old). Etiologic diagnosis were congenital scoliosis in 28, early onset idiopathic scoliosis in 6, neuromuscular scoliosis in 2, and scoliosis associated with achondroplasia in 1. The average preoperative coronal Cobb's angle was 58° (ranged 40°-120°). On the postoperative CT scans, the penetration of medial, lateral pedicle cortex and anterior vertebral cortex by screws were analyzed.

Results: A total of 242 pedicle screws were inserted with 6.5 screws per patient. There were 18 screw malpositions (7.4%) with the definition of 2 mm penetration out the cortex. The malpositions were lateral in 5, medial in 8 and anterior in 5. Screw related neurologic complication occurred in two patients, one transient paraparesis and one dural tear. Two screws were pulled out and repositioned during surgery. There were no other screw-related visceral complications. The mean postoperative Cobb's angle was 28° (ranged 6°-65°). The incidence of screw malposition in malformed vertebra and in concave side was higher than that in normal vertebra and in the convex side.

Conclusion: Screw mal-positioning in posterior pedicle instrumentation was not rare but neurological complication related to the mal-positioning was low.

Significance: Pedicles screws used in unmaturing spine won't increase the risk of neurologic complication.

E-Poster #217

Sagittal Spinopelvic Parameters of Children with Early Onset Scoliosis

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Nathan D. Bodin, MD; Charles R. d'Amato, MD, FRCSC

Canada

Summary: Sagittal spinopelvic parameters have not been defined for children with Early Onset Scoliosis (EOS). Sagittal-plane alignment may affect the natural history as well as affect the outcome of surgical treatment for this condition. With the exception of pelvic tilt, sagittal-plane spinopelvic parameters in a group of children with EOS were found to be similar to those published for children without spinal deformity.

Introduction: Abnormal sagittal spinopelvic parameters have been demonstrated to be related to the development of spondylolisthesis. In children without spinal deformity, these parameters change during the first ten years of life; however, spinopelvic parameters have not been defined in children with significant Early Onset Scoliosis (EOS). Sagittal plane alignment may affect the outcome of growing systems used in the treatment of EOS. The purpose of this study is to define sagittal plane spinopelvic parameters in children with EOS.

Methods: Standing, lateral radiographs of 33 untreated patients with EOS greater than 50 degrees were evaluated. Sagittal spine parameters (sagittal balance, thoracic kyphosis (TK), lumbar lordosis (LL)) and sagittal pelvic parameters (pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), modified pelvic radius angle (PR)) were measured. These results were compared to those reported by Mac-Thiong et al (Spine, 2004) for a group of asymptomatic (i.e. without spinal deformity) children of similar age.

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Results: These patients had a mean age of 9.5 years and mean scoliosis of $74.8 \pm 3.7^\circ$. Mean sagittal spine parameters were: Sagittal balance ($+3.1 \pm 4.9$ cm), TK ($41.0 \pm 26.3^\circ$), and LL ($46.6 \pm 18.9^\circ$). These values were similar to those reported for asymptomatic subjects. Mean sagittal pelvic parameters were measured for PI ($48.5 \pm 16.0^\circ$), PT ($11.3 \pm 12.4^\circ$), SS ($36.8 \pm 12.1^\circ$), and PR ($63.8 \pm 22.2^\circ$). Although PI and SS were similar to age-matched normals, PT was significantly higher in the study population.

Conclusion: Sagittal plane spine parameters in children with EOS were similar to those found in children without spinal deformity. Likewise, pelvic parameters (PI,SS,PR) were similar; however, those children with EOS had increased pelvic tilt as compared to normal.

Significance: Sagittal plane spinopelvic parameters have been defined for a group of children with EOS and, with the exception of pelvic tilt, were found to be similar to those published for children without spinal deformity. This data may be useful as a baseline in determining prognosis for children with EOS who are treated with growing systems.

E-Poster #218

CT Lung Volume Studies are Still Necessary to Document Volume Changes in Early-Onset Scoliosis (EOS)

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United States

Summary: Plain xray measures of thoracic dimensions have moderate correlation to CT volume determinations, but predicted lung volumes from surrogate measures on 2 dimensional xrays are too discrepant from actual CT volume to allow CT scans to be replaced for lung volume determination in EOS patients.

Introduction: Due to radiation-related health concerns, CT scanning is being more critically scrutinized in pediatric patients. Attempting to identify surrogate measures of thoracic/lung volume parameters from plain xrays, we have correlated such measures to CT volumes in our EOS population.

Methods: Xray measures of deformity and thoracic dimensions (MT Cobb, T1-12 coronal length, T6 coronal width, T6-sternal sagittal width, pelvic width), and 2 products of Th measures were correlated to 84 CT volume studies (range 181-2020 cc) obtained in 69 patients with EOS (age 0+6-9+3). Scan dx's included 41 congenital, 12 syndromic, 17 IIS, 8 idiopathic-like, 2 NF, 4 skel. dysplasia. Pearson correlation coefficients were determined for 7 variables with 3 CT volumes (convex, concave, and total lung).

Results: MT Cobb (mean 54° , range 13-108) and T6 sag width had no correlation with any CT volume. T1-12 length ($r=.69$), T6 width ($r=.65$), pelvic width ($r=.58$), chest vol (T1-12 x T6wid x T6 sagwid) ($r=.67$) all correlated with total CT volume at $p<.0001$, with same significance for CT vol convex and concave. Multiple regression of thoracic measures resulted in a prediction equation $CT\ total = -885 + 4.6 (T6\ width) + 4.65 (T1-12\ length) + 6.1 (pelvic\ width)$, $r^2=0.56$, with T1-12 length the most significant contributor. Equations for convex and concave predicted volumes had similar $r^2 = .53$ and $.51$ respectively. However predicted total CT volume was only within 163cc (21%) of actual volume in 50% of cases, and within 394cc (86%) in 95% of cases. Concave and convex predicted values were similarly discrepant with actual volumes.

Conclusion: Plain 2-dimensional xray measurements of thoracic parameters statistically correlate moderately with actual CT volumes. However predicted volumes from these plain xray measures are insufficiently accurate to be useful for documentation of indication for or result of treatment. Surrogate measures do not replace actual CT volume determinations in our EOS population.

Significance: Direct CT volume measurement remains the most accurate method to evaluate lung volume in EOS patients.

E-Poster #219

Severity Classification of Early-Onset Scoliosis

Sumeet Garg, MD; Anna McClung, RN; Charles E. Johnston, MD; B. Stephens Richards, MD
United States

Summary: A severity score for early onset scoliosis (EOS) is described incorporating the systemic fragility often associated with EOS. An increased severity score may provide information regarding prognosis of the disease.

Introduction: Early-onset scoliosis (EOS) is usually classified by radiographic deformity, neglecting associated systemic disease. A new classification system was developed to incorporate the overall medical and bone fragility with the spine and chest deformity of patients with EOS.

Methods: To stratify severity, score includes age at first intervention (0-2 points), nutritional + functional status (0-5 points: BMI, osteopenia, co-morbidities, ambulatory status), pulmonary status (0-3: degree ventilator dependence), radiographic deformity (1-4: Cobb, flexibility, T1-12 length, anomalies). Maximum possible score is 14. To achieve this score a patient would be non-ambulatory due to systemic disease, on full time mechanical ventilation, have a severe, stiff, congenital spinal deformity

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with multiple rib fusions or absences, and have intervention before age 4. Records and radiographs of all patients treated surgically at a single institution were reviewed and scored.

Results: 36 patients have been treated surgically for EOS since 2003. Mean age at start of treatment was 5.1 yr (range 1.3-9.3). Diagnoses include syndromic (20), neuromuscular (6), congenital (5), idiopathic (3), and thoracogenic (1). 9 patients had congenital EOS, with 8 having either multiple rib fusions or absences. Average BMI was 15.9 (range 10.1-30.2); only 6 patients had BMI > 20. 12 patients are nonambulatory, 4 are ventilator dependent either night or fulltime. 23 had growing rod spine implants and 13 had growing implants with rib anchors. Severity scores ranged from 2 (e.g. IIS with normal BMI) to 11 (ventilator-dependent non-ambulator with myopathy and low BMI/osteopenia), with a mean of 6.

Conclusion: Radiographic deformity alone fails to classify patients with EOS adequately. Many patients have severe co-morbidities that directly affect outcome of surgical intervention, thus the need for a comprehensive yet usable scoring method assessing medical, functional, and radiographic parameters.

Significance: The EOS severity score should be useful as a prognostic tool when evaluating treatment options for these complex patients.

E-Poster #220

Increased Rates of Anchor Failure can be Predicted by an Early Onset Scoliosis Severity Score

Sumeet Garg, MD; Anna McClung, RN; Charles E. Johnston, MD; B. Stephens Richards, MD
United States

Summary: Spine and rib anchor implant failure is common in early onset scoliosis. A prognostic scoring system incorporating systemic severity of EOS was predictive in identifying patients at risk for more frequent episodes of implant failure.

Introduction: Surgical treatment with fusion-less spine and rib-based implants for patients with early onset scoliosis (EOS) is almost universally beset by implant complications. A comprehensive assessment score of overall severity may identify those at risk for complications.

Methods: An EOS severity score including nutritional status, medical health, radiographic deformity/flexibility and functional status was developed, with a maximum score of 14. Records and radiographs of all patients treated surgically at a single institution were reviewed. Complications were divided into implant (spine or rib-based), neurologic, surgical site infection, and skin erosion. 36 EOS patients have been treated surgically since 2003 with an average age of 4.7 years (range 1.3-9.3). Diagnoses included syndromic (20), muscular dystrophy (6), congenital (5), idiopathic (3), and thoracogenic (1). 4 patients recently operated have not been lengthened and are excluded from complications analysis.

Results: Severity scores ranged from 2-11 (mean 6). 23 had spine-based growing implants (mean severity 5.4) while 13 had rib-based (mean severity 8.1, $p < .001$). Implant complications were common, averaging 0.55 episodes of rib anchor failure and 0.25 episodes of spine anchor failure per surgical procedure, in spite of 11 patients having no failures. Overall anchor failures/procedure was 0.65. Patients with > 0.4 failures/procedure had higher severity score (7.9 vs 5.5, $p < .008$) than those with < 0.4. Complications not correlated to severity score included 5 infections requiring I&D, 3 implant erosions through skin, 4 intra-operative neuromonitoring changes and 2 late motor deficits (1 brachial plexus injury after VEPTR, 1 paraparesis from thoracic pedicle screw migration).

Conclusion: Many EOS patients have severe co-morbidities that directly affects success of surgical intervention. A higher (more severe) score correlates with an increased frequency of anchor complications. Patients with more severe disease are more likely to be treated with rib-based devices. The incidence of neurologic injury, infection, and skin erosion was too small to be related to the severity score.

Significance: The EOS severity score appears to identify patients at higher risk for anchor complications.

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).

E-Poster #221

MRI Analysis of Idiopathic Scoliosis with a Curvature >25 Degrees: A Prospective Study

Masatoshi Inoue; Hidehisa Torikai; Hirotaka Murakami; Yoshinori Nakata, MD
Japan

Summary: MRI revealed that 27(13%) of 215 patients with idiopathic scoliosis with a curvature > 25 degrees had neural axis abnormalities(NAA), such as syringomyelia and Chiari malformations. Male gender, the age at first visit < 11 years, and abnormal

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neurologic deficits were statistically significant differences between patients with NAM and those without NAM.

Introduction: With the development of magnetic resonance imaging (MRI), neural axis abnormalities (NAA) such as syringomyelia and Chiari malformations are frequently found in patients with idiopathic scoliosis (IS). However, there have been no large prospective studies for identifying NAA in patients with brace treatment.

Methods: This is a prospective case series of consecutive patients with a presumed diagnosis of IS between 2005 and 2009. 215 (18 males and 197 females) patients with a curvature > 25 degrees were examined for NAA using MRI. All patients had a presumed diagnosis of IS. At first visit, the mean age at first visit was 12.2 years and the mean Cobb's angle was 31.3 degrees. Using MRI, hindbrain and spinal cord abnormalities were examined. The criterion used for the diagnosis of Chiari 1 malformation was herniation of at least one tonsil 5mm or more below foramen magnum. The presence of neurologic symptoms and abnormal neurologic signs were also examined.

Results: There were 27 (13%) patients (5males and 22 females) who had NAA on MRI. MRI revealed syringomyelia with Chiari malformations in 11 patients, syringomyelia in 8, Chiari malformations in 7, and low conus medullaris in 1. The mean initial Cobb's angle with NAA is 30 degrees, while the mean initial Cobb's angle without NAA is 31 degrees. Regarding the age at first visit <11 years, male gender, and presence of abnormal neurologic signs including asymmetric superficial abdominal reflex (SAR), sustained clonus, and diminished sensation, there were statistically significant differences between the patients with NAA and those without NAA ($p<0.05$). During follow-up, 48 patients received scoliosis surgery, and 5 patients received foramen magnum decompression surgery. 10 (37%) of 27 patients with NAA received scoliosis surgery, while 38 (20%) of 188 patients without NAA received ($p<0.05$).

Conclusion: Our results suggest that MRI studies are recommended in patients with brace treatment, especially in early-onset patients with abnormal neurologic deficits. The presence of NAA on MRI might be a risk factor for curve progression.

E-Poster #222

A Randomized, Double Blind, Controlled Trial of Perioperative Gabapentin Use to Decrease Opioid Consumption in the Pediatric Idiopathic Spinal Fusion Patient

Lynn M. Rusy, MD; Keri Hainsworth, PhD; Tom J. Nelson, PharmD, RPh; Michelle Czarnecki; J. C. Tassone, MD; John G. Thometz, MD; Roger Lyon, MD; Richard J. Berens, MD; Steven Weisman, MD
United States

Summary: Surgical correction of idiopathic scoliosis results in challenging post operative pain control. The use of Gabapentin was an effective perioperative analgesic, allowing the reduction in the amount of morphine needed to treat post operative pain.

Introduction: In a double-blind, randomized controlled trial, we examined whether gabapentin decreases post-operative opioid consumption for pediatric spinal fusion patients with idiopathic scoliosis.

Methods: Patients, ages 9-18, received preoperative gabapentin (15mg/kg, treatment) or placebo. Anesthesia was standardized. After surgery, all patients received standardized patient-controlled analgesia (PCA) opioid and continued on either gabapentin (5mg/kg) or placebo three times per day for 5 days.

Results: Data from 59 patients (30 placebo, 29 gabapentin) did not differ in demographics or side effects. Total morphine consumption was significantly lower in the gabapentin group on Postop day 0, 1 and 2. Gabapentin significantly reduced first pain scores in the recovery room (2.5) and the evening of surgery (3.4).

Conclusion: Perioperative use of gabapentin appears to be an efficacious adjunct to standard opioid therapy for postoperative pain in teenage children undergoing spine fusion.

Significance: Perioperative oral gabapentin reduced amount of morphine used for postoperative pain after spinal fusion surgery. Initial pain scores were lower in the treatment group.

E-Poster #223

Direct Vertebral Body Derotation, Thoracoplasty or Both: Which is Better with Respect to Inclinator and SRS-22 Scores?

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United States

Summary: We evaluated 203 patients from a prospective, longitudinal database to ascertain which surgical techniques of thoracoplasty (Th), direct vertebral body derotation (DVBD), or both (Th/DVBD) achieved the best post-op results by inclinometer and SRS scores. Patients with mild rib prominences have equivalent post-op inclinometer values for all three groups, but

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higher SRS self-image scores for Th/DVBD. For larger rib humps, significantly better results are achieved with thoracoplasty, but SRS scores remain comparable.

Introduction: DVBD and Th are powerful tools for correction of rib humps in patients with AIS. We evaluated Th, DVBD, and Th/DVBD with respect to post-op inclinometer readings and SRS scores to determine which provides the best correction of rib hump and patient satisfaction.

Methods: A prospective longitudinal database was queried to identify AIS patients who underwent a PSF with pedicle screws and 2 yrs follow-up. 203 patients were identified and divided into 3 groups: 1) Th alone (N=30), 2) DVBD alone (N=122), and 3) both Th/DVBD (N=51). Patients were subdivided into categories based on their pre-op inclinometer reading: 1) $\leq 9^\circ$ (mild), 2) 10-15° (moderate), and 3) $\geq 16^\circ$ (severe). Pre- and post-op inclinometer readings and SRS scores were compared using ANOVA.

Results: Overall, the groups were similar preoperatively except for the DVBD group having higher percent thoracic flexibility. The preoperative rib hump values were Th=13.2, DVBD=14.0, and Th/DVBD=12.9 ($p=0.27$). Taken collectively, the post-op 2-year inclinometer readings were similar for all three groups (Th=5.2, DVBD=7.0, Th/DVBD=5.6, $P=0.66$). However, the SRS-22 self-image scores were significantly better for patients having both Th/DVBD (Th=3.4, DVBD=3.4, Th/DVBD=3.8, $P<0.01$). When patients were stratified by severity of pre-op rib humps, all patients with mild prominences achieved similar corrections, although SRS self-image scores were highest in the Th/DVBD group. In patients with moderate and severe pre-op rib prominences, the addition of Th was necessary for optimal rib hump correction, but there was no difference in SRS-22 domains (Table 1).

Conclusion: Our results suggest that Th alone, DVBD alone, or both Th/DVBD provide equivalent inclinometer results in patients with mild preoperative rib humps, but higher SRS-22 self-image scores are achieved using both Th/DVBD. For more severe rib prominences ($> 10^\circ$), better inclinometer readings are achieved with thoracoplasty, although SRS-22 self-image scores are comparable.

Significance: Although thoracoplasty provides optimal correction in patients with moderate to severe rib humps, SRS self image scores are equivalent when compared to direct vertebral body derotation alone.

E-Poster #224

Neurocentral Synchronosis Screws to Create and Correct Experimental Deformity

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United States

Summary: In an immature pig model, pedicle screw epiphysiodesis of the neurocentral synchronosis (NCS) produced an average scoliosis of 39 degree to the ipsilateral side and the deformity was limited by delayed screw inhibition of the NCS on the contralateral side with 46% correction. This study demonstrated that pedicle NCS screw placement inhibited the overgrowth of the NCS to prevent further curve progression obtaining some correction of the deformity. This strategy may have some role in the treatment of growing patients with spinal deformity.

Introduction: Pedicle screw neurocentral synchronosis (NCS) epiphysiodesis can create scoliosis to the ipsilateral side in an immature pig model. This study sought to determine whether screw inhibition of the NCS on the contralateral side could limit or correct this scoliosis.

Methods: 11 one-month-old pigs were randomly assigned to 3 groups: Sham (n=3) no pedicle screw fixation; Scoliosis-untreated (n=4); right double pedicle screws crossing the NCS from T7 to T14; Scoliosis-treated (n=4); the same as scoliosis-untreated except that a second set of double pedicle screws were placed in the left pedicles at 6 weeks. All animals were euthanized at 17 weeks and plain radiographs, axial CT images and histological analyses were performed.

Results: All animals had surgery without neurologic problems. Scoliosis was seen in: sham: 0 of 3 animals; scoliosis-untreated: 4 of 4 animals, average of $38.8 \pm 10.4^\circ$; and scoliosis-treated: 4 of 4 animals, average of $20.8 \pm 4.7^\circ$. Apical vertebral rotation occurred toward the screw side and was greater in the untreated ($24.5 \pm 2.6^\circ$) than in the treated ($15.2 \pm 3.6^\circ$) and the sham group (0°) ($p=0.0001$). The NCS screws produced 12% shortening of the pedicle and 43% narrowing of the spinal hemi-canal on the screw-insertion side to create scoliosis in every animal. In the scoliosis-treated group a 38% reduction of the apical vertebral rotation and a 46% correction of the scoliosis was seen (Figure).

Conclusion: Contralateral staged pedicle NCS screw placement inhibited the overgrowth of the NCS to prevent further curve progression obtaining some correction of the deformity. The NCS screw epiphysiodesis can create and reverse the scoliosis in an immature pig model.

Significance: Pedicle screw epiphysiodesis of the faster-growing NCS has the potential to arrest or reverse progressive spine deformity. This growth modulation strategy would be especially useful in young scoliosis patients where formal arthrodesis of the spine results in a short trunk and limits lung development and ultimately has a detrimental effect on pulmonary function.

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E-Poster #225

Bilateral 'Percutaneous' Rib-to-Pelvis VEPTR Technique for the Management of Early Onset Scoliosis. An Alternative to 'Growing Rods'?

John T. Smith, MD

United States

Summary: This is a retrospective review of 37 patients with EOS treated with the Bilateral Rib-to-Pelvis VEPTR technique. This technique is a viable alternative to Growing rods with comparable adverse events.

Introduction: Early Onset Scoliosis (EOS) describes progressive spinal deformity of varying etiologies in the growing child. The management of EOS is a challenging problem with many treatment options and strategies, but no conclusive evidence for the optimal treatment method.

Methods: This is an IRB approved retrospective review of 37 consecutive patients treated for EOS at our institution using the Bilateral Percutaneous VEPTR Technique without concomitant thoracoplasty.

Results: Patients were divided into two functional groups: 18 were ambulatory (Group A) and 19 were non-ambulatory (Group B).

For Group A, the diagnosis was: EOS:14; Neurofibromatosis Type I:2; Neuromuscular Kyphosis:1; Kyphoscoliosis:1. The average age was 6.0 years. The average pre-op coronal cobb angle was 63 degrees and was 44 degrees at last follow-up. The average sagittal cobb angle was 61.1 degrees and corrected to 54 degrees at last follow-up. The average length of follow-up was 83.9 months. There were 18 adverse events in 121 procedures (14%). 7 of 18 patients developed significant crouched gait requiring conversion rib-to-spine fixation (39%).

There were 19 non-ambulatory patients in Group B. The diagnosis was Spina Bifida:6; Myopathy:6; Cerebral Palsy:4; and syndromic scoliosis:1. The average length of follow-up was 63.8 months. The average pre-op coronal cobb was 64 degrees and improved to 38 degrees at latest follow up. The sagittal cobb improved from 70 degrees pre-op to 47 degrees. There were 15 adverse events in 100 procedures (15%).

Conclusion: The Salt Lake City Bilateral Percutaneous Rib to Pelvis VEPTR technique represents the only FDA approved approach to the management of EOS using growing instrumentation. This procedure is simple, minimally invasive, and does not compromise alternative treatment pathways if there is failure of the technique. We no longer use this technique in ambulatory children due to the significant incidence of crouched gait postoperatively. Complications are comparable to growing rod procedures.

Significance: This technique represents one method in the ongoing evolution of new ways to manage EOS in the growing child.

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).

E-Poster #226

Off Label Use of rhBMP2 in Spinal Surgery: Significant Variation in Amount, Location, and Use in Spine Surgery

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United States

Summary: Although the FDA has approved rhBMP 2 for use in anterior spinal fusion since 1990, there has not been approval for alternative locations. Many surgeons, however, use rhBMP 2 in an off label manner. This survey of adult spinal deformity surgeons determined that amount, location and use of BMP varied significantly amongst spinal surgeons. Additionally, significant complications were associated with BMP use including persistent drainage and radiculitis.

Introduction: rhBMP 2 (InFuse) was approved for anterior interbody fusion in an LT cage in 1990. Since that time, it has been used in increasing numbers by spinal deformity surgeons, in off label applications. Some authors have reported improved fusion rates, however there are associated risks. These include increased cost and complications. There are no Level 1 studies to guide surgeons in the use, location and amount of BMP in spinal deformity surgery. The purpose of this study is to survey the use of BMP amongst spinal deformity surgeons across the country.

Methods: 14 surgeons, specializing in adult spinal deformity, were surveyed to determine the indications, complications, location and amount of BMP used for deformity spinal fusions. The results were tallied and statistical analysis was performed.

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Results: The indications for using rhBMP 2 in spinal fusion varied widely among the surgeons surveyed. The most important factors that led to BMP use were revision surgery, levels to be fused, and smoking history. The most frequent complications that were attributed to BMP use were increased post-operative drainage (8/14 surgeons) and radiculitis (10/14 surgeons). Anterior BMP (within a cage or femoral ring) was used commonly (11/14 responders), most often for multilevel anterior lumbar interbody fusion. The amount of BMP used anteriorly varied from 3 to 6 mg/level. 10/14 used BMP routinely for posterior multilevel fusions with the amount varying from 0.85 mg/level to 3.4 mg/level. Revision posterior surgery had the highest use overall, with 12/14 surgeons using BMP routinely. The amount of BMP used for posterior multilevel revision surgery varied from 0.85 mg/level to 4.29 mg/level.

Conclusion: Off label use of BMP has become prevalent among spinal deformity surgeons in an effort to enhance fusion rates and improve surgical outcomes in spinal deformity patients. However, there was a wide variation in the indications, amount and location of BMP used. BMP use is not benign and there is an increasing recognition of potential complications. The appropriate indications and dosage of BMP in spinal deformity patients remains unknown.

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).

E-Poster #227

Single Growing Rods: Outcome of 23 Cases with Minimum 2 Year Follow-Up after Definitive Fusion

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Summary: This consecutive series of 23 patients treated with single submuscular growing rods attained a 58% correction in deformity and 4.4cm gain in T1-S1 height when followed up at least 2 years beyond definitive fusion.

Introduction: Growing rods remain an evolving technique in the treatment of early onset scoliosis. Following a period of serial distractions, definitive fusion defines the completion of this treatment regime. In contrast to the increasing numbers of studies examining the outcomes of growing rods, studies reviewing the results after final fusion are limited.

Methods: A retrospective study reviewing clinical and radiological outcomes in 23 patients who had undergone definitive spinal fusion after a serial distraction program between 2006 and 2008 at a single centre. Radiological parameters including assessment of sagittal and coronal deformity correction, coronal and sagittal balance, T1-S1 heights at: preoperative, pre-final fusion, post- final fusion and at the latest follow up. Complications during the treatment period were also examined.

Results: The average period of distraction before final fusion was 4.6 years with an average of 5.6 distractions. Average Coronal Cobb angle preoperatively was 67 degrees, post growth rod insertion was 39 and at the latest follow up after final fusion was 38, amounting to 58 % correction. The average total gain in T1 S1 length was 4.4cm. Six rod fractures were noted in this series with one superficial wound infection. There were no neurological complications and there was no complications related to final fusion surgery.

Conclusion: The single growing rod technique achieves acceptable clinical and radiological results following completion of treatment at 2 years post definitive fusion.

Significance: Serial distraction with the single rod technique remains an effective method of correcting deformity and maintaining growth. Good outcomes without significant adverse effects were noted with followup beyond definitive fusion for this group of patients with early onset scoliosis.

E-Poster #228

Age- and Sex-Related Changes in Sagittal Sacropelvic Morphology and Balance in Asymptomatic Adults

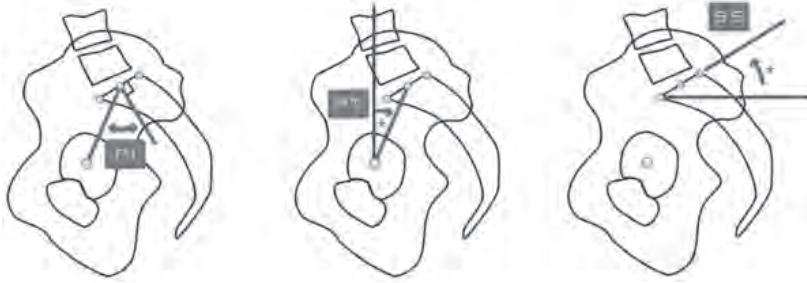
*Jean-Marc Mac-Thiong, MD, PhD; Pierre Roussouly, MD; Eric Berthonnaud, PhD; Pierre Guigui
Canada*

Summary: This study documents the age- and sex-related changes in sagittal sacropelvic morphology and balance in the normal adult population. The range of values corresponding to the mean \pm 2 SD can provide invaluable information to clinicians about the normal range of values expected in 95% of the normal population. This large database can be used as a comparison for subjects with spinal pathologies.

Introduction: Many studies suggest the importance of the sagittal sacropelvic balance and morphology in spinal and hip disorders. There is still some debate concerning the relationships between sacropelvic parameters and age or sex in adults. This study investigates the normal age- and sex-related changes in sacropelvic morphology and balance in a white Caucasian adult population.

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$$PI = PT + SS$$



Methods: A sample of white Caucasian adults without spinal disorder consisting of 354 males and 355 females aged 37.9 ± 14.7 and 35.7 ± 13.9 years, respectively. Sacral slope (SS), pelvic tilt (PT), and pelvic incidence (PI) were assessed from a prospective cohort of 709 asymptomatic adults without spinal pathology (Figure). The ratio between the parameters (SS/PI, PT/PI, PT/SS) were also calculated. For all parameters, the range of values corresponding to the mean ± 2 standard deviations (SD) was provided. Parameters were compared between males and females using Student t tests, while the

relationships between the parameters and age were assessed using Pearson's coefficients.

Results: There was no significant difference in PI, SS, PT, PT/PI, SS/PI, or PT/SS between males and females. The mean $\pm 2SD$ range was 32° - 74° , 0° - 27° , and 24° - 55° for PI, PT and SS, respectively. The mean $\pm 2SD$ range was greater than 0.5 for SS/PI and less than 0.5 for PT/PI. PI was not related to age in either sex group. PT, SS, PT/PI, SS/PI, and PT/SS presented only weak correlation coefficients ($r \leq 0.21$) with respect to age.

Conclusion: The current study presents the largest cohort of asymptomatic adults in the literature dedicated to the evaluation of sagittal sacropelvic morphology and balance. The range of values corresponding to the mean ± 2 SD can provide invaluable information to clinicians about the normal range of values expected in 95% of the normal population.

Significance: The reported results constitute a strong database that can be used as a comparison for subjects with spinal disorders, as many clinicians now recognized the importance of assessing sacropelvic balance and morphology when evaluating the spine.

E-Poster #229

Can Intraoperative Spinal Cord Monitoring Reliably Help Prevent Paraplegia during Posterior VCR Surgery?

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Age (yrs)	Dx	Additional Diagnoses	Osteotomy Level(s)	Maneuver at Time of SCM Change	Intervention	Interval for Return (min)
8	KS	Prune belly syndrome	T10-11	Osteotomy	Correct subluxation/elevate BP	3
				Rod compression	Partial release of correction	4
10.1	KS	Neurofibromatosis, Noonan syndrome	T7-9	Bilateral rod placement	One rod removal	4
				After one rod removal	Correct subluxation	3
				Rod compression	Insert larger cage	1
11.3	AK	Congenital dislocation T12-L1	L1	Rod compression	Insert larger cage	3
13.2	KS	Congenital kyphoscoliosis	T10-11	Rod compression	Correct subluxation/further decompression/elevate BP	18
14.2	KS	Dandy-Walker syndrome	T7	Osteotomy	Lessen anterior spinal cord compression by correct kyphosis/elevate BP	5
				Rod compression	Remove pedicle screw	7
15.5	KS	VATER syndrome	T7-8	Osteotomy	Elevate BP	13
15.9	GK	Syringomyelia	T5	Osteotomy	Elevate BP/lessen traction	6
18.1	KS	Idiopathic scoliosis	T10	Osteotomy	Elevate BP	14
18.3	SS	Idiopathic scoliosis	T9	Patient found to be hypothermic	Elevate temperature	60
18.6	GK	Congenital kyphosis	T10	Rod compression	Partial release of correction/elevate BP	3

KS=kyphoscoliosis, AK=angular kyphosis, GK=global kyphosis, SS=severe scoliosis, BP=blood pressure

Summary: The prevalence of intraoperative spinal cord monitoring data deterioration during VCR surgery was 14.1% (10/71), most of which occurred during rod compression (6/10) and osteotomy (5/10). All patients had return of data with immediate intervention (mean 10.3 min, range 1-60) and had intact lower extremity neurologic function postoperatively.

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Introduction: Posterior vertebral column resection (VCR) is an increasingly common technique to treat severe adult and pediatric spinal deformity but carries a potentially high risk of major spinal cord deficits.

Methods: Analysis of 71 consecutive adult and pediatric pts (mean age 23.7 yrs, range 7.5-74.0) who underwent VCR at or above L1 (spinal cord level) with detectable intraoperative spinal cord monitoring (SCM) data for severe spinal deformity was performed. All surgical procedures were performed between 2002-2009 by 1 surgeon at 1 institution. The electrophysiologic monitoring (both DNEPs and SSEPs) records, surgeon's operative reports, and radiographic studies were used.

Results: 10 pts (6M/4F; mean age 14.3 yrs) out of 71 (14.1%) had either loss of SCM data (n=8) or degradation to meet warning criteria (n=2) during surgery. Diagnoses included 6 kyphoscoliosis, 2 global kyphosis, 1 angular kyphosis, and 1 severe scoliosis. 6 were revisions. Mean operative time was 449 min and EBL was 975 mL. The avg pre- and postop scoliosis for these 10 pts were 99.8o (11-152o) and 44.7o (0-76o), respectively. The avg pre- and postop kyphosis were +110.5o (60-170o) and +57.0o (32-100o), respectively. 6 pts had SCM change during rod compression, requiring partial release of correction in 2, larger cage insertion in 2, correction of sublaxation in 1, and removal of pedicle screw in 1 pt. SCM fluctuated during osteotomy on 5 occasions that stabilized with elevation of blood pressure in all cases, in addition to correction of sublaxation in 1, anterior spinal cord decompression in 1, and lessening traction in 1 pt. 1 pt experienced SCM changes during rod placement/removal and another due to hypothermia. All 10 pts had return of SCM data following prompt intervention (mean 10.3 min, 1-60) and awoke with intact lower extremity neurologic function.

Conclusion: The prevalence of intraop SCM data change during VCR surgery was 14.1%, most of which occurred during osteotomy and rod compression. All pts had return of data with immediate intervention and had intact lower extremity neurologic function postop. These SCM "saves" strongly emphasize the importance of using multimodal neurophysiologic monitoring during such high risk cases to minimize postop paraplegia.

E-Poster #230

Clinical and Radiographic Factors that Distinguish Between the Best and Worst Outcomes of Scoliosis Surgery for Adults 18-45 Years Old

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United States

Summary: Young adult scoliosis patients treated surgically with the worst outcomes are older, have more baseline pain and narcotic use, have greater body mass index, and have a higher prevalence of depression/anxiety and smoking, compared to those with the best outcomes. Except for modest associations with follow-up sagittal balance and Cobb angle, no other radiographic or surgical parameters distinguished between patients with the best and worst outcomes.

Introduction: It remains unclear why some adults with scoliosis markedly improve with surgery, while others fail to improve. Our objective was to assess for factors that differ between patients aged 18-45 yrs with the best and worst outcomes following surgery for scoliosis.

Methods: This is a secondary analysis of a prospective multicenter deformity database. Inclusion criteria included: age 18-45, Cobb angle >20°, no prior instrumentation and availability of outcomes measures (ODI or SRS-22) at minimum of two years following surgery. Patients were sorted based on each outcome measure at follow-up, and the best and worst ~15% were selected for comparison.

Results: For ODI, best (ODI=0) and worst (ODI>30) groups consisted of 19 (22%) and 15 (17%) patients, respectively. For SRS-22, best (SRS-22>4.5) and worst (SRS-22<3.1) groups consisted of 15 (17%) and 13 (15%) patients, respectively. Factors that were statistically significantly different between the best and worst groups are summarized in Table 1. This included higher pre-operative pain levels, narcotic use, greater body mass index, higher proportions of depression/anxiety and smoking. There was a trend towards differences in follow-up sagittal balance and Cobb angles between the groups. There was no statistically significant difference in pre-operative Cobb angle, pre-operative coronal or sagittal balance, comorbidities, occurrence of minor or major complications, operative time, estimated blood loss, and need for revision surgery between the two groups.

Conclusion: Compared with those having the best outcomes, younger adult scoliosis patients treated surgically with the worst outcomes are older, have more pain and narcotic use at baseline, have greater BMI, and have higher proportions of depression/anxiety and smoking. Except for modest associations with follow-up SB and Cobb angle, the factors that distinguished between the patients with the best and worst outcomes were not radiographic or surgical parameters.

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E-Poster #231

Characterization of Osteopenia/Osteoporosis in Adult Scoliosis. Does Bone Density Affect Surgical Outcome?

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Summary: Only 10% of adult scoliosis patients were osteoporotic and comparable age and sex matched bone density exists among adult scoliosis patients. There were no correlation between curve magnitude, complication rates and surgical fusion rate. Scoliosis does not predispose to osteoporosis of vice versa and patients can safely be treated surgically with acceptable results.

Introduction: To assess the prevalence of low bone mineral density (BMD) among females with adult scoliosis (AS) and relate that to surgical treatment outcome. We are not aware of a major comprehensive review of BMD in surgically treated adult scoliosis patients.

Methods: A retrospective chart and X-ray review of 176 females treated surgically for adult idiopathic (AIS 150pts) or degenerative scoliosis (DS 26pts). BMD of the lumbar spine, L1-L4 and femoral neck were determined by dual-energy X-ray absorptiometry (DEXA). patients were categorized as follows: concordance (osteoporosis, osteopenia, or normal BMD on both sites), minor discordance (osteoporotic in 1 site and osteopenic in the other site), and major discordance (osteoporosis in 1 site and normal the other site). BMI, pre operative Cobb angle, fusion ratio and complication were recorded. Statistical analysis included student's t-test, chi-square test, regression coefficient test and simple linear regression. P value was set at $p < 0.05$.

Results: The mean age was 51 ± 12 years (26-82 yrs). Average follow-up was 3.4 yrs (2-7 yrs). The mean T-score of the hip was -1.23 ± 1.18 and of the spine was -0.52 ± 1.63 . Major discordance in BMD 7 (4%) pts, minor discordance 68 (39%) pts and concordance was 101 (57%) pts. There was moderate correlation between T-score of hip and spine ($R = 0.55$ $p < 0.01$). T-score of the hip and of the spine showed 10.8% and 10.2% of the patients were osteoporotic. The mean Z-score of the hip and of the spine showed comparable age and sex matched values. Regression analysis showed no correlation between BMD and Cobb angle ($R = 0.05$ $p = 0.464$). The fusion rate was 93% (164/176) and surgical complication rate was 13.6% (24/176). No significant correlation was observed between BMD and fusion ($p = 0.47$) complication ($p = 0.80$).

Conclusion: Comparable bone density exists among adult scoliosis patients with no correlation between BMD and curve magnitude, fusion and complication rates. The difference in BMD of the hip and of spine can not be fully explained in the review. These results will guide in surgical planning, patient select on the treatment options.

E-Poster #232

Does Prior Short-Segment Surgery for Adult Scoliosis Impact Clinical Outcome among Patients Undergoing Scoliosis Correction?

Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Leah Y. Carreon, MD, MSc; Steven D. Glassman, MD; Frank J. Schwab, MD; Virginia C. Lafage, PhD; Kai-Ming Fu, MD, PhD; Sigurd H. Berven, MD; Keith H. Bridwell, MD

United States

Summary: This matched cohort study did not identify significant differences in complications rates or clinical outcome for adults with a history of prior short-segment spine surgery who undergo more extensive scoliosis correction.

Introduction: In many adults with scoliosis, symptoms may be referable to focal pathology, and may be addressed with short-segment procedures. Our objective was to assess whether these "small fixes" impact surgical parameters and clinical outcomes for those who subsequently require more extensive scoliosis correction.

Methods: This is a matched cohort study based on a prospective multicentered deformity database. Inclusion criteria included: age > 21 , Cobb angle $> 20^\circ$, clinical outcomes measures at 2 or 3 yrs following scoliosis surgery. Patients with prior short-segment (< 5 levels) surgery were propensity matched to patients with no prior surgery based on age, Oswestry Disability Index (ODI), Cobb angle and sagittal balance (SB).

Results: Thirty matched pairs were identified. Among previously operated patients, 30% had prior instrumentation. 40% had prior arthrodesis, and the mean number of operated levels was 2.4 ($SD = 0.9$). Previously operated patients had a trend toward greater blood loss and increased number of instrumented levels, but did not differ significantly based on complication rates, length of surgery, blood loss, or clinical outcome based on ODI, SRS-22 or SF-12 PCS (Table).

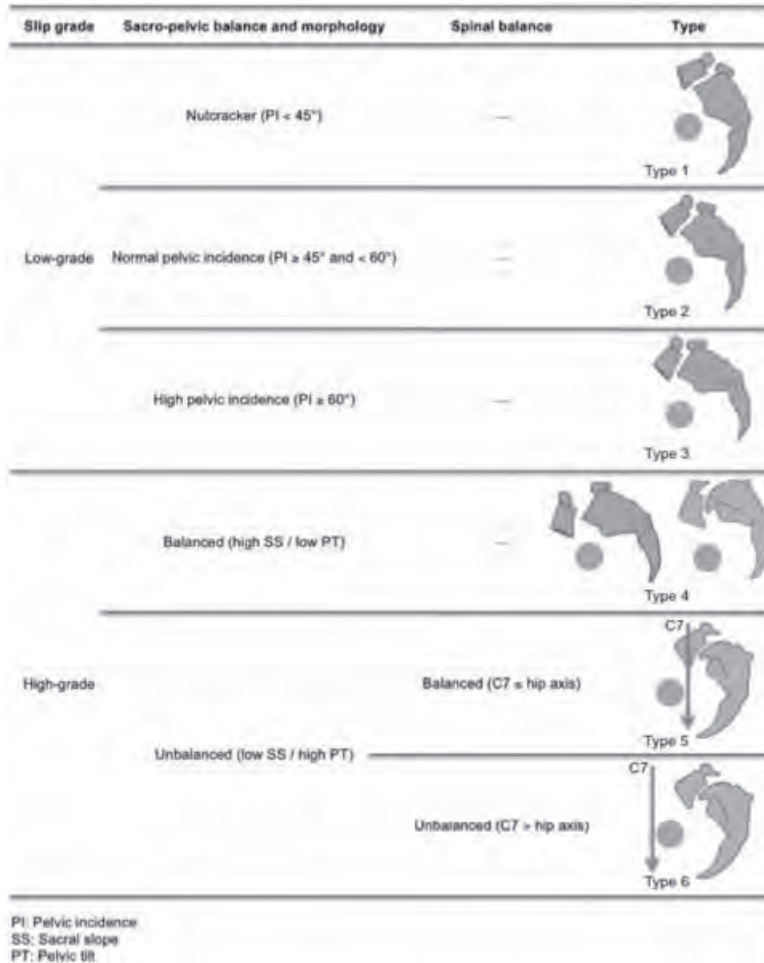
Conclusion: Compared with patients without a history of prior spine surgery, adult scoliosis patients with a history of prior short-segment spine surgery who undergo more extensive scoliosis correction do not have significantly different complication rates or experience less clinical improvement.

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E-Poster #233

Reliability of the SDSG Classification of Lumbosacral Spondylolisthesis

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Canada



Summary: This study evaluates the reliability of the Spinal Deformity Study Group (SDSG) classification of lumbosacral spondylolisthesis based on slip grade, pelvic incidence, sacro-pelvic and spinal balance. Substantial intra- and inter-observer reliability was found, and all six types of spondylolisthesis described in the classification were observed. The reliability of the SDSG classification compares favorably with the reliability of other spinal classification systems.

Introduction: The SDSG has proposed a new classification of lumbosacral spondylolisthesis based on slip grade, pelvic incidence (PI), sacro-pelvic and spinal balance (Figure). Three types of low-grade spondylolisthesis are described: low PI (Type 1), normal PI (Type 2), and high PI (Type 3). High-grade spondylolisthesis are defined as Type 4 (balanced sacro-pelvis), Type 5 (retroverted sacro-pelvis with balanced spine), and Type 6 (retroverted sacro-pelvis with unbalanced spine). This study evaluates the reliability of the SDSG classification of lumbosacral spondylolisthesis.

Methods: Full length standing lateral radiographs of the spine of 40 subjects with lumbosacral spondylolisthesis were reviewed twice by seven observers. Custom software was used by the observers to identify 7 anatomical landmarks on each radiograph, in order to determine the SDSG type for all subjects. Percentage of agreement and kappa coefficients were used to determine the intra- and inter-observer reliability.

Results: All six types of spondylolisthesis de-

scribed in the classification were identified. Overall intra- and inter-observer agreements were 80% (kappa: 0.74) and 71% (kappa: 0.65), respectively. Intra- and inter-observer agreements associated with determination of slip grade were 92% (kappa: 0.83) and 88% (kappa: 0.78), respectively. As for sacro-pelvic and spinal balance, intra- and inter-observer agreements were 86% (kappa: 0.76) and 75% (kappa: 0.63) for low-grade slips, while they were 88% (kappa: 0.80) and 83% (kappa: 0.75) for high-grade slips.

Conclusion: Substantial intra- and inter-observer reliability was found for the SDSG classification, and all six types of spondylolisthesis were identified. Refinement of the computer-assisted technique is expected to further increase the reliability of the classification and facilitate its clinical use.

Significance: There is a need for a reliable classification of spondylolisthesis since past classifications are inadequate for guiding treatment, resulting in significant variations in treatment plans. The SDSG classification is reliable and is designed to facilitate clinical evaluation of spondylolisthesis and therefore hopefully allow more comprehensive investigation of future progression and treatment of this pathology.

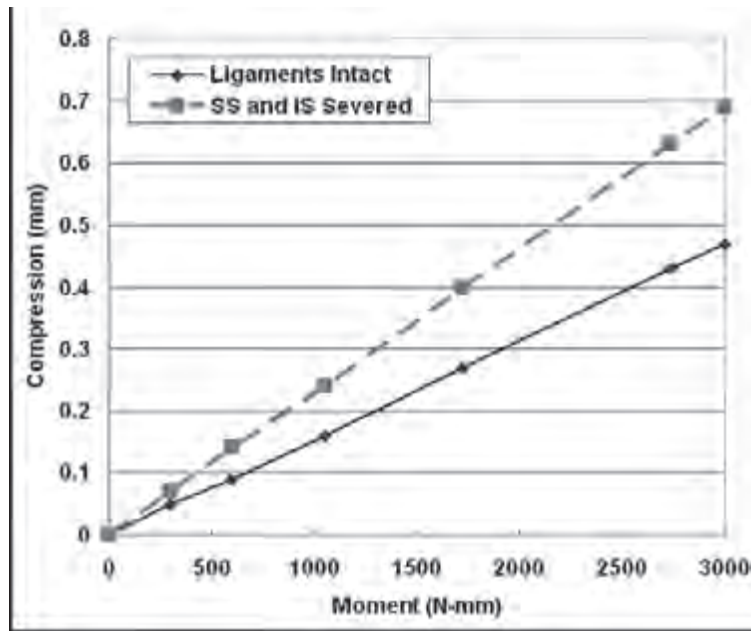
Electronic Poster Abstracts

E-Poster #234

The Role of the Interspinous and Supraspinous Ligaments in Preventing Proximal Junctional Kyphosis

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Summary: We have utilized a finite element model to demonstrate the importance of the interspinous and supraspinous ligaments (ISL/SSL) in preventing pathologic intradisc pressure and excessive range of motion at the level above a scoliosis construct. When the ISL/SSL are absent, range of motion is increased by 29% and intradisc pressure by 32%.

Introduction: Proximal junctional kyphosis (PJK), a vexing complication of spinal deformity surgery, is defined as a focal kyphosis at the level immediately superior to a long instrumented fusion. It leads to deformity, disability, and extension of the instrumentation into the cervical spine. The factors that lead to PJK have not been clearly defined. It has been suggested that the interspinous and supraspinous ligaments play an important role in stabilizing the motion segment in flexion by acting as a tether against hyperflexion. In this study, we have attempted to quantify the effect of sectioning the interspinous and supraspinous ligaments in the upper thoracic spine by employing a finite element model of the spine with a long thoracic fusion from T2 to

T12. We have quantified the differences in range of motion and intradiscal pressure with and without the presence of the interspinous and supraspinous ligaments.

Methods: The spine solid model was first altered to accurately simulate the non-homogeneous structure of the vertebral bodies. A generic instrumented spinal fusion construct and ligaments were incorporated into the model according to published stiffness values. The model was run through a series of flexion tests while measuring the effect of the interspinous and supraspinous ligaments on the range of motion and stress levels in the adjacent structures. A 3000N-mm moment was applied to the motion segment. Variations in sagittal range of motion and anterior disc compression were recorded.

Results: The flexion arc of T1 is 29.35% greater with the interspinous and supraspinous ligaments sectioned, while while pressure within the disc is nearly 32% greater. The stress along the anterior of the disc is much higher with the posterior ligaments severed (Figure 1).

Conclusion: It is important to preserve the interspinous and supraspinous ligaments in order to prevent proximal junctional kyphosis above a long instrumented construct ending at the base of the cervical spine.

Significance: When the ISL/SSL complex is compromised, the surgeon should consider extending the construct cephalad.

E-Poster #235

Asymmetric Pedicle Subtraction Osteotomy. A Useful Tool for Severe Scoliotic Deformities

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Egypt

Summary: Asymmetric PSO is poorly reported in the literature for correcting severe scoliotic deformities. This prospective multicenter study proves its safety and effectiveness when compared to staged anterior release and posterior fixation and fusion.

Introduction: Different spinal osteotomies have been described to improve the correction power and to eliminate the need for anterior release, application of traction as well as staged surgeries in severe spinal deformities. Pedicle Subtraction Osteotomy (PSO) has been extensively applied for correcting kyphosis of various etiologies. However, the use of asymmetric PSO for correcting coronal plane deformities has been inadequately reported in the literature. The aim of this work is therefore to study the outcome and safety of using asymmetric PSO in treating severe scoliotic deformity.

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Methods: Twenty-two patients (14 females and 8 males, age range 15-27 years) with severe rigid scoliosis that does not correct on bending to less than 50° were treated by asymmetric PSO and were prospectively followed for a minimum of 2 years. This group was compared to a historical group of 25 patients treated earlier by the same surgeons by staged anterior release and posterior fixation and fusion 2 weeks later. Preoperative Cobb angle ranged between 75°-145° in the asymmetric PSO and between 70°-150° in the staged group. Both groups were stabilized posteriorly with pedicle screws only.

Results: The total operative time and the duration of hospital stay were significantly shorter in the asymmetric PSO group. The amount of blood loss was also significantly less in the asymmetric PSO group. The average preoperative Cobb angle improved from 110° to 38° postoperatively in the asymmetric PSO group (65%), and from 102° to 50° in the staged group (50%). The difference between the two groups was statistically significant in favor of the PSO group. Complications were minimal in both groups.

Conclusion: Asymmetric PSO appears to be a very effective tool to correct severe coronal plane deformities. It also minimizes blood loss, operative time and the duration of hospitalization when compared to two-stage procedures.

E-Poster #236

Selective Thoracic Fusion in Lenke 1C Curves: Prevalence and Criteria

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Summary: Factors other than those included in the Lenke et al classification system are being used to select fusion levels (selective thoracic vs fusion of both curves) for type 1C curves. Larger TL/L curves and MT:TL/L ratios, more TL/L clinical deformity and a greater patient desire for appearance change favored performance of a nonselective fusion.

Introduction: Classification systems for Adolescent Idiopathic Scoliosis (AIS) have been developed to help surgeons identify curve types and select appropriate fusion levels. Selective thoracic fusion has been advocated for the so-called "false double major" curve (Lenke 1C, King II). Despite this recommendation, many surgeons continue to perform non-selective fusions for this curve type. It is unknown to what extent these classification systems and other factors influence the surgeon's selection of fusion levels.

Methods: A prospective multicenter database included 264 patients with surgically treated 1C curves. Patients were divided into two groups: the selective thoracic fusion group (ST) included patients with the lowest instrumented vertebra (LIV) at or cephalad to L1, while the non-selective group (NS) included patients with the LIV at or caudal to L3. Preoperative radiographic, clinical (scoliometer) and SAQ/SRS questionnaire data were analyzed and compared between the groups.

Results: (See table). Only 138/264 (49%) underwent an ST fusion. Gender ratio (90% vs 86% female), avg age (14.7 vs 14.8yrs), and preop main thoracic (MT) Cobb angles ($56.0^{\circ} \pm 9.9$ vs $55.3^{\circ} \pm 11.4$) were not significantly different between groups (ST vs NS). However, the avg thoracolumbar/lumbar (TL/L) preop Cobb angle was significantly smaller in the ST group ($42.1^{\circ} \pm 8.6$ vs $47.0^{\circ} \pm 9.0$; $p < 0.001$) while the MT:TL/L Cobb ratio (1.35 ± 0.20 vs 1.18 ± 0.15 ; $p < 0.001$), AVT ratio (1.82 ± 0.59 vs 1.31 ± 0.53 ; $p < 0.001$) and AVR ratio (1.16 vs 0.98 ; $p < 0.001$) were significantly greater in the ST group. Sagittal parameters (including T10-L2 kyphosis) were not significantly different between the groups. Preop TL/L scoliometer measures were significantly less in the ST group ($8.1^{\circ} \pm 3.7$ vs $10.3^{\circ} \pm 5.4$; $p = 0.001$). On the Scoliosis Appearance Questionnaire, patients in the ST group had less desire for an appearance change ($p < 0.05$).

Conclusion: Despite a recommendation to fuse only the structural thoracic curve in a 1C curve type, only 49% in this multicenter series were treated with an ST fusion. Patients who underwent an ST fusion had a smaller TL/L Cobb angle and TL/L scoliometer measures, with larger AVT and AVR ratios, and significantly less desire to change their appearance versus those undergoing an NS fusion.

E-Poster #237

Impact of Vertebral Derotation Maneuvers on the Thoracic Sagittal Plane in Adolescent Deformity Correction

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Summary: Direct vertebral body derotation does not adversely affect the sagittal plane.

Introduction: With widespread use of pedicle screw fixation in adolescent scoliosis surgery, increasing attention is being focused on its effect on the sagittal profile. Furthermore, greater corrective forces such as direct vertebral derotation can be applied to correct axial deformity, and this has been implicated as a factor diminishing kyphosis. We examined the effect of applying derotation techniques on the sagittal plane.

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Methods: We retrospectively queried a large, multicenter prospectively collected database for patients who underwent surgical correction of adolescent idiopathic scoliosis. All patients had a minimum of 2 year follow-up and clear documentation of whether or not a derotation maneuver was performed during surgery.

Results: Of the 312 patients identified, 262 had a vertebral body derotation maneuver performed during surgery and 50 did not. The two groups were statistically similar in all areas preoperatively except thoracic curve flexibility ($38\pm 24\%$ vs. $46\pm 20\%$, $p=0.004$). At 2 years follow-up, only the percent thoracic curve correction (non-derotation: $72\pm 15\%$ vs. derotation: $63\pm 16\%$, $p=0.001$) was significantly different between groups. Therefore, patients having undergone derotation maneuvers had more flexible thoracic curves preoperatively but less percent correction at 2 years. The following variables did not show any significant difference between the two groups: pre-op thoracic curve and post-op variables of T5-12 kyphosis, T2-5 kyphosis, proximal junctional kyphosis, and distal junctional kyphosis. Most importantly, no significant differences existed between either group at 2 years follow-up in the sagittal plane.

Conclusion: Application of derotation techniques does not appear to have any increased negative effect on the sagittal profile.

E-Poster #238

Does Contiguous Multilevel Pedicle Screws Offer Added Curve Correction over Alternate Level Screw Strategy in AIS Patients When Curve Flexibility is Taken into Account?

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China*

Summary: This study assessed the radiographic and cost analysis of contiguous multilevel pedicle screws to alternate level pedicle screw strategy (ALSS) in the context of the fulcrum bending correction index (FBCI) in AIS patients treated with titanium instrumentation. The study noted similar FBCIs between strategy-types, but significant cost reductions associated with ALSS.

Introduction: With the use of each pedicle screw in AIS surgery, there is an increase in instrumentation-related costs, operative time, risk of complications and health-care expenses. As such, alternate level screw strategy (ALSS) is an alternative to contiguous multilevel screw strategy (CMSS). Moreover, studies have demonstrated the importance in accounting for the flexibility of the curve based on the fulcrum bending radiograph when assessing postoperative curve correction. Therefore, being cognizant of curve flexibility, the following study addressed a radiographic and cost analysis comparing CMSS to ALSS for the treatment of thoracic AIS with titanium instrumentation.

Methods: Seventy-seven AIS patients underwent surgery (range: 6-15 levels). Thirty-five patients received CMSS, characterized as bilateral screw fixation at every level. Forty-two patients underwent ALSS, which entailed bilateral screw fixation at alternate levels. Titanium rods were utilized in all cases. Pre- and postoperative postero-anterior and fulcrum bending radiographic Cobb angles were obtained of all patients. The fulcrum flexibility and the fulcrum bending correction index (FBCI) were assessed. Cost analysis was also performed.

Results: There was a statistically significant difference between screw strategy-type to that of pre- and postoperative Cobb angles, and postoperative curve correction ($p<0.05$). No statistically significant difference was noted between screw strategy-type and fulcrum flexibility (CMSS mean, 66.9%; ALSS mean, 62.7%; $p>0.05$). The mean FBCIs of the CMSS and ALSS were 126.1% and 122.1%, respectively, and did not statistically differ ($p=0.734$). In comparison to the CMSS, the ALSS was associated with pedicle screw cost reductions of up to 46.2%.

Conclusion: This study is the first to illustrate that regardless of curve rigidity, ALSS utilizing less pedicle screws can achieve comparable FBCI as CMSS. We attribute this to the relatively flexible titanium rods used in this study. Thus in this context, ALSS is as effective as CMSS in terms of coronal curve correction, it has the added benefits of reducing operative time and neurological complication risk, as well as the possibility of better kyphosis restoration compared to the lordosing effect of CMSS.

E-Poster #239

Correction of Moderate (<70-Degree) Lenke 1A and 2A Curve Patterns: Comparison of Hook, Hybrid and All-Pedicle Screw Systems at 2-Year Follow-Up

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Summary: 110 AIS patients underwent primary PSF with various constructs (53 pedicle screw, 48 hybrid, 9 hook). Preoperative and OR data were similar between groups. All-pedicle screw systems had better absolute and % coronal Cobb correction, LIV

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tilt, scoliometer and SAQ measures than hooks and hybrid constructs. The improved coronal correction in the PS group is likely due to the higher number of spine fixation points than in the hook or hybrid group constructs.

Introduction: The purpose of this study is to compare the outcomes of various constructs for the correction of moderate AIS (<70-degree) curves.

Methods: A prospective, multi-center database on AIS identified patients with <70-degree main thoracic curves surgically treated with a posterior spinal fusion. Inclusion criteria were: Lenke 1A and 2A curve patterns, neurologically normal, primary surgery only, and >13 years of age at surgery or Risser 3 or greater, with a minimum f/u of 2 years postoperative. Patients were excluded if surgeries included any releases, which may increase curve flexibility.

Results: A total of 110 patients satisfied the criteria for inclusion: pedicle screws/PS (n=53), hybrid (n=48) and hook (n=9). Pre-operative patient data and curve characteristics and operative data were similar between the 3 groups. Postoperative thoracic coronal Cobb demonstrated PS had better proximal thoracic (PT) and main thoracic (MT) correction (absolute and %) and correction index (CI) than hybrid or hooks. Interestingly there were no differences in CI/fixation point between the 3 groups, indicating PS constructs achieved better correction due to the greater number of spine fixation points. LIV tilt and rotational correction was better in the PS group than hooks and hybrid. At 2-year f/u, PS had better absolute FEV1 values, trunk shift and total SAQ than hybrids. T5-T12 sagittal alignment was unchanged at 2-year f/u for PS vs. increased kyphosis in hybrids. PS had greater increase in negative sagittal balance than hybrids. There were no differences in FVC, coronal decompensation, AVT, T1 tilt, TL/L measures, clavicle angle, coronal angulation below LIV, coronal position of LIV to CSVL, UIV tilt, T2-T5, T12-S1, complications or SRS scores between the 3 groups.

Conclusion: All-pedicle screw systems had better coronal correction, LIV tilt, scoliometer and SAQ measures than hooks and hybrid constructs. The improved coronal correction in the PS group is likely due to the higher number of spine fixation points than in the hook or hybrid groups.

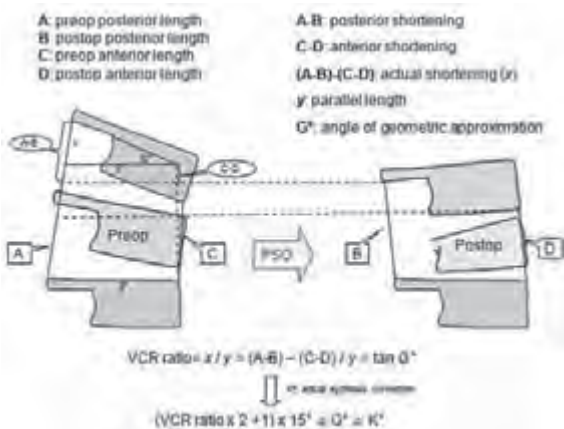
Significance: PS constructs demonstrate better overall correction of moderate Lenke 1A and 2A curve patterns than hybrid or hook constructs.

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).

E-Poster #240

Anterior Lengthening Does Occur in Pedicle Subtraction Osteotomy (PSO) at the Osteotomized Body as well as the Discs Above and Below: Geometric Analysis

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Summary: Recently we invented a formula after analyzing a series of VCR cases, and this study proved the validity of the formula in PSO's. With the formula, we geometrically found that even in PSO's, anterior lengthening also occurs usually at the discs level above and below, but also at the osteotomized body! There was no correlation between posterior shortening and anterior lengthening. Cage insertion into the osteotomized body was not always effective in preventing anterior shortening.

Introduction: We recently created a formula after analyzing a series of VCR cases, that provides the intraop approximation of angular kyphosis correction. The purpose of this study was to validate then analyze the formula in kyphosis correction following Pedicle Subtraction Osteotomy (PSO).

Methods: 22 patients with primarily kyphosis corrected by PSO and with clear landmarks on preop and postop x-rays were selected, and

several anatomical lines and angle measurements were utilized as depicted previously in the VCR formula (see below). 2 approximations were calculated: the geographic approximation (G)=(tanG*2+1)*15°; and the rough approximation (R) which is about the same amount of x(actual shortening), if y≥40; twice of x, if y<40. For each Pt, the change of segmental kyphosis angle (K°) was measured and compared with G and R, and the correlation between each value analyzed. In 3 cases, a cage was inserted into the osteotomized body, those cases were analyzed separately.

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Results: The absolute Mean±SE for K-G and K-R was $2.33^\circ \pm 0.34$, $6.09^\circ \pm 0.58$, respectively. K-G is less than 3° ($p=0.03$). K-R is less than 8° ($p=0.001$). In other words, K was close to G and R and thus can be predicted by these. Average posterior shortening, anterior shortening and kyphosis correction at each level were 20.8 ± 2.0 mm, -3.64 ± 1.5 mm (which equates to anterior lengthening), and $31.05^\circ \pm 2.0$ respectively. Anterior lengthening occurred in 13 cases (In 4 cases, both at the body as well as at the disc above and below.) The correlation between posterior and anterior shortening was 0.03 ($p=0.88$). There were 3 cage insertion cases: 1 had anterior lengthening, while 2 had anterior shortening even with the cage.

Conclusion: With both approximations, the amount of kyphosis correction can be estimated precisely. Even in PSO, anterior lengthening usually occurred at the discs, but it can also occur at the body! There was no correlation between posterior shortening and anterior lengthening. Cage insertion is not always effective in preventing anterior shortening.

Significance: This study proved the validity of the VCR formula in PSO. With the formula, we analyzed PSO geometrically, and found that anterior lengthening does occur even in PSOs usually at the discs, but occasionally at the osteotomized body.

E-Poster #241

Neurological Outcome of Late Onset Myelopathy in Severe Kyphoscoliotic Deformities Treated with Posterior Only Vertebral Column Resection Osteotomy

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Posterior vertebral column resection osteotomy in a congenital kyphoscoliotic deformity. Note the compression of the cord in the preoperative CT myelogram. Column resection and shortening allows the cord to move into the concavity of the to curve thus decompressing it (post op myelogram).

congenital (5), neurofibromatosis (3) and tuberculous (4). Mean preoperative kyphotic deformity was 73.6 deg (10 - 135 deg). Average scoliotic deformity was 84.3 deg (52 - 129 deg). Patients were treated with a single stage posterior vertebral resection osteotomy. Minimum follow-up was 2 years (2-5 years)

Results: Mean surgical time was 6.5 hrs and average blood loss was 958 ml. All patients except one showed neurologic improvement. Neurological recovery started within 1 week of surgery in 6 patients, within 1 month in 4 patients and after > 1 month in 1 patient. Completely neurological recovery was observed in 100%, 66%, 80% of patients with preoperative Frankel of B, C & D respectively. All had a complete recovery of bladder function. Complications seen in 5 patients (41%), which included brachial plexus (root lesion) (1), transient cord deficit (2), implant failures (2), revision (1), pseudo-arthrosis (1). Mean kyphotic deformity correction was 50.4% while scoliotic corrections averaged 39%.

Summary: Vertebral resection osteotomy (VCR) is an effective method of treating complex spinal deformities with neurologic deficits. In addition to providing a better environment for the stretched cord, this procedure also serves to correct the deformity, which probably results in a longer lasting favorable outcome.

Introduction: There are no standard recommendations for treating cord deficits due to severe spinal deformity. Traditionally the surgical treatment has been a staged anterior & posterior approach. OBJECTIVE of study:

1. Evaluate neurological recovery patterns
2. To audit unfavorable results and complications
3. Define role of posterior VCR in the setting of myelopathy

Methods: Records of 13 consecutive patients with cord deficits due to severe angular kyphotic deformity were analyzed (2003- 2008). One patient had died of unrelated cause and 12 patients were available for follow up. There were 1, 3, 3 and 5 patients classified as Frankel A, B, C & D respectively. 4 patients had bladder dysfunction. Average duration of neurological deficit was 4.2 months (0.5 to 12). Out of the 12 patients, 7 patients had an additional scoliotic component. Etiologies were

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Conclusion: Although a technically demanding surgery which involves a significant complication rate, the pattern of neurological recovery as seen in this study makes the surgical procedure rewarding. Global decompression and shortening of spine contributes to a superior neurological outcome.

E-Poster #242

Cervical Scoliosis in the Klippel-Feil Patient

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Summary: A radiographic and medical chart analyses was performed addressing the manifestation of cervical scoliosis in 30 patients with Klippel-Feil syndrome (KFS). Specific congenitally fused cervical patterns and additional vertebral malformations were noted to be highly associated with cervical scoliosis. Cervical scoliosis was not found to be significantly associated with cervical spine-related symptoms in young KFS patients.

Introduction: In patients with Klippel-Feil Syndrome (KFS), the role of congenitally fused cervical patterns, risk factors, and cervical symptoms associated with cervical scoliosis were addressed.

Methods: Plain radiographs assessed the presence and extent of fused segments as well coronal cervical alignment. The Samartzis et al KFS classification scheme (Types I-III) was utilized. Patient demographics and the presence of cervical symptoms were evaluated.

Results: 30 KFS patients were assessed (mean age, 13.5 years). The mean coronal cervical alignment was 18.7 degrees and scoliosis was noted in 16 patients. Patients that exhibited congenital fusion of the mid and lower cervical spine region, had multiple, contiguous congenitally fused segments (Type III), and associated vertebral malformations (e.g. hemivertebrae) were highly associated with the presence of cervical scoliosis ($p < 0.05$). Symptoms were not significantly associated with cervical alignment/scoliosis ($p > 0.05$).

Conclusion: Prevalence of cervical scoliosis was 53.3% in young KFS patients. Numerous risk factors exist associated with the presence of cervical scoliosis. The presence of cervical scoliosis is not synonymous with symptoms.

Significance: Numerous risk factors exist associated with the presence of cervical scoliosis but such a manifestation is not synonymous with symptoms.

E-Poster #243

Dual Motor Monitoring Using Transcranial Motor Evoked Potentials and Neurogenic MEP's During Spinal Deformity Surgery May Offer the Best of Both for Challenging Deformity Surgery

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Summary: Dual motor monitoring using transcranial MEP and neurogenic MEP was reviewed in a series of 101 patients with severe spinal deformity demonstrating complimentary identification of critical changes resulting in no neurologic deficits.

Introduction: Despite good success reported with neurogenic motor evoked potential (NMEP) monitoring in spine deformity, transcranial MEP (TcMEP) have taken on a greater role because of perceived theoretical true monitoring of motor tracts only. The purpose of our study was to evaluate the combination if NMEP and TcMEP monitoring on a group of patients who had both modalities utilized in addition to SSEP.

Methods: A retrospective review of a consecutive series of patients undergoing spine deformity surgery using NMEP, TcMEP and SSEP at a single institution was reviewed. The likelihood of obtaining baseline values and the incidence of critical changes in all 3 modalities was studied.

Results: There were 101 patients with 105 surgeries, 62 female, 39 male at 14.5 years operated over a 2 year period. The diagnoses were AIS-45, neuromuscular-22, syndromic-12, juvenile IS-6, revision-7, other-9. The preoperative curve averaged 75.8° (43 to 141°) and 11.5 (7-17) levels were fused. Successful baseline data were obtained in 88 (87.1%) patients and 92 surgeries (87.6%). Critical changes occurred in 7 of 92 (7.6%) surgeries- 5 of 7 were identified by TcMEP and NMEP. Two patients had transient motor deficits, both identified by TcMEP and NMEP. TcMEP detected 6 of 7 (4 false positives) while NMEP identified 3 of 7 with 1 false positive and was stable in 3 of the cases in which TcMEP changed. TcMEP identified critical changes 6.12 minutes faster than NMEP ($p < 0.05$).

Conclusion: Dual modality motor monitoring using TcMEP and NMEP (in combination with SSEP) may be a more effective method than either one alone since TcMEP identifies earlier critical changes allowing for prompt responses. NMEP adds important information especially in cases they remain stable when TcMEP are lost.

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E-Poster #244

Operative Treatment of Isthmic Spondylolisthesis in Children up to the Age of 12 Years - A Long-Term, Retrospective Comparative Study with Matched Cohorts

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Summary: A retrospective, long-term follow-up study examined operative treatment for isthmic spondylolisthesis in children (≤ 12 yrs). Outcomes were comparable with adolescents. In children there seems to be less low back pain in adulthood. Bony remodeling decreases vertebral slip in children.

Introduction: Few data exist on the surgical treatment of isthmic spondylolisthesis in children (≤ 12 yrs). A retrospective follow-up study compared preoperative characteristics and long-term outcomes of operative treatment for isthmic spondylolisthesis between children (≤ 12 yrs) and adolescents (> 12 yrs).

Methods: 287 consecutive patients (6 -19 yrs; reductions excluded) were operated on between 1977-91. 31 (11%) were ≤ 12 yrs at the time of surgery. The follow-up time averaged 17 yrs (10.7 - 26.3 yrs). Two cohorts, Children (11.1 [8.1-12.4] yrs; n=27; 12 high-grades) and Adolescents (15.8 [12.9-19.3] yrs; n=27), were formed and matched for gender, severity of slip, operative method and age at final follow-up. Operative methods: 4 pts direct repair, 28 pts posterior or posterolateral, 12 pts anterior and 10 pts circumferential fusion.

Results: Preoperatively there were more females in children (7:1) and tended to be more high-grades when compared to adolescents (39% vs. 24 %). The preoperative slip averaged 47.6% (9 - 107) in Children and 44.0% (9 - 82) in Adolescents. The slip improved postoperatively on average 7.8 % points in Children but remained unchanged in Adolescents. Non-union was noted in 1/3. SRS-24 and SF-36 scores were similar. The mean ODI was 3.3% (0-11) in Children and 7.5% (0-32) in Adolescents ($p=0.021$). The VAS (low back pain) averaged 10.3 (0-48) and 19.7 (0 - 84), respectively ($p=0.104$). Non-union did not affect the outcome.

Conclusion: Children (≤ 12 yrs) with isthmic spondylolisthesis can be operated on with good long-term clinical outcome that is comparable with adolescents. In children there seems to be less low back pain in adulthood. Bony remodeling decreases vertebral slip in children.

Significance: Spinal growth and bony remodelling seem to diminish the vertebral slip after in situ fusion.

E-Poster #245

Revision Surgery for AIS Results in SRS Scores Comparable to Primary Surgery Patients

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Summary: A multicenter database was used to compare patients undergoing primary surgery for AIS to those having revision surgery. The incidence of complications and were comparable between groups. Those with revision surgery had had similar SRS scores to the primary patients at two year follow-up despite more frequent spinal cord monitoring changes intraoperatively and less correction of the main curve.

Introduction: The incidence of revision surgery for adolescent idiopathic scoliosis (AIS) has been recently reported from several institutions with some variability. There are no published studies which have analyzed the radiographic and clinical outcomes following revision AIS surgery.

Methods: A prospective multi-institution prospective database was reviewed. A group of AIS patients who had primary surgery were compared to those who underwent revision surgery. Radiographic, surgical and functional scores were compared for the two groups.

Results: There were 3317 patients in the primary group and 115 in the revision group. The most common reasons for revision were curve progression (23.2%), symptomatic instrumentation (20.5%), pseudoarthrosis (12.5%) and implant failure (7.1%). There were no differences in gender or BMI. The primary patients were younger (14.8 vs 16.4 years, $p<0.05$), had larger preoperative major curves (57.4° vs 45.5°, $p<0.05$), greater trunk shift (19.9 vs 15.3 mm, $p<0.05$) and had greater curve correction (62.6% vs 45.3%, $p<0.05$) at two years. The primary group had less preoperative thoracic kyphosis (22.2° vs 30.9°, $p<0.05$) but the revision group improved such that the thoracic kyphosis at two years (22.1° vs 22.9°) was similar between the two groups. There were no differences in baseline SSEP or MEP, but there was a trend toward a higher incidence of critical changes in SSEP (1.2% vs 3.4%, $p=0.07$) and MEP (3.0% vs 5.9%, $p=0.09$) for the revision group. Preoperatively, the revision patients had lower SRS-30 Pain (4.07 vs 3.65, $p<0.05$) and Activity (4.09 vs 3.85, $p<0.05$) domain scores and a lower Total score (3.82 vs 3.66, $p<0.05$). At two

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years, the revision patients improved, such that their SRS scores were similar to the primary group.

Conclusion: Patients undergoing revision surgery for AIS improve their thoracic sagittal deformity, but have greater incidence of critical changes in SSEP and MEP. Despite worse preoperative pain and activity scores, patients undergoing revision AIS surgery demonstrate similar scores in these domains and total SRS-scores at two years.

E-Poster #246

Saving Lumbar Motion Segments with Selective Thoracic Fusion for Lenke 1C Curves Provides Good Radiographic Outcomes but No Added Functional Benefit at 2 Years When Compared to Nonselective Fusions

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United States

Summary: When comparing selective and nonselective thoracic fusions for Lenke 1C curves, there was a larger residual lumbar curve, with some mild coronal imbalance in the selective group. However, despite saving 4 lumbar motion segments, there was no benefit to a selective fusion in any SRS-30 category.

Introduction: Selective thoracic fusion for Lenke 1C curves offers the advantage of maintaining a mobile lumbar spine; however, left decompensation and further surgery to restore coronal balance may be necessary. There are few large studies analyzing radiographic and functional outcome data comparing selective and nonselective fusion patients.

Methods: A prospective database was reviewed to identify all patients who had Lenke 1C curves. Patients who had a selective thoracic fusion were compared to those who had fusion of the thoracic and lumbar spine.

Results: 126 patients were reviewed: 69 in the selective (S group) and 57 in the nonselective (NS group). The average age, gender and ethnicity were similar between groups. The fusion level difference was 4.2 (9.1 S group vs 13.3 NS group). There was no difference between the S and NS groups for thoracic curve magnitude preoperatively (56.9 vs. 55.6°) and 2 year postop (25.2 vs 24.1°), however, the thoracolumbar/lumbar curve was smaller preoperatively (43.0 vs 48.0°) but larger 2 years postop (23.0 vs 17.6°) in the S group ($p < 0.001$). Thoracic AVT was greater preoperatively (46.6 vs 40.9mm, $p = 0.04$) but not at 2 years (22.0 vs 17.9mm) while the TL/L AVT was smaller preop (21.4 vs 31.7mm) and larger at 2 years (19.9 vs 14.3 mm) in the S group ($p < 0.001$). At 2 years, coronal position of the LIV was worse in the selective group (11.4 vs 6.5mm) ($p < 0.001$) as was coronal balance (18.5 vs 9.9mm) ($p < 0.001$) but both were less than 2cm. Kyphosis of 3.0° from T10 to L2 was seen in the S group compared to 6.5° of lordosis in the NS group ($p < 0.001$). There was an overall improvement at 2 years in all domains for both groups including activity (S-4.21 to 4.39; NS-4.06 to 4.25), satisfaction (S-3.67 to 4.43; NS-3.71 to 4.53) and total (S-3.89 to 4.27; NS-3.80 to 4.23) without differences between groups.

Conclusion: Selective thoracic fusion for Lenke 1 curves had larger residual lumbar curves, and less measured coronal balance with more kyphosis below the fusion. However, all functional outcome measurements at 2 years were similar between the selective and nonselective patients. The clinical and functional benefit of saving 4 lumbar motion segments was not realized at 2 years but would be expected to improve over time.

E-Poster #247 – WITHDRAWN

E-Poster #248

Fellowship and Practice Composition Impact Surgical Decision Making in Patients with Adult Lumbar Degenerative Scoliosis: Spinal Deformity vs. Degenerative Spine Surgeons

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United States

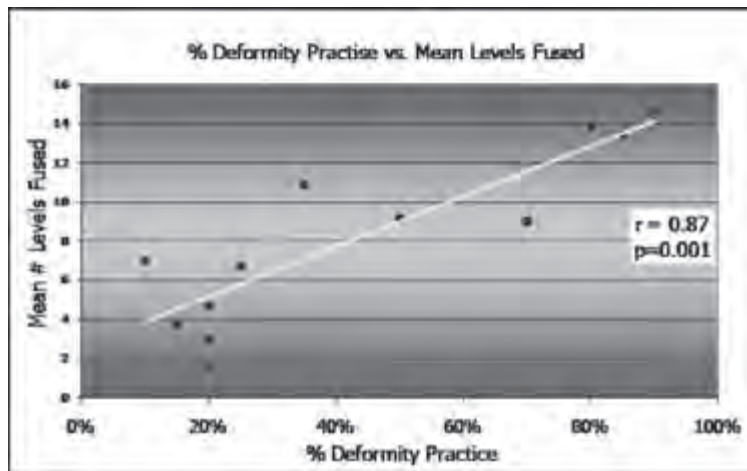
Summary: Depending on the treating physician, patients with Adult Lumbar Scoliosis (ALS) may receive a spectrum of surgical treatments. 6 Spinal Deformity and 6 Degenerative Spine surgeons were shown 7 cases of ALS with radiculopathy. Deformity surgeons had significantly higher group consistency and planned a greater number of fusion levels than degenerative surgeons in ALS cases without significant sagittal malalignment. In patients with ALS, fellowship and practice composition have a significant influence on physicians surgical planning.

Introduction: Depending on the treating physician, patients with Adult Lumbar Scoliosis (ALS) may receive a spectrum of surgical treatments. This study aims to investigate the differences in operative planning between two groups of spine surgeons.

Methods: 12 Surgeons; 6 Spinal Deformity and 6 Degenerative Spine surgeons were shown 7 cases of ALS with radiculopathy.

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Radiographic inclusion included: lumbar curve between 25°-40°, T2-12 Kyphosis, 20°-50°, L1-S1 Lordosis: 30°-65°, and SVA: 0-80mm. Each case included the history, PE findings, and imaging. Surgeons completed a questionnaire including: fellowship and practice deformity experience and planned operative intervention including the number of fusion levels. Student T-Test and Pearson Correlation was used for statistical analysis. Intraclass correlation (ICC) was used to investigate the internal agreement among degenerative and deformity surgeons.



Results: Fellowship and Practice

Deformity surgeons (mean 65%, range 50-80%) were exposed to a significantly higher % of deformity cases during fellowship than degenerative surgeons (mean 33%, range 10-75%), $p < 0.01$. Practice deformity pathology was 68% (35-90%) and 18% (10-25%) for deformity and degenerative surgeons respectively. Correlation between fellowship and practice deformity composition was $r = 0.62$, $p < 0.01$.

Fusion Levels

Deformity surgeons (mean 11.8, range 5.3-17.7) fused a significantly greater number of vertebral levels than degenerative surgeons (mean 4.5, range 2.8-6.2), $p = 0.003$. Correlation between % practice spinal deformity and number of fusion levels was $r = 0.87$, $p < 0.01$. ICC analysis for the agreement among deformity surgeons for the number of levels fused

per case was $r = 0.327$, 95% CI: 0.07-0.76, $p = 0.004$. ICC for Degenerative Surgeons was $r = 0.01$ (95% CI: -0.16-0.18, $p = 0.842$).

Conclusion: A significant association between practice composition and deformity experience during fellowship training exists. Deformity surgeons had significantly higher group consistency and planned a greater number of fusion levels than degenerative surgeons in ALS cases without significant sagittal malalignment.

Significance: In patients with ALS, fellowship and practice composition have a significant influence on physicians surgical planning.

E-Poster #249

Does Magnitude of Deformity Correlate with Symptoms in Adult Spinal Deformity?

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Summary: Surgical decision making for adult spinal deformity is complex.

Introduction: The purpose of this study was to correlate symptoms of pain and disability with magnitude of deformity and spinal imbalance in adult spinal deformity patients.

Methods: Ninety-six (M 34, F 62) consecutive patients, referred to spine-center for surgical consult with the diagnosis of scoliosis/kyphosis and back pain were evaluated. Surgical decision-making was shared between the clinician and patients after watching peer-reviewed educational video. Minimum follow-up was 2 yr in surgical group and 1 year in the nonsurgical group. Deformity was classified as decompensated (T1 plumb line deviated beyond 5cm of normal in either coronal or sagittal planes) ($n = 52$) or compensated ($n = 44$). Data were collected prospectively including ODI index, SF-36, VAS, and pain drawing.

Results: In the decompensated deformity group 29 patients (56%) elected non-surgical treatment, and their mean disability index were ODI 25, PCS score 38, and VAS 3/10. Remaining 23 patients (44%) had surgical treatment, and their mean disability were ODI 68 and 32, PCS score 18 and 36, and VAS 8/10 and 4/10, before and after surgery respectively. There was no significant difference in the magnitude of deformity or decompensation. In the compensated deformity group 36 patients (82%) declined surgery, and their mean disability scores were ODI index 22, PCS score 39, and VAS 3/10. Only 8 patients (18%) elected to have surgery, and their disability scores before and after surgery were ODI 65 and 32, PCS 19 and 29, and VAS 8/10 and 4/10. There was no difference in magnitude of deformity between the surgical and nonsurgical treatment groups.

Conclusion: Decompensated deformity more frequently produced significant clinical symptom. However, there was no correlation between the magnitude of decompensation or deformity, and pain or disability. Despite significant improvement after surgical treatment, residual pain and disability was marginally greater than the patients who declined surgical treatment.

Significance: Adult spinal deformity does not always produce significant pain or disability. Surgical decision making should be shared with the patient on the basis of symptom and not magnitude of deformity.

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E-Poster #250

Assessment of Factors Predictive Of Post-Operative Infection in 941 Spinal Deformity Patients

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Summary: Age, BMI, levels fused, Lenke 3-4 curve type, osteotomy, and comorbidities were predictors of infection. Of these, Lenke 3-4 and neuromuscular comorbidity correlated with deep infection.

Introduction: Post-operative infection occurs following spinal surgery in 1 to 15% of cases varying with patient factors and type of procedure performed. This study aimed to identify patient and surgery related factors associated with an increased risk of infection from a single surgeon database.

Methods: Retrospective review of 941 patient records from a single-surgeon database of deformity patients treated from 2000-07. Demographic (age, gender, body mass index (BMI), comorbidities), surgical (prior surgery, approach, type and number of procedures, etc), radiographic, and peri-operative complications were assessed. Infection was classified as deep, superficial, or possible. Deep infection always required operative irrigation and debridement, while superficial infection was treated non-operatively. Patients restarted on antibiotics for wound drainage without fever, positive culture, or abnormal laboratory values were categorized as a possible infection.

Results: There were 13 deep (1.4%) and 17 superficial infections (1.8%). Patients were treated with an anterior (n=193), posterior (n=590), or combined (n=140) approach with the following procedures: spinal fusion (n=873), growth rod distraction (n=23), revision (n=145), vertebral column resection (n=32), and osteotomy (n=162). Predictors of infection were: age, BMI, number of levels, Lenke 3-4, osteotomy, and number of comorbidities ($p < 0.001$ to $p < 0.05$). Lenke types 3-4, combined approach, number of levels, and kyphosis correlated with superficial infection ($p < 0.001$ to $p < 0.05$). Lenke 3-4 and neuromuscular comorbidity was predictive of deep infection ($p < 0.001$).

Conclusion: Age, BMI, number of levels, Lenke 3-4 curves, osteotomy, and number of comorbidities were found to be predictors of any infection. Of these, only Lenke 3-4 and neuromuscular comorbidity was correlated with deep infection.

E-Poster #251

Effects on Lung Growth and Function of Serial Vertical Expandable Prosthetic Titanium Rib (VEPTR) Expansion Thoracoplasty in Children with Thoracic Insufficiency Syndrome (TIS) : A Longitudinal Study

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Summary: Pulmonary Function Tests were performed under general anesthesia at the time of VEPTR surgery on 31 children over a mean of 4.2 years (range 1.0 - 15.1). Forced Vital Capacity (FVC) increased substantially for the group over the course of the study. The respiratory system compliance decreased at an annual rate of 2.2%, with the most reduction in the neuromuscular group. The decreasing respiratory compliance over time should be considered in patient selection. Level of Evidence: Level IV

Introduction: Information on the longitudinal effect of VEPTR expansion thoracoplasty on lung growth and function of young children with thoracic hypoplasia and scoliosis has been limited due to difficulties in studying Pulmonary Function Tests (PFT) in non-anesthetized children. The study objective was to obtain such information.

Methods: Pulmonary Function tests were performed on anesthetized children undergoing VEPTR insertion or expansion in the operating room by means of a forced deflation technique with a mobile unit prior to surgery (Motoyama et al. ARRD, 1987).

Results: A total of 314 VEPTR procedures, including insertions and expansions, were performed every 6 months in 31 children (mean 10.1 procedures; range 3-19) in whom 244 PFTs were performed over the time span of at least 12 months (mean 4.2yr; range 1-15.1). The mean age of children at the initial VEPTR implant was 4.3 years (median 3.7, range 1-9.7). Forced vital capacity (FVC) at the initial test was 75.5 +/- 4.56% of predicted; 18 of 31 had moderate to severe restrictive defects. As a group, there was a substantial increase over the study period of absolute FVC (13.1 +/- 9.1% per year; $p < .05$), which represents about 50% of the normal rate of growth. In 16 children, specific respiratory system compliance (Cr_s, mL/cmH₂O/kg) was abnormally decreased at the first test. With repeated expansions, Cr_s decreased in 21 of 30, with a group annual rate of -2.2 +/- 13.3%. The reduction in Cr_s appeared worst in those with neuromuscular diseases.

Conclusion: Multiple VEPTR expansions increase lung volume with clinical improvements. Further studies are needed to see if the observed trend of decreasing Cr_s over time may be a possible limiting factor of this procedure.

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E-Poster #252

Adding Fusion to the Thoracic Curve in Lenke 5 Curves - Risks and Benefits

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Summary: Patients with Lenke type 5 curves fused only in the thoracolumbar/lumbar region were matched with a group of similar patients fused across the thoracic curve as well. A comparison of radiographic and clinical outcomes demonstrated the group with the longer thoracic and lumbar fusion to have slightly improved coronal correction, however, at the expense of reduced flexibility and thoracic kyphosis.

Introduction: The Lenke classification suggests a limited thoracolumbar fusion for type 5 curves; this is not however routinely accepted. We wished to determine the costs and benefits with regards to the outcomes of non-selective vs. selective fusions in a matched set of Lenke 5 curves.

Methods: Prospectively collected cases from a multi-center database were analyzed. Lenke 5 AIS patients were divided into two groups (109 selective: only TL/L curve fused and 41 non-selective: both TL/L and Th curves fused). Patients were then matched based on pre-op radiographic and clinical measures. Two year post-op radiographic and clinical outcomes were compared utilizing ANOVA with bonferonni correction ($p < 0.008$).

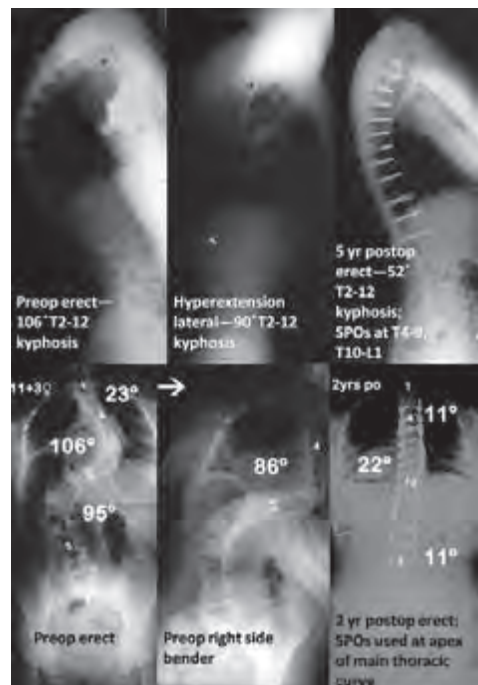
Results: Thirty-five matched pairs (70 pts) of Lenke 5 curves were available. There was no difference pre-operatively between the groups in age, thoracic (33° vs 36°) or lumbar (49° vs 48°) curve magnitude, curve flexibility (60% vs 54%), thoracic kyphosis, clinical trunk flexibility or SRS scores. Post-op, patients in the non-selective group exhibited greater coronal curve correction for both curves (Table I). However, the longer fusions had significantly less thoracic kyphosis and truncal side bending/rotational flexibility. There was no difference in clinical balance or SRS-22 scores.

Conclusion: Surgeons attempt to achieve balanced correction with the fewest motion segments fused. Our data suggests that primary thoracolumbar scoliosis fusion into the thoracic spine may add modest improvement in coronal correction, but at the cost of decreased thoracic kyphosis and clinical flexibility (at 2 years). Ultimately, long term effects of these longer fusions will be needed to determine if selective thoracolumbar fusions should be approached with the same vigilance as selective thoracic fusions.

E-Poster #253

Radiographic Outcomes of Smith-Petersen Osteotomies in the Treatment of Spinal Deformity

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United States



Summary: We evaluated radiographs of 74 patients undergoing posterior spinal fusion with Smith-Petersen osteotomies. For kyphosis, average correction was 8.9° per SPO. SPOs in the thoracolumbar area provided the most correction, followed by lumbar, mid thoracic, and proximal thoracic. Younger patients had more correction per SPO. SPOs lower in the spine resulted in greater sagittal balance improvement. For scoliosis, coronal Cobb measurements improved significantly for proximal thoracic, main thoracic, and thoracolumbar/lumbar curves, and over osteotomized segments. Previously-operated curves corrected less.

Introduction: Many reports have described the deformity correction from PSO or VCR, but less is known about SPOs. We report radiographic outcomes following SPOs for kyphotic and scoliotic deformities.

Methods: We retrospectively reviewed the radiographs of 74 patients undergoing posterior fusion with SPOs to correct kyphotic and/or scoliotic deformity, with min. 2 year follow-up. Exclusion criteria: concomitant PSO or VCR; anterior releases. Standard sagittal and coronal Cobb angles were measured, as well as segmental angles of contiguous SPOs and per-level angles for each SPO (sagittal only).

Results: 74 patients aged 35.7 ± 21 yrs (11.3-77.8) underwent 314 SPOs (4.2 per patient); SPOs were for kyphosis only in 38 patients, scoliosis only in 10, and both purposes in 26. Follow-up was 2.9 ± 1.1 yrs. For kyphosis, SPO segment

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Cobb improved from 33.7° to 11.2° ($p < 0.0001$); > 3 SPOs corrected more than ≤ 3 SPOs ($p = 0.0004$). Overall kyphosis correction was 8.9° per SPO. Correction varied by region of the spine ($p < 0.0001$): prox thoracic (PT) 3.3°, mid-thoracic (mid-T) 7.3°, thoracolumbar (TL) 12.0°, and lumbar (L) 10.0°. Patients < 21 yrs corrected more than those ≥ 21 (9.7° vs. 7.9°, $p = 0.03$). Sagittal balance improved (2.9 to -0.04 cm, $p = 0.0009$), but more so with TL or L SPOs ($p = 0.03$). Inter-observer reliability for per-level SPO measurements was 0.98 (assessed for 12.5% of sample).

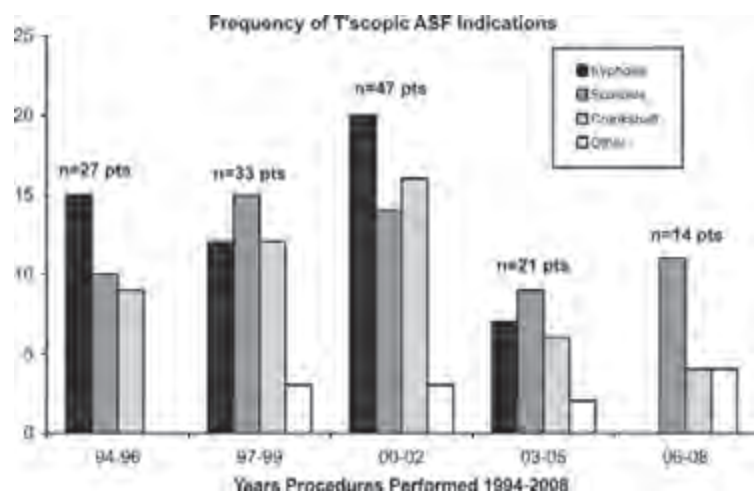
For scoliosis, coronal Cobb improved ($p < 0.0001$) for SPO segments and for PT, main thoracic (MT), and TL/L curves. Correction rates were 49% for SPO segments, 37% for PT, 46% for MT, 55% for TL/L. Segmental Cobb divided by # of SPOs gave a 6.53° correction per SPO. No significant loss of correction occurred. Segmental correction was greater for primary SPOs than SPOs through revision levels ($p = 0.008$), but was not impacted by patient age or spinal region. Coronal balance did not change.

Conclusion: SPOs resulted in 8.9° of kyphosis correction per level, and varied by region (TL $>$ L $>$ mid-T $>$ PT). Younger patients corrected more. Sagittal balance improved more with TL and L SPOs. SPOs were also successfully utilized in coronal-plane deformities, with a 49% correction rate over osteotomized segments. Primary SPOs were more effective at coronal correction than SPOs through revision levels.

E-Poster #254

The 15-Year Evolution of the Thoracoscopic Anterior Release: Does it Still Have a Role?

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Summary: 142 patients pediatric spinal deformity patients from 1994-2008 who received thoracoscopic anterior release/fusion demonstrated a decline in the frequency of the procedure over time. Hyperkyphosis as an indication for the technique has been eliminated. Crankshaft prevention and large scoliotic deformities remain indications for thoracoscopic release/fusion at our center.

Introduction: Prior to the advent of segmental pedicle screw fixation, anterior release was performed for severe spinal deformity. The thoracoscopic approach significantly reduced the morbidity compared to open thoracotomy procedures. While a decrease in the frequency its use has been observed, A single site's experience was reviewed to determine the indications for anterior thoracoscopic release and fusion have evolved over time.

Methods: A retrospective single-center chart and radiograph review of pediatric spinal deformity patients from 1994-2008 undergoing thoracoscopic anterior release/fusion (with subsequent posterior instrumentation) was performed. Indications for the thoracoscopic procedure were assigned to one of four categories: hyperkyphosis, large/stiff scoliosis, crankshaft prevention, and "other" (e.g. pseudoarthrosis prevention, thoracic lordosis). Indications were grouped into three-year intervals and a descriptive analysis was performed to determine how the indications for this procedure have evolved over the past 15 years.

Results: A total of 142 patients (age: 15 years, 2-28) underwent the procedure. These patients had 172 identified indications for their thoracoscopic procedures. The frequency of performing a thoracoscopic anterior release has decreased after reaching a peak in the years 2000-2002. Initially, hyperkyphosis was the most frequent indication and since 2006 this has not been an indication for the procedure. The use of thoracoscopy to prevent crankshaft has also declined, but remains an indication for the most immature cases. Severe (ave. 81°, 70-110°) or rigid scoliosis (bend $> 50^\circ$) continues as an indication at our center, with this now the most common reason for performing a thoracoscopic release/fusion.

Conclusion: The indications for a thoracoscopic anterior release/fusion have evolved as both our understanding of this procedure and posterior fixation with pedicle screw instrumentation have improved. While less common than in the past decade, there remains an important role for thoracoscopy in select spinal deformity patients.

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E-Poster #255

Factors Predicting Coronal Decompenation of Lenke 1 Curves Following Selective Fusion

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Summary: Relatively high rates of early frontal decompenation may be improved by careful attention to preoperative socio-clinical and radiographic characteristics.

Introduction: Selective fusion of main thoracic curves (Lenke I) can lead to coronal decompenation. This study examines factors which may predict decompenation, including the relationship between the lowest instrumented vertebral level and lowest end vertebral level (LIV-LEV).

Methods: Review of a prospective multicenter database revealed 460 AIS patients who have been treated with primary selective posterior spinal fusion for Lenke Type 1 curves. Patients with coronal decompenation (defined as trunk shift > 2cm away from CSVL) 2 years following surgery were compared to those without such imbalance. The LIV-LEV relationship was compared between groups, with a negative number implying an LIV proximal to the LEV of the main thoracic curve.

Results: Rates of coronal decompenation 2 years postoperatively were as follows: Type A (19/250, 7.60%), Type B (5/73, 6.85%), Type C (16/137, 11.68%). No significant differences in age, sex, total levels fused, or LIV level were noted between those decompenated and those not decompenated for all curve types. The relationship between LIV and LEV did not correlate with decompenation for 1A ($p=.2$), 1B ($p=.6$) or 1C ($p=.3$) curves. 1B curves with coronal decompenation were found to have a significantly higher curve correction (74.5% vs. 58.5%, $p=.02$). 1C curves with coronal decompenation were found to have significantly higher BMI (24.8 vs. 21.3, $p=.01$) and preoperative curve size (64.8° vs. 55.4°, $p=.005$).

Conclusion: The relationship between LIV and LEV was not associated with rates of curve decompenation for any curve type. In 1B curves, overcorrection may lead to increased rates of decompenation. In 1C curves, larger curves and higher BMI correlated strongly with decompenation.

Significance: In 1B curves, care must be taken not to overcorrect the main thoracic curve. In 1C curves, consideration should be given to either nonselective fusion or earlier intervention before curve magnitude increases, especially in patients with higher BMI.

E-Poster #256

Combined Results of the Three US IDE Randomized Cervical Arthroplasty Trials with 2-Years of Follow-Up

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United States



PRESTIGE cervical disc, flexion/extension views.

Summary: There have been three prospective, randomized, multi-center trials of cervical disc arthroplasty evaluating the PRESTIGE cervical disc, the BRYAN cervical disc, and the Pro-Disc C cervical disc. We have included non-published 24 month follow-up data from the PRESTIGE cervical disc trial. In total there were 605 investigational patients and 561 control patients. Cervical disc arthroplasty is a viable alternative to standard anterior cervical discectomy and fusion.

Introduction: There have been three prospective, randomized, multi-center trials of cervical disc arthroplasty evaluating the PRESTIGE cervical disc, the BRYAN cervical disc, and the Pro-Disc C cervical disc. The 24-month data from these randomized, controlled trials has been published and all have found that cervical disc replacement is a reasonable

alternative to anterior cervical discectomy and fusion. We performed an analysis of these three trials with unpublished full 24-month follow-up from the PRESTIGE cervical disc trial.

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Methods: All included studies had at least 24 months of available follow-up. Heller, et al. evaluated the BRYAN cervical disc enrolling 242 patients in the study arm and 221 in the control arm. Murray, et al. studied the ProDisc-C implant with 103 in the study group and 106 in the control group. Finally, Burkus, et al. studied the PRESTIGE disc with 276 patients in the investigational group and 265 in the control group; we had access to the full two year data set from the Prestige trial which has not yet been published. In total there were 605 investigational patients and 561 control patients.

Results: The trials were similar in the demographic variables of preoperative mean age, sex, neck disability index scores, SF-36 scores. The trials also had similar post-operative fusion rates (>90%) in the control arms, and maintenance of range of motion in the study arm (ranging from 6.5 - 9.36 degrees). The total secondary surgery rate was 3.1% for the combined arthroplasty cohort (19 revision/removal/reoperation) vs. 8.2% for the combined fusion cohort (46 revision/supplemental fixation/removal/reoperation). In an analysis of successful neurologic outcome, the relative risk was noted to be 1.08 (CI 1.03 - 1.12) favoring cervical disc arthroplasty.

Conclusion: Cervical disc arthroplasty is a viable alternative to standard anterior cervical discectomy and fusion. Reoperation rates are lower for the arthroplasty devices in the three randomized US IDE trials with two years of follow-up.

Significance: This is an analysis of the three largest cervical arthroplasty trials to date with full two 2-year follow-up.

E-Poster #257

Preoperative Risk Factors Predicting Loss of Sagittal Alignment After Short Fusions (T10-Pelvis) for Adult Idiopathic Scoliosis

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Summary: Failure of short fusion (T10-pelvis) constructs leading to loss of sagittal alignment has been reported in adult idiopathic scoliosis patients. Our cohort analysis has identified several pre-operative risk factors for failure of short fusions in these patients.

Introduction: Previous studies have shown that maintenance of global sagittal balance is critical, and that loss of sagittal alignment over time produces delayed failures and poor clinical outcomes. We sought to compare successful and failed short fusion scoliosis patients in attempts to identify key preoperative radiographic risk factors.

Methods: A radiographic outcomes assessment was made on 26 patients with adult thoracolumbar and lumbar idiopathic scoliosis treated with short fusions (UIV: T8-11) and a minimum 2-year f/u. Preoperative and all post-operative radiographs were analyzed for: coronal curve magnitude, coronal alignment, cervical lordosis, C2 and C7 sagittal vertical axis (SVA), cervicothoracic, thoracic and thoracolumbar kyphosis. We also recorded the incidence of proximal junctional kyphosis (PJK), progressive loss of sagittal balance, revision surgery, and previous anterior cervical discectomy and fusion (ACDF).

Results: 23 females and 3 males with mean age of 61 yrs (44-73), avg. f/u 34.7 mos. At final f/u, 17 patients maintained sagittal balance (avg. C7 SVA: -2.0cm, PJK: -4.3°). 9 patients had progressive loss of sagittal alignment (avg. C7 SVA: 4.2cm, PJK: -9°), ($p < 0.05$) of which 4 patients required revision surgery. Preoperative radiographs of the failed group revealed a statistically significant increase in thoracic kyphosis (T2-T12: -49° v. -32°), cervical sagittal imbalance (C2 SVA: 2.0 v. 1.46cm), cervicothoracic (T1 tilt: 28.7° v. 21.8°) and thoracolumbar kyphosis (-6.75° vs. 2.8°) compared to the balanced group ($p < 0.05$). History of prior ACDF was also found to be significantly higher in short fusion failure patients (38% vs. 0%), ($p < 0.05$).

Conclusion: Our study is the first to identify key preoperative radiographic risk factors which may increase the likelihood of sagittal imbalance after short fusions. We theorize that rigid cervical, thoracic and thoracolumbar kyphosis may cause constant cantilevering forces leading to progressive loss of sagittal balance.

Significance: This study identifies critical preoperative risk factors that may lead to failures of short (T10-pelvis) fusions, and could encourage consideration of extending fusion constructs proximally at the time of index surgery. Prospective studies are warranted.

E-Poster #258

Effect of Multi Rib Osteotomy on Pulmonary Functions after Correction of Adolescent Scoliosis

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Egypt

Summary: Rib osteotomy technique is used for giving more flexibility of the spine during correction. However, it leads to chest cage disruption and affection of pulmonary functions

Introduction: Rib osteotomy technique is used for giving more flexibility of the spine during correction especially in severe and rigid curves. However, rib osteotomy leads to a type of chest cage disruption and affection of pulmonary functions

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Methods: A prospective study of 50 patients who underwent posterior spinal fusion for correction of adolescent scoliosis. Patients were divided according to number of ribs osteotomy into two groups. Group 1 (n=16) who underwent posterior fusion in addition to rib osteotomy from 1-3 ribs, while group 2 (n=34) who had rib osteotomy from 4-6 ribs. All patients were evaluated regarding pulmonary functions and Cobb's angle preoperatively, post operatively, one year and two years post operatively. All patients received pulmonary rehabilitation program from one week postoperative till one years post operative

Results: Curve correction: The mean Cobb's angle at the preoperative and final follow up for group 1 was 72.9 ± 22.9 degree and 11.2 ± 3.9 degree respectively (85% correction). In group 2 it was 75.7 ± 21.7 degree preoperatively and 18.3 ± 10.9 degrees at final follow up (76% correction). Pulmonary functions: Pre operatively there was no significant difference between 2 groups. Immediately postoperative there was significant reduction regarding FVC by about 39% in group 1 and 69% in group 2. Another significant reduction was observed in MVV by about 60% in both groups. One year post operative FVC showed significant improvement in group 1 by 57% while in group 2 it was 28%. MVV showed another significant improvement by about 72% and 54% in group 1 and 2 respectively. Two years post operative showed no mean improvement in both groups which not exceeded 6% improvement

Conclusion: Multi rib osteotomy more than 3 ribs has a negative effect on pulmonary function extended till one year postoperative even with application of pulmonary rehabilitation program. However, rib osteotomy from 1-3 ribs has a negative effect just immediately postoperatively which converted at 1 and 2 years post operative

Significance: Rib osteotomy technique has a positive significant effect on curve correction however it has severe negative effect on pulmonary functions especially with osteotomy for more than 3 ribs. Pulmonary rehabilitation program has positive significant effect on improving pulmonary functions

E-Poster #259

A Radiologic Classification System (ICVAS) for Segmentation Defects of the Vertebrae that Aids in the Determination of Molecular Genetic Etiology

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Summary: We report on a system for classifying congenital segmentation defects of the vertebrae (SDV) that can be easily used to group patients by different molecular genetic etiologies. This system was tested by two groups of clinicians, found to have a better intraobserver variability than traditional systems, was able to distinguish between important causes of congenital spine deformity, and identified patients with clinically important extra-spinal manifestations.

Introduction: Existing nomenclature systems for congenital SVD are inconsistently applied, and lack the ability to predict molecular genetic etiology. The aim of this project was to develop and assess a new classification system that distinguishes between molecular genetic etiologies.

Methods: A multidisciplinary group of clinicians developed this classification system to place patients into groups that helps with molecular etiology, underlying diagnosis, determination of abnormalities in other organ systems, and as an aid in research. The classification system relies on radiographs and generates ten "scores" which define: the type of vertebral malformation, which are subgrouped as Multiple; Single; Regional; Generalized; and Undefined. In a first group, 5 clinicians independently classified 10 cases. Inter-observer reliability was assessed using kappa. In a second study, 7 independent general radiologists unaffiliated with the development of the classification examined 20 cases before and 20 cases after the system was explained.

Results: Inter-observer reliability for Group 1 yielded a kappa value of 0.41. A consensus diagnosis was established for the 10 cases. For Group 2, before the system was explained, one of 70 scores (1.4%) agreed with the Group 1 consensus diagnoses. Group 2 offered 12 different diagnoses, but 38 of 70 (54.3%) responses were 'Don't Know'. After the ICVAS system was explained, 57 of 70 responses (77.1%; 95% CI 65.5, 87.0) agreed with the Group 1 consensus, an improvement of 75.7% (95% CI 62.5, 85.6, $p < 0.00005$), with no 'Don't Know' responses. The system was able to distinguish between conditions such as caudal regression; Diabetic Embryopathy; Goldenhar; Jarcho-Levin; Kneist; Neurofibromatosis; Spondylocostal Dysostosis; Spondylo-thoracic Dysostosis; and VACTERL.

Conclusion: The ICVAS radiological classification system was found to be reliable and applicable for SDV phenotypes.

Significance: This system distinguishes between important molecular genetic causes of congenital spine deformity, and identifies patients with important extra-spinal clinical manifestations.

TRADITIONAL POSTER ABSTRACTS





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Poster #301

Abnormal Leptin Bioavailability in Girls with Adolescent Idiopathic Scoliosis

Zhen Liu; Hiu Yan Yeung; Guang-quan Sun; Kwong-man Lee, PhD; Wei-jun Wang; Yong Qiu; Jack C. Cheng, MD
Hong Kong

Summary: Girls with adolescent idiopathic scoliosis (AIS) was reported to be associated with lower body mass index (BMI) and lower bone mineral density (BMD). Many recent studies have revealed the importance of leptin in the normal regulation of fat and bone metabolism in children and adolescents.

Introduction: Our previous study found lower plasma leptin level in AIS girls and its association with low BMD without further defining whether the effect is related to low leptin level or its bioavailability. This pilot study aimed at investigating the leptin bioavailability by assessing the ratio of serum leptin to soluble leptin receptor (sOB-R) levels in AIS girls versus that in normal control.

Methods: 66 AIS girls and 27 normal age-matched girls were recruited in this study. Anthropometric data, puberty stage, clinical parameters and curve severity in AIS were documented in detail. Serum leptin and sOB-R levels were quantified with ELISA. Free leptin index (FLI) was calculated as the ratio of leptin to sOB-R levels. The relationships between leptin, sOB-R, FLI, age and pubertal stages were also analyzed with multivariate regression model.

Results: AIS girls (Cobb's angle 11-94°) and healthy controls were similar in age (14.1±1.5 and 14.2±1.6yr, respectively) and body weight (43.8±7.5 and 45.6±7.5kg, respectively). AIS girls was found to have significantly longer arm span and lower BMI. Although insignificant lower leptin level was found in AIS subjects, the sOB-R level was however significant higher than controls (p=0.004; Table 1). No significant correlation was found between leptin, sOB-R, FLI and curve magnitude in AIS girls. Multivariate regression showed that age and Tanner stage were the independent variables predicting the change of leptin and FLI. After adjusted for age, AIS girls consistently showed significantly lower FLI than the control girls (p=0.036). However, after corrected for Tanner stage, there was no significant difference in FLI level between AIS and normal girls (p=0.068).

Conclusion: This is the first pilot report on the finding of the significantly different leptin bioavailability in AIS girls versus healthy matched controls. This finding may implicate different central and peripheral effect of leptin in AIS girls. The lower BMI of AIS girls may be related to the lower leptin bioavailability during their pubertal age period rather than the serum leptin level itself. Further study on the detail pathophysiological effect of leptin bioavailability on AIS etiopathogenesis is warranted.

Poster #302

Factors Influencing the Decision for Surgical Intervention in Early Onset Scoliosis

Pooria Salari, MD; Jeff Pawelek, BS; Gregory M. Mundis, MD; Paul D. Sponseller, MD; Oheneba Boachie-Adjei, MD; Richard M. Schwend, MD; Patrick Bosch, MD; Laurel C. Blakemore, MD; Behrooz A. Akbarnia, MD
United States

Survey Questions

What is the minimum age you will perform surgery?
Is there a specific diagnosis (with EOS) that you will not perform surgery?
What is the minimum weight for age percentile you will perform surgery?
What is the minimum pulmonary function you will perform surgery?
Which cardiac issues do you consider as a contra-indication for surgical treatment?
What is the minimum Bone Mineral Density Z-Score you will perform surgery?
Rank the 4 most important factors in your decision making.

Table 1. List of questions posed to surgeons regarding contraindications for the surgical treatment of early-onset scoliosis.

Summary: When surveyed, scoliosis surgeons felt age and weight were the most significant factors in decided whether to perform vs. avoid surgery in early onset scoliosis (EOS). Diagnosis, pulmonary function, cardiac status and bone mineral density alone do not appear to be major contraindications for surgery in EOS.

Introduction: Children with early onset scoliosis (EOS) range from otherwise healthy idiopathic type to complex spinal anomalies with serious medical issues. No definitive recommendations exist

regarding contraindications to the surgical treatment of EOS. We aimed to identify surgeons' limits when considering surgical intervention in this complex group of patients.

Methods: A survey was designed to assess the demographic, diagnostic and clinical thresholds surgeons use when considering surgery in EOS. Seven multiple choice questions were selected based on a variety of clinical factors and were posed to surgeons who specialize in the treatment of EOS (Table 1).

Results: 31 surgeons responded to the survey. 27 (87%) surgeons considered age as a factor when considering surgical treatment and 22 (71%) would operate on patients between 6 months and 2 years of age. Osteogenesis imperfecta was the most common (14%) diagnostic contraindication for surgery; however, 22 of 28 (79%) respondents stated the patient's diagnosis was not a factor. While nearly half (53%) of surgeons stated weight was not a contraindication for surgery, the 25th

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weight-for-age percentile was most commonly (33%) reported as the minimum weight range considered for surgical treatment. If cleared by a pulmonologist, pulmonary function was not a factor for 23 of 31 (74%) surgeons. Similarly, if cleared by cardiology, 24 of 30 (80%) respondents would operate despite the presence of a cardiac disorder. Bone mineral density (BMD) was not a consideration for 22 of 31 (71%) surgeons; however, 22% of surgeons would avoid surgery if the Z-score < -2.5. When asked to rank the top 4 factors that influence their decision whether or not to perform surgery, 28 of 31 (90%) surgeons indicated patient age was most critical variable.

Conclusion: The survey results indicate diagnosis, pulmonary function, cardiac status and BMD alone are not major influencers in the decision to perform surgery in EOS while age and weight are more critical factors. However, the decision to perform or avoid surgery is often complicated by the combination of these factors, and an obvious need to arrest the natural history of the spinal deformity may outweigh potential risks.

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).

Poster #303

Treatment of Severe and Rigid Adult Idiopathic Scoliosis by Anterior and Posterior Spinal Fusion with Hybrid Segmental Instrumentation. Are Resection Procedures Necessary to Achieve Optimal Results?

Masayuki Ishikawa; Oheneba Boachie-Adjei, MD; Gerard K. Jeong, MD; Gregory M. Mundis, MD; Matthew E. Cunningham, MD, PhD United States

Summary: Anterior posterior spinal fusion for severe scoliosis achieves optimal outcomes.

Introduction: This study was aimed to assess radiographic outcomes and complication rates of anterior and posterior spinal fusion with hybrid segmental instrumentation for treatment of severe and rigid adult idiopathic scoliosis.

Methods: 20 consecutive adult patients (18 females and 2 males) with average age 48.1 years underwent combined anterior and posterior spinal fusion for scoliosis equal to or more than 80° with flexibility less than 25%. Two groups (Group 1: Cobb angle 80°, < 100°, N=11, Group 2: Cobb angle 100°, N=9) were reviewed for curve correction and complication rate. Mean follow-up period was 4.4 years (2-8.3 years).

Results: Scoliosis averaged 89.4° in Group 1 and 117.8° in Group 2 preoperatively. It measured 48.4°(45.9%) in Group 1 and 64.2°(45.5%) in Group 2 at final follow-up. Thoracic kyphosis and lumbar lordosis averaged 36.3° and 45.5° in Group 1, and 57.1° and 55.6° in Group 2 preoperatively, and averaged 36.2° and 56.9° in Group 1, and 49.8° and 64.5° in Group 2 at final follow-up. Sagittal balance improved from preoperative means of 50.7mm to 26.8mm in Group 1 and 41.2mm to 35.3mm in Group 2 at final follow-up.

Seventeen complications were observed in 10 patients (50%). Major complications (25%) included two implant failures, one deep wound infection, and two pulmonary emboli. There were no neurologic deficits and no pseudoarthrosis at follow-up.

No difference in curve correction or complication rate was observed between both groups.

Satisfaction score of SRS-22 questionnaire averaged 4.5 in Group 1 and 4.6 in Group 2.

Conclusion: Combined anterior posterior spinal fusion for severe rigid scoliosis may be associated with high pulmonary complication but is a more familiar and effective approach than technically demanding resection procedures with potential neurologic risks. Balanced curve correction is achieved with a high patient satisfaction.

Poster #304

Loss of Correction after Pedicle Subtraction Osteotomy in Degenerative Sagittal Imbalance

Kyu-Jung Cho, MD; Ki-Tack Kim, PhD; Whoan Jeang Kim; Sang-Hun Lee; Jae-Hoon Jung Korea, Republic of

Summary: Twenty-six patients underwent pedicle subtraction osteotomy with no anterior column support for degenerative sagittal imbalance. All PSO were performed at one segment. The patients with complications causing loss of correction were excluded. The loss of correction of lordotic angle at each lumbar segment was about 2o after PSO, and was not different between at the osteotomy site and non-osteotomy site. Therefore, anterior column support at any segments within the fusion construct would be helpful to reduce the loss of correction.

Introduction: Loss of correction (LOC) after pedicle subtraction osteotomy (PSO) is common in the patients with degenerative sagittal imbalance. Anterior column support at the mobile segments is recommended to reduce LOC. However, it is not

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determined which segments have more LOC within the fusion construct. The purpose of this study was to determine where the LOC occurred more often after PSO in degenerative sagittal imbalance.

Methods: Twenty-six patients who underwent PSO with no anterior column support were analyzed with a minimum 2 year follow-up. This study excluded the patients with any complications causing loss of correction such as pseudarthrosis and implant failure. The mean age was 66.6 years, ranging from 56 to 74. All of the PSO were performed at one segment, including at L3 (n=24) and L4 (n=2). The average number of levels fused was 6.8 segments. The upper instrumented vertebra was T10 (n=8), T11 (n=6), T12 (n=10), and L1 (n=2). The fusion extended to the sacrum in all patients. Twelve patients had additional iliac screw fixation.

Results: The osteotomy angle, measured from the upper endplate of the vertebra one above the osteotomy to the lower endplate of the vertebra one below the osteotomy, was 9.3° preoperatively, -28° after surgery, and -24° at the last visit. The LOC was 4.2°, corresponding to 2.1° at one segment. The lumbar lordosis, measured from L1 to S1, was 1.4° before surgery, -37° after surgery, and -27° at the final follow up. The LOC was 10°, corresponding to 2° at one segment. The average LOC at each lumbar segment was about 2°. The LOC at the osteotomy site was not different from the LOC at the non-osteotomy site. The sagittal C7 plumb was 192.7mm before surgery, corrected to 39.7mm after surgery, and changed to 86.8mm at the last visit. The correction of sagittal C7 plumb was 105.9mm, and the LOC was 47.1mm.

Conclusion: The loss of correction of lordotic angle at each lumbar segment was about 2° after pedicle subtraction osteotomy in degenerative sagittal imbalance, and was not different between at the osteotomy site and non-osteotomy site. Therefore, anterior column support at any segments within the fusion construct would be helpful to reduce the loss of correction.

Poster #305

Results of Surgical Treatment for Scheuermann's Kyphosis using Combined Front-Back Approach & Pedicle-Screw Constructs: A Base for Benchmark Comparisons Through Analysis of 111 Cases

Heiko Koller, MD; Oliver Meier; Luis Ferraris, MD; Axel Hempfing; Marianne Umstätter; Rene Schmidt; Juliane Zenner, MD Germany

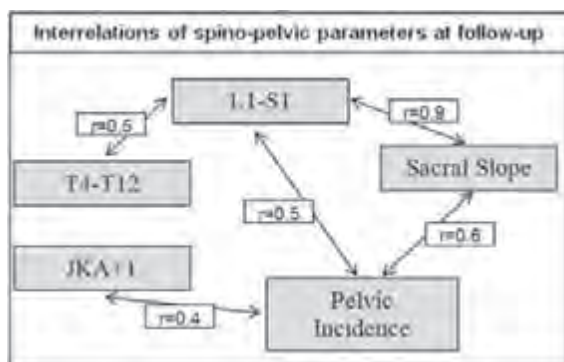


Fig.1

Summary: Analysis of surgical results with anterior-open release and posterior fusion using pedicle-screw constructs in the treatment of 111 Scheuermann's kyphosis (SK). The combined approach offered good results in a large series. Findings of our study emphasize the impact of curve flexibility on curve correction in SK and curve flexibility as the decisive parameter to compare cohorts treated with combined vs. posterior-only approach. Concerning the pathogenesis of PJK, we identified the spino-pelvic morphology as a potential key-parameter for further research.

Introduction: A paucity of data on treatment for Scheuermann's kyphosis (SK) exists regarding the ideal strategy. The impact of combined strategy (ant.release & post.fusion; AR/PSF) on correction rate & surgical outcome is yet to be defined.

Methods: Review of 111 consecutive SK operated w/ AR/PSF. Assessment of demographics, complications & radiographs incl. flexibility & correction measures, prox. junctional kyphosis angle (JKA+1) & spino-pelvic parameters focusing on impact of curve flexibility on correction & outcomes (ODI, SRS-24).

Results: Age 23±11y, follow-up 25 mo. Number of levels treated 8±1.5. Correction per level was 4±2°. Screw-density rate was 87±13%. Cobb angle (CA) at fusion length was 68±12° preop, 41±16° postop. Flexibility on traction films was 35±14% & correction rate 47±22%. 22 pat sustained minor complications. 21 pat had additional surgery. Statistics showed a mean difference betw/ CA at fusion length on traction-films vs postop films of 9±11°. Postop & follow-up CA were highly correlative w/ preop traction-films (r=.7). Correction sign. depended on preop flexibility on traction-films (r=.6). Statistics revealed additional scoliosis reduced flexibility (p=.01) & correction (p=.03). Higher screw-density increased correction (p<.001, r=.4). In 46 pat prox. JKA+1 could be assessed in detail averaging 8°±9.21 of 46 pat (46%) had a PJK (JKA+1 ≥10°, ≥10° than preop) of 16°±6. Pat w/ increased JKA+1 were at higher risk for revision (p=.049) while pat w/ revision or subsequent surgery had decreased outcomes (SRS-24; p<.01; ODI; p<.01). Concerning spino-pelvic balance, interrelations betw/ pelvic & spinal parameters maintained. Median PI was 46±11°. The preop JKA+1 sign. correlated w/ PI (r=.4), number of levels fused (r=.4) and postop loss of correction (r=-.3).

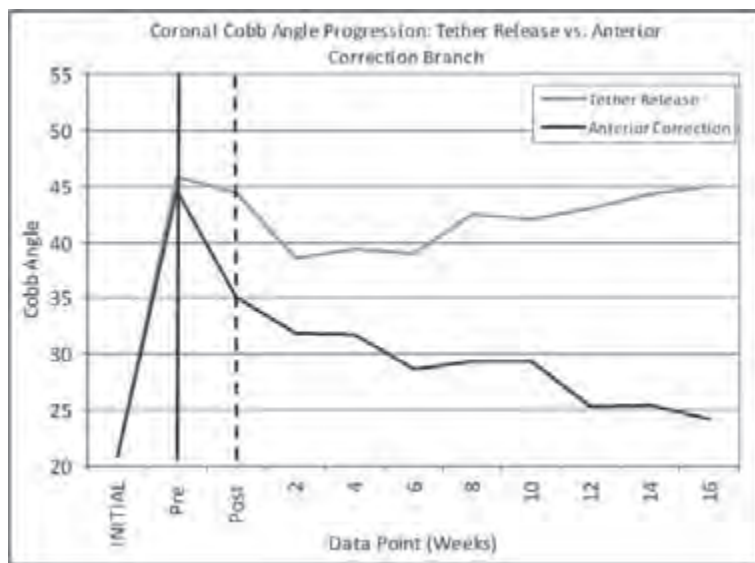
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Conclusion: Our study highlights that flexibility is the decisive measure when comparing outcomes w/ different treatment strategies. Findings might indicate that changes at the junctional level are a) impacted by individual spino-pelvic morphology and b) exacted by the individually predetermined thoracolumbar curvature & sagittal balance. Good results could be achieved w/ AR/PSF. Data are open for benchmark comparisons w/ posterior-only strategies yielding for a refinement of surgical indications in SK.

Poster #306

Progressive Spinal Deformity Correction via an Anterior Based Tether in a Porcine Scoliosis Model: A Detailed Radiographic Analysis

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United States



Summary: Non-fusion techniques for surgical correction of scoliosis in an immature spine have recently received substantial interest. Using the porcine scoliosis model, this study aims to investigate the impact of an anterior corrective convex spinal tether on radiographic alignment compared to a control group. Application of an anterior based convex staple-screw-tether construct in group 2 resulted in significant progressive correction of the coronal deformity (~ 50%) without significant sagittal plane re-alignment. Data from this study support the possibility of clinical techniques for non-fusion scoliosis correction

Introduction: Non-fusion techniques for surgical correction of scoliosis in an immature spine have recently received substantial interest. Using an established Porcine Scoliosis Model (PSM), this study aims to investigate the impact of an anterior convex spinal tether on radiographic alignment changes with growth (non-fusion)

Methods: This IACUC approved Study included 10 immature Yorkshire Pigs divided equally into 2 groups; tether release group (TR) and anterior corrective tether group (AC). All animals underwent scoliosis induction surgery (max. coronal Cobb: 17°-25°) at 12 weeks of age and progressed a mean 4.0°/week. Once >50° was noted, a second surgical intervention was pursued: TR had release of the inducing tether; AC had tether release and placement of a corrective device over the 5 apical vertebrae. Both groups were observed for an additional 16 weeks with bi-weekly radiographs. Student t-test was used to investigate radiographic differences between groups

Results: No significant differences existed between TR and AC regarding; induced Cobb angle, days with deforming tether, or coronal and sagittal alignment before the 2nd intervention (all, p>0.05).

Coronal Plane:

Significant differences in Cobb angle between TR and AC animals were noted following the 2nd intervention (resp. 44.4°±2.2° and 35.0°±2.4°; p=0.001) and bi-weekly beyond 4 weeks (p<0.01). Final Cobb measurements were 45.0°±2.9° for TR and 24.4°±9.0° for AC (p=0.001).

Sagittal Plane:

No significant differences existed in sagittal alignment between TR and AC animals immediately following the 2nd intervention (resp. 14.4°±26.2° and 16.2°±10.2°; p=0.88) and at final follow up; 16.2°±20.9° and 21.2°±12.3° respectively (p=0.65)

Conclusion: Using the PSM, this study investigated radiographic differences between control and treatment groups. Application of a non-fusion anterior based convex staple-screw-tether resulted in significant progressive correction of the coronal spinal deformity (~ 50%) without significant sagittal plane re-alignment

Significance: Data from this study support the possibility of clinical techniques for non-fusion scoliosis correction in the immature spine through growth modulation

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Poster #307

Instrumenting Proximal to the Left Bending Stable Vertebra in Lenke IA and IB Adolescent Idiopathic Scoliosis Predicts Adding On

Hossam Salah, MD FRCS; Hazem B. Elsebaie, FRCS, MD; Ahmed Ezz
Egypt



3 year postop xray showing the development of adding on distal to the fusion. Earlier xrays showed neutral lumbar vertebrae without tilting distal to the instrumentation.

Summary: A retrospective analysis of Lenke IA and IB AIS cases was performed. The lower end vertebra, the stable vertebra, the neutral vertebra, the left bending stable vertebra and lower instrumented vertebra were recorded. Latest x-rays were sought for adding on. Instrumenting proximal to the left bending stable vertebra had an 83% incidence of adding on.

Introduction: Adding on denotes the inclusion of additional vertebra into the major curve distal to the lower instrumented vertebra. Selection of the distal level of fusion seems to be a key factor in the prevention or otherwise of this phenomenon.

Methods: 56 patients with Lenke IA and IB adolescent idiopathic scoliosis had their radiographs retrospectively reviewed. There were 52 females and 4 males. The mean age at the time of surgery was 14.2 years. The following data were documented: the lower end vertebra (LEV), the stable vertebra (SV), the neutral vertebra (NV), the most proximal lumbar vertebra bisected by a central sacral perpendicular line in the supine left side bending films, we designated the left bending stable vertebra (LBSV), and the lower instrumented vertebra (LIV). The presence of adding on below the fused segment was searched for in the latest follow up radiographs. The mean follow up was 35.4 months with a minimum of 26 months.

Results: the LBSV was proximal to the SV in 42 patients (75%). Five patients (9%) showed adding on in their latest radiographs. All patients that had their LIV at or distal to the LBSV were balanced without adding on. On the other hand, five out of the six patients (83%) who had their LIV proximal to the LBSV developed adding on at the latest follow up.

Conclusion: The assessment of the left bending stable vertebra (LBSV) can be used as a guide to determine the lower instrumented vertebra in the Lenke IA and IB AIS. This can allow saving levels in the proximal lumbar spine while achieving coronal balance and avoiding the risk of adding on.

Significance: A guide to selecting the lower instrumented vertebra in Lenke IA and IB AIS and a predictor of adding on is presented in this series.

Poster #308

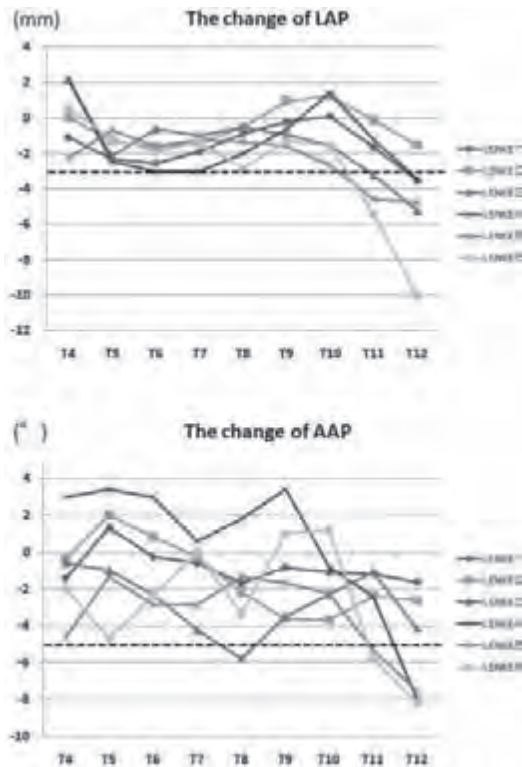
The Changes of Relative Position of the Aorta to the Vertebra after Posterior Instrumentation in AIS with Right Thoracic Curve

Yoshiyuki Okada; Koki Uno, MD, PhD; Hiroshi Miyamoto, MD; Yoshihiro Inui; Teppei Suzuki; Takuto Kurakawa; Minoru Doita, MD
Japan

Summary: Relative movement of the aorta to the spine in thoracic curves of Adolescent Idiopathic Scoliosis (AIS) after posterior fusion with pedicle screws were examined by CT scan. After surgery, there were few relative movement of the aorta to the spine in Type 1, 2 curves. However, in Type 3, 4, 5, 6 curves, the aorta moved towards the pedicle. These results suggest that special care needs to be taken for thoracic pedicular screwing at concave side in Type 3, 4, 5, 6 curves of AIS.

Introduction: There were few reports evaluated the position of the aorta after posterior surgery for adolescent idiopathic scoliosis (AIS) and no reports evaluated this position according to the curve types. The purpose of this study is to analyze the aorta movement after the posterior correction and instrumentation in AIS on Lenke classification.

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Methods: 92 patients with right-thoracic or thoracolumbar curve of AIS were included. CT scans were reviewed pre(805 vertebrae) and post(738 vertebrae) operatively. All cases were female with Lenke Type1(n=33), Type2(n=18), Type3(n=13), Type4(n=5), Type5(n=17) and Type6(n=6) curves. No differences were found among the Lenke types with respect to age(16.8 ± 4.9), body height(156.1 ± 7.6 cm) and correction rate($72 \pm 14\%$). CT measurements included **LAP** (the length between an aorta and an insertion point of PS) and **AAP** (the angle between Aorta and Pedicle). We defined the vertebrae with LAP ≥ 30 mm and $\leq -5^\circ$ AAP $\leq -5^\circ$ as **HRV**(High Risk Vertebrae).

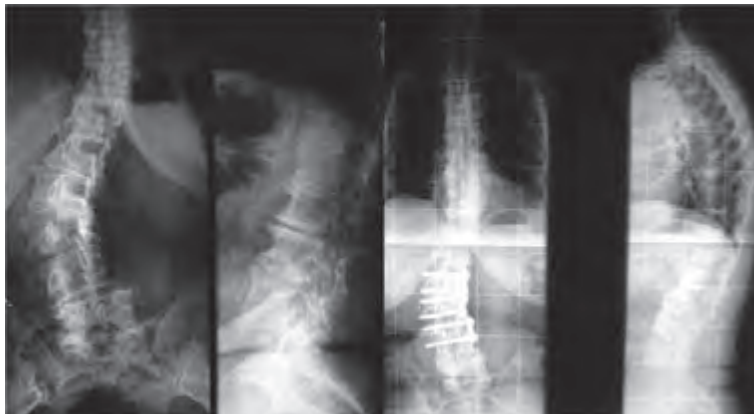
Results: The LAP with over 3mm decrease was observed in Type1(T12), Type3(T11,12), Type4(T6,7,12), Type5(T11,12) and Type6(T11,12). On the other hand the absolute value of AAP with over 5° decrease was observed in Type3(T8), Type4(T12), Type5(T11,12) and Type6(T11,12). Before surgery, HRV $\geq 20\%$ was observed in Type1(T4,10,11), Type2(T4,11), Type3(T10,11), Type4(T4,5,10,11), Type5(T4,8,9) and Type6(T4). Though the number of HRV did not change in Type1 and 2, the number of HRV in Type3(T4), Type4(T12), Type5(T5-7,10) and Type6(T5,10) increased after surgery.

Conclusion: After surgery, there were few relative movement of the aorta to the spine in Type1,2 curves. In Type3,4,5,6 curves, however, the aorta moved towards the pedicle. These results suggest that special care needs to be taken for thoracic pedicular screwing at concave side in Type 3,4,5,6 curves.

Poster #309

Changes in Coronal and Sagittal Plane Alignment after XLIF Procedure in the Treatment of Degenerative Scoliosis

Leonardo Olivera; Luis Marchi; Etevaldo Coutinho; Luiz Pimenta
Brazil



Summary: This paper presents a lateral retroperitoneal minimally invasive approach (eXtreme Lateral Interbody Fusion - XLIF) for the treatment of adult scoliosis requiring more than four levels of arthrodesis without the morbidity of an open procedure

Introduction: The traditional treatments to degenerative scoliosis consist in open surgeries, with high incidence of morbidity. Here we present a lateral retroperitoneal minimally invasive approach for the treatment of adult scoliosis. Symptomatic adult scoliosis deformity presents as a difficult problem to solve. Traditional treatments include anterior and posterior open approaches.

Methods: A prospective, non-randomized, single center clinical trial with 60 patients, mean age 66.95

(50-87 years), that underwent XLIF procedure to treat degenerative scoliosis. Lateral, A-P, flexion-extension X-rays, neurological examination and clinical outcome assessments using Oswestry and VAS scores were performed at the preoperative, 1, 6 week, 3, 6, 12, 24, 36, 48 and 60 months postoperative intervals. The extreme lateral approach was done through the retroperitoneal space and through psoas muscle avoiding vascular lesions. A partial discectomy was done and the end-plate cleaned preserving ALL, keeping the spine more stable than the traditional anterior surgery. The operated levels ranged from four to seven levels, including T10-T11 to L4-L5.

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Results: The procedures were performed without complication in an average 121 minutes and with less than 50cc blood loss. Ten patients had four levels of fusion; two patients had five levels and two patients with seven levels of arthrodesis. VAS pain scores improved from an average 8.33 at pre-op to 3.47 at 5 years, standard deviation 1.49 and 1.34 respectively. Oswestry scores improved from an average 51.2 at pre-op to 29.52 at 5 years with standard deviation of 13.42 and 13.47 respectively. Coronal and sagittal alignments improved from average Cobb angles of 16.4 degrees at pre-op and 7.5 degrees at 5 years, and average lordosis angles of 17.1 degrees at pre-op to 34.2 degrees at 5 years.

Conclusion: Using the XLIF approach we were able to treat long thoracolumbar deformities in a minimally invasive way targeting the pain improvement after surgery without the risks and morbidity associated with big corrections. Our intent was pain improvement and stabilization. We found reasonable coronal and sagittal correction in addition to successful clinical improvements in pain and function in long thoracolumbar reconstructions.

Poster #310

Biomechanical Analysis of Osteotomy Type (OWO, CWO) and Rod Diameter for Treatment of Cervicothoracic Kyphosis

Justin K. Scheer, B.S.; Jessica A. Tang; Vedat Deviren, MD; Jennifer Buckley, PhD; Murat Pekmezci, MD; Robert T. McClellan, MD; Christopher P. Ames, MD
United States

Summary: Pure moment biomechanical testing showed that CWO (closing wedge osteotomy) is more mechanically stable than OWO (opening wedge osteotomy) and increasing rod diameter from 3.5 to 4.5mm results in a non-trivial increase in rigidity.

Introduction: Sagittal imbalance of the cervicothoracic spine causes severe pain and loss of horizontal gaze. Traditionally, C7 OWO has been performed for patients with ankylosing spondylitis, but for those without, CWO may be considered for more controlled closure. This study characterizes the structural stability of the two osteotomy types and the independent effect of rod diameter.

Methods: 14 human spines (M/F=8/6; 60±10y.o.; C3-T6) underwent sagittal alignment and posterior bilateral screw-rod fixation (C4-C6 4.0x16mm lateral mass screws; T1-T3 4.0x34mm pedicle screws) with both 3.5 and 4.5mm Ti posterior fixation rods (Ulrich Medical). Half the specimens received OWO and half received CWO. Non-destructive flexion/extension (FE), lateral bending (LB), and axial rotation (AR) tests were conducted to 4.5 Nm. 3D motion tracking monitored primary range-of-motion (ROM) across the fixation (C4-T3) and osteotomy (C6-T1).

Results: Independent of osteotomy type, constructs instrumented with 4.5mm rods exhibited a significant increase in rigidity compared to the 3.5mm rods in all bending modes ($p<0.01$). Relative to 3.5mm rods, 4.5mm constructs showed $31\pm 12\%$ greater rigidity in FE, $37\pm 39\%$ in LB, and $31\pm 11\%$ in AR. At the osteotomy, there was a $43\pm 23\%$ increase in FE rigidity, $45\pm 36\%$ in LB, and $41\pm 17\%$ in AR. Independent of rod diameter, CWO was significantly stiffer than OWO in FE bending only ($p<0.05$). Relative to OWO, CWO demonstrated 42% greater rigidity in FE for the construct and 56% for the osteotomy.

Conclusion: OWOs and CWOs demonstrated similar sensitivity to changes in rod diameter, meaning that the surgeon can expect a similar increase in construct rigidity in switching from 3.5 to 4.5mm rod independent of osteotomy type. The increased stiffness observed in specimens receiving CWOs has an anatomical basis. OWOs disrupt the ALL and leave a significant anterior gap while CWOs create a wedge through the vertebral body and leave the ALL and the discs above and below the osteotomy intact. The closure in CWOs leaves no anterior gap providing greater axial loading stability. This greater bone on bone contact in CWOs is likely a significant reason for the anterior stiffness and may provide greater fusion rates in the non ankylosing spondylitis patient population.

Poster #311

Melatonin Modulates the Proliferation and Differentiation of Human Growth Plate Chondrocytes

Guangquan Sun, PhD; Hiu Yan Yeung; Wei-jun Wang; Kwong-man Lee, PhD; Zhen Liu; Yong Qiu, MD; Jack C. Cheng, MD
Hong Kong

Summary: Girls with adolescent idiopathic scoliosis (AIS) were shown to have abnormal systemic skeletal growth during peri-pubertal period. Reports have suggested that melatonin might play an important role in bone formation and could be related to the etiopathogenesis of AIS.

Traditional Poster Abstracts

Introduction: Though melatonin receptors were found in resting and hypertrophic chondrocytes, the role of melatonin in chondrocytes and endochondral ossification is not clear. We hypothesize that melatonin may play a role in modulating chondrocyte activity which in turn could affect the process of endochondral ossification. The present pilot study was aimed to investigate the role of melatonin on the proliferation and differentiation of human growth plate chondrocytes (GPC).

Methods: Growth plate chondrocytes were isolated from aborted human fetus after obtaining proper consent. Melatonin receptor expressions (MT1 and MT2) on GPCs were detected by immunofluorescence technique. Effect of melatonin on the proliferation of GPC were studied under different concentrations of melatonin in the presence/absence of melatonin antagonist (pertussis toxin and 4P-PDOT). The effect of melatonin on differentiation was assessed through collagen type X gene and alkaline phosphatase gene expression in GPCs after treated with different concentration of melatonin for 2 weeks. The levels of mRNA expression of the two genes were determined by RT-PCR.

Results: Both MT1 and MT2 receptors were expressed in isolated GPCs. The GPC proliferation was significantly inhibited by melatonin. The inhibitory effect was blocked partially by pertussis toxin and 4P-PDOT. Melatonin increases the mRNA level of collagen type X and alkaline phosphatase in differentiated GPCs.

Conclusion: These findings indicated that melatonin could inhibit the proliferation and stimulate differentiation of GPC in human. Both MT1 and MT2 membrane receptors in GPC were involved in mediating the proliferative effect of melatonin. Based on the present findings, further studies are warranted to further uncover the pathophysiological mechanism on how melatonin modulates endochondral ossification.

Poster #312

Spinal Deformities in 30 Patients with Sotos' Syndrome

Koki Uno, MD, PhD; Noriaki Kawakami, M D; Morio Matsumoto, MD; Taichi Tsuji, MD; Kota Watanabe; Teppei Suzuki; Toshiaki Kotani; Shohei Minami; Tsutomu Akazawa, MD
Japan

Summary: We examined the spinal deformity in 30 patients with Sotos' syndrome.

There were different kind of curve pattern and curve progression in this disease and the curve was not always progressive. Early operative intervention such as growing rod or Shilla operation needs to be carefully reconsidered for the mild curves in this disease.

Introduction: In patients who have Sotos' syndrome, bone age is advanced in all children, and the rapid skeletal growth may account for a 4% incidence of scoliosis. However most of the papers concerning spinal deformity in this disease were case reports and no large series of cases was reported. So the characteristics of spinal deformity in this disease is still unclear. We examined the spinal deformity in 30 patients with Sotos' syndrome, which is the largest series of cases to our knowledge.

Methods: There were 30 patients. 18 were male and 12 were female. 20 patients were performed surgery (Surgery Group) and 10 were observed with or without brace treatment (Non-Surgery Group). Average age at first surgery in Surgery Group was 10.3 years and average age at latest follow up in Non-Surgery Group was 6.1 years. Growing rod was performed in 8, posterior fusion in 8, anterior release and posterior fusion in 2, anterior fusion in 1, growth enhanced operation (Shilla) in 1 patient. Preoperative standing AP and lateral radiographs of the Surgery Group or radiographs of Non-Surgery Group at latest follow up were obtained and characteristics of their curve were examined.

Results: There were 23 scoliosis and 7 kyphoscoliosis or kyphosis. In Patients who underwent surgery due to scoliosis, average magnitude of the scoliosis before surgery was 73.5 degrees. In patients who underwent surgery due to kyphosis or kyphoscoliosis, average magnitude of the kyphosis before surgery was 82 degrees. In Non-Surgery Group, average magnitude of the scoliosis at latest follow up was 51.2 degrees and magnitude of the curve in 8 patients out of 10 was less than 50 degrees and did not progress with average of 3 years follow up.

Conclusion: Based on our study, it is likely that the spinal deformity in Sotos' syndrome is not always progressive. Early operative intervention such as growing rod or Shilla operation needs to be carefully considered for the mild curves in this disease.

Traditional Poster Abstracts

Poster #313

The Potassium Voltage-Gated Channel, Shaw-Related Subfamily, Member 4 (KCNC4) Locus as Strongly Associated to Adolescent Idiopathic Scoliosis (AIS) Progression

*Rakesh Chettier, MS; Roberto A. Macina, PhD; James W. Ogilvie, MD; Lesa M. Nelson, BS; Kenneth Ward, MD
United States*

Summary: Our genome wide association study identified single nucleotide polymorphisms (SNPs) associated with AIS curve progression. Fine mapping of the chromosomal region around the gene for one ion channel (KCNC4 a Shaw-related, voltage-gated potassium channel) identified a number of haplotypes associated with AIS progression.

Introduction: AIS is a structural, lateral curvature of the spine $> 9^\circ$, without a known cause, and diagnosed between age 9 and skeletal maturity. Our genome wide association study identified single nucleotide polymorphisms (SNPs) associated to AIS curve progression. We conducted fine mapping of six selected regions identified by the GWAS to identify additional associated variants and to discover AIS progression-associated haplotypes.

Methods: We delimited the fine-mapping regions according to the HapMap LD region. For LD regions that were small or had a low density of SNPs ($< 20\text{kb}$), we extended the region to include SNPs located $\pm 50\text{kb}$ from the GWAS-associated variants. A total of 1041 SNPs were selected from HapMap and were genotyped on the Illumina iSelect (Illumina, San Diego, CA) platform utilizing 221 severe AIS and 490 mild AIS samples.

Results: Of all six regions, the KCNC4 locus contained many additional SNPs with the stronger association signals in the fine-mapping analysis. The strongest signal came from rs958798, located in an intronic region of the gene KCNC4 ($p = 8.8 \times 10^{-6}$). KCNC4 codes a Shaw-related, voltage-gated potassium channel protein. We also identified a number of haplotypes associated to AIS progression. Of these, the haplotype with the strongest association also belongs to the KCNC4 locus ($p = 0.0002$).

Conclusion: Fine-mapping of the KCNC4 region yielded additional SNPs with good association signal, which indicates that the KCNC4 locus is strongly associated with AIS curve progression. The KCNC4 protein has been previously implicated in central nervous system diseases such as Alzheimer's and skeletal muscle disorders, i.e. periodic paralysis. This and other proteins involved in nervous system development and skeletal muscle function may play critical roles in AIS etiology and progression.

Significance: The KCNC4 locus could be utilized to develop potential diagnostic and prognostic assays and the protein coded by the KCNC4 gene could be used as a potential therapeutic target for adolescent idiopathic scoliosis curve progression.

Poster #314

Proximal Junctional Kyphosis in Primary Adult Deformity Surgery - PJK of 20 Degrees as a Critical Angle

*Matthew M. Kang, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Lukas P. Zebala, MD; Joshua M. Pahys, MD; Samuel K. Cho, MD; Woojin Cho, MD PhD; Ian G. Dorward, MD; Christine Baldus, RN MHS
United States*

Summary: PJK ≥ 20 occurred in 27.8% of adult idiopathic/degenerative scoliosis patients undergoing primary surgery between 2002-2007. PJK ≥ 20 had the strongest association with older age and constructs from the lower thoracic spine to the pelvis. PJK ≥ 20 generally did not lead to revision surgery for PJK, but a trend toward significance in worse SRS self image scores were seen.

Introduction: The goal of this study was to identify a proximal junctional kyphosis (PJK) angle leading to negative outcomes by comparing primary adult idiopathic/degenerative scoliosis surgical patients using 20 degrees as a critical angle as prior studies using 10 have not demonstrated negative outcomes. No study has analyzed PJK at a 20 degree threshold on predominantly pedicle screw/rod constructs while excluding patients with sagittal imbalance syndromes.

Methods: Clinical and radiographic data of 90 consecutive primary surgical patients at a single institution (2002-2007) with adult idiopathic/degenerative scoliosis and 2 yr minimum follow up (avg. 3.5 yrs) were analyzed. Assessment included various radiographic measurements, but most notably sagittal Cobb angle of the PJ angle at preop, between 1-2 months, 2 yrs, and ultimate follow up.

Results: Prevalence of PJK ≥ 20 at 3.5 years was 27.8% (N=25). Those with PJK ≥ 20 at ultimate follow up were older (mean 56 vs. 46 yrs.), had lower number of levels fused (median 8 vs. 11) and were proximally fused to the lower thoracic spine more often than upper thoracic spine (all $P < .001$). PJK ≥ 20 was associated with significantly higher BMI and fusion to the sacrum with iliac screws ($P < 0.016$, $P < 0.029$ respectively). Except 1 patient revised for traumatic increase of PJK from 1 to 40, there were no statistical differences in SRS outcomes scales in patients with ≥ 20 degrees of PJK vs. < 20 . Mean changes in SRS outcomes (PJK ≥ 20 vs. PJK < 20), for self image were 0.91 vs. 1.29 ($p = 0.083$), for pain were 0.87 vs. 0.9 ($p = 0.9$), and function were 0.33 vs. 0.42 ($p = 0.6$).

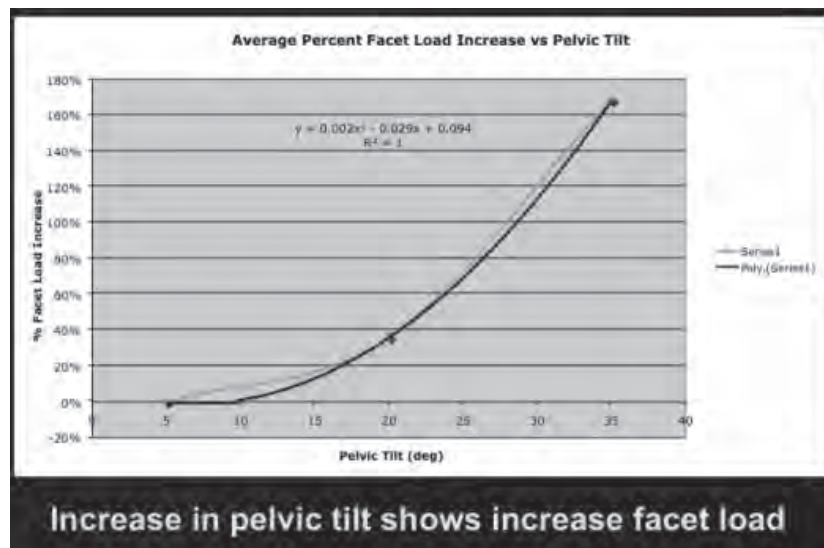
Traditional Poster Abstracts

Conclusion: PJK ≥ 20 degrees, in primary adult idiopathic/degenerative scoliosis with mainly pedicle screw/rod constructs, in general, does not lead to revision surgery for PJK, but is significantly associated with a mean age of 56yrs or more, shorter constructs starting in the lower thoracic spine, obesity, and fusion to the sacrum. SRS outcome score changes were lower for PJK ≥ 20 in all domains, but not significantly different from those with PJK < 20 , however, there was a strong trend towards less improvement in self image scores ($p=0.083$).

Poster #315

An In-Vitro Analysis of Pelvic Incidence and its Affect on the Lumbosacral Junction and the Development of Spondylolisthesis

Justin V. Bundy, MD; Michael D. Daubs, MD; Alpesh A. Patel, MD; Darrel S. Brodke, MD
United States



Summary: Pelvic Incidence (PI) has been found to clinically correlate with the presence and severity of isthmic spondylolisthesis. No study has evaluated the biomechanical characteristics of PI on the lumbosacral (LS) junction or its potential role in the development of spondylolisthesis. Our study shows that high pelvic incidence substantially increases load across the facets and annulus. In the setting of L5 spondylolysis, high PI and pelvic tilt (PT) caused listhesis.

Introduction: The angular relationship of the sacrum to the pelvis has been described as pelvic incidence (PI). PI describes the global shape of the pelvis and the position of the sacrum within the pelvis. High PI has been shown to clinically correlate with both the presence and severity of isthmic spondylolisthesis. No study has evaluated the biome-

chanical effect of varying degrees of PI on the lumbosacral junction and its potential role in the development of spondylolisthesis. The purpose of this study was to develop an in-vitro model to analyze PI and its affect on annular strain, shear loads, facet loads, and shear motion at L5-S1 and identify any causative relationship to the development of isthmic spondylolisthesis.

Methods: Seven cadaveric lumbosacral spines were mounted in a pneumatically controlled spine simulator with the S1 segment in a custom sacro-pelvic fixture that allowed for controlled changes in sacral slope. Varying degrees of PI were recreated by changing PT through the alteration of the magnitude and vector position of the follower load on the lumbar spine at L5, and by changing the sacral slope (SS). Using an optoelectronic motion measurement system at the disc and pressure transducers in the L5-S1 facet joints, the facet load and shear motion were measured at varying degrees of PI. The pars interarticularis was then osteotomized bilaterally to simulate spondylolisthesis, and the specimens were re-tested.

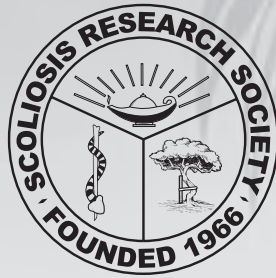
Results: Pelvic incidence had a linear affect on annular strain and exponentially increased loads across the facet joints. Specimens with intact pars exhibited no motion at any degree of PI. Only after pars osteotomy was performed did L5 listhesis occur and it was most influenced by increasing PT.

Conclusion: Our findings show that a high PI substantially increased the loads across the facets and annulus at the LS junction. In the setting of spondylolysis, high PI biomechanically caused listhesis and may be an important factor in the development of spondylolisthesis.

Significance: This biomechanical model allows the opportunity for further investigation into the potential causative relationship between pelvic incidence and isthmic spondylolisthesis.

ABOUT SRS





The Scoliosis Research Society gratefully acknowledges Zimmer Spine for their overall support of the 45th Annual Meeting.



About SRS

Goals and Mission Statement

Scoliosis Research Society Mission Statement

The purpose of scoliosis research society is to foster the optimal care of all patients with spinal deformities

Goals and Aspirations of the Scoliosis Research Society

The scoliosis research society is composed of physicians and scientists, who, prior to becoming members, have concentrated on the problems of spinal deformities and who, as members, make a continuing commitment to solve the problems of spinal deformity, to participate in research and to contribute to the society's educational and service efforts the business of the scoliosis research society is knowledge the society is concerned with the development of new knowledge, the continuing education of its members, and the communication of knowledge to others Because knowledge brings responsibility, members are committed to the highest standards of ethical practice and professional service to the society and the community research, education and care of patients are the central activities through which members channel their expertise it is expected that members will be active to some extent in each of these areas, but with different emphasis based on individual interests and talents.

Research

It is not by accident that the word "research" occupies a central place in the name of our society the members of the society are committed to research in spinal deformities.

All members participate in some research activity which leads to increased knowledge the one society-sponsored research project in which every member can participate is the Morbidity and Mortality report this project has produced more useful information for the society than any other single research program other means of participation in research include individual basic scientific or clinical studies, interinstitutional studies or society-sponsored projects in all forms of research, members strive for objectivity and meticulous honesty.

Education of Members

New data and new techniques evolve rapidly in the medical and surgical care of spinal disorders the members of the scoliosis research society take responsibility for their own continuing medical education in addition, the society provides structured educational experiences through printed material, IMAST, worldwide conferences and the Annual Meeting. These educational efforts are focused on the members of the society, who already possess a high degree of expertise, and their value depends on the member's willingness to participate. Members contribute to the education of others by reporting on cases from their own practices in the open forums of the Annual Meeting and IMAST.

Education of Residents and Fellows

We believe that the possession of specialized knowledge and expertise carries with it the responsibility to transmit this to others. The members of the society, collectively and individually, will participate in the design and structuring of residency and fellowship programs. We expect society members to be active in AAOS and comparable educational programs in spinal deformities for orthopaedists.

Public Education

The scoliosis research society recognizes a responsibility to public education and the need for effective liaison with lay organizations dedicated to some aspect of the prevention and treatment of spinal deformities. We believe that we have a responsibility to be the leading resource for information and encouragement to these groups.

The society has dedicated time and resources to the development of educational programs for the public. We expect members to support and participate locally in those programs with which the society cooperates.

Ethical Practice

The members of the scoliosis research society are dedicated to the highest standards of ethical practice.

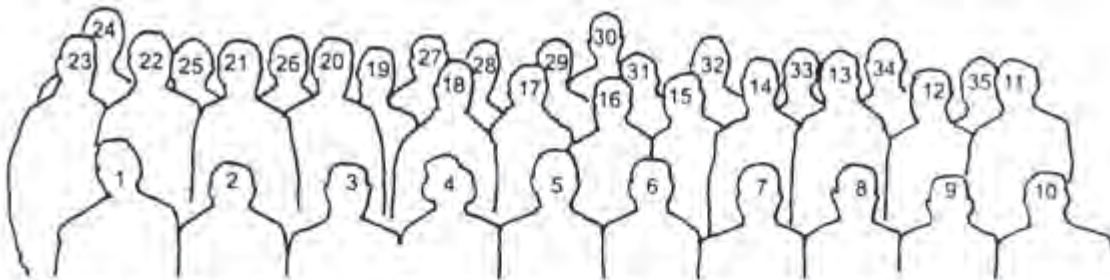
Members strive to:

1. Develop thoughtful diagnoses and treatment plans based on common sense, scientific principles and data.
2. Recognize personal, technical and cognitive limitations.
3. Charge fair and appropriate fees for the services performed and assist in providing health care to all members of the community.
4. Distinguish appropriate alternative treatment plans from ill conceived ones when giving opinions and not disparage physicians who recommend other acceptable treatments.
5. Recognize that the assessment of evolving technology is difficult and therefore maintain a degree of caution about new techniques, using these to improve patient care rather than to gain a competitive advantage.

Acknowledging Support

The society as a whole and individual members have benefited from the generous support of private and corporate sponsors. We will give full acknowledgment for this support without concern that such recognition of assistance may be misinterpreted.

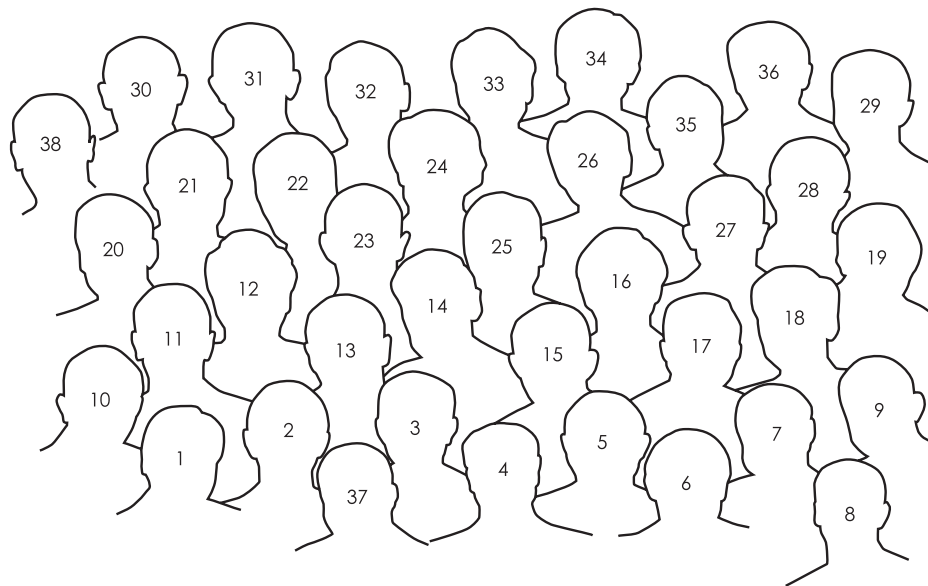
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- | | | |
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Harrington Archives

Past Presidents



SRS Past Presidents	Year(s) Served
1 R. Kirklín Ashley	1971-72
2 Harry L. Shufflebarger	2000
3 Vernon T. Tolo	1996
4 John E. Lonstein	1991
5 Theodore R. Waugh	1982
6 Robert N. Hensiger	1989
7 James W. Ogilvie	2004
8 Randal R. Betz	2005
9 Paul R. Harrington	1973
10 Behrooz A. Akbarnia	2006
11 Gordon L. Engler	1994
12 Wilton H. Bunch	1986
13 Clyde Lester Nash, Jr.,	1983
14 John P. Kostuik	1987
15 John H. Moe	1966-68
16 Daniel R. Benson	1992
17 Allen S. Edmonson	1985
18 David S. Bradford	1984
19 Kenton D. Leatherman	1975
20 Denis S. Drummond	2002
21 Ronald L. DeWald	1988
22 Robert B. Winter	1974
23 Marc A. Asher	1997
24 Keith H. Bridwell	2003
25 Edward H. Simmons	1976
26 William J.Kane	1980
27 Gordon W.D. Armstrong	1981
28 Alvin H. Crawford	2001
29 Edgar G. Dawson	1995
30 Jessie H. Dickson	1990
31 John Carlisle Brown	1993
32 John E. Hall	1960-70
33 G. Dean MacEwen	1977-78
34 Donald P.K. Chan	1998
35 Courtney W. Brown	1999
36 David B. Levine	1979
37 George H. Thompson	2007-08
38 Oheneba Boachie-Adjei, MD	2009

Past Meetings and Officers

1st Annual Meeting

October 2-4, 1966 – Minneapolis, MN, USA

President	John H. Moe
Secretary-Treasurer	William J. Kane
Directors	William F. Donaldson Louis A. Goldstein John E. Hall Paul R. Harrington David B. Levine Jacquelin Perry

2nd Annual Meeting

1967 – Minneapolis, MN, USA

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President-Elect	John E. Hall
Secretary-Treasurer	William J. Kane
Directors	William F. Donaldson Louis A. Goldstein Paul R. Harrington David B. Levine Jacquelin Perry

3rd Annual Meeting

1968 – Houston, TX, USA

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President-Elect	John E. Hall
Secretary-Treasurer	William J. Kane
Directors	William F. Donaldson Louis A. Goldstein Paul R. Harrington David B. Levine Jacquelin Perry

4th Annual Meeting

Sept. 4-6, 1969 – Anaheim, CA, USA

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Secretary-Treasurer	William J. Kane
Past President	John H. Moe
Directors	Allen S. Edmonson Richard M. Kilfoyle Jacquelin Perry James W. Tupper

5th Annual Meeting

Sept. 10-12, 1970 – Toronto, ON, CANADA

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Secretary-Treasurer	William J. Kane
Sec.-Treas.-Elect	David B. Levine
Past President	John H. Moe
Directors	Robert P. Keiser Theodore R. Waugh, Jr. Robert C. Zuege

6th Annual Meeting

Sept. 8-10, 1971 – Hartford, CT, USA

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President-Elect	Paul R. Harrington
Secretary-Treasurer	David B. Levine
Past President	John E. Hall
Directors	Charles H. Herndon John C. Kennedy John H. Moe Frank C. Wilson, Jr.

7th Annual Meeting

1972 – Wilmington, DE, USA

President	G. Dean MacEwen
President-Elect	Paul R. Harrington
Secretary-Treasurer	David B. Levine
Treasurer-Elect	James H. Hardy
Past President	John E. Hall
Directors	Kenton D. Leatherman Lawrence Noall Albert C. Schmidt

8th Annual Meeting

1973 – Gothenburg, SWEDEN

President	Paul R. Harrington
President-Elect	Robert B. Winter
Secretary	David B. Levine
Treasurer	James H. Hardy
Past President	G. Dean MacEwen
Directors	Gordon W.D. Armstrong Kenton D. Leatherman Lawrence Noall

9th Annual Meeting

Sept. 11-13, 1974 – San Francisco, CA, USA

President	Robert B. Winter
President-Elect	Kenton D. Leatherman
Secretary	David B. Levine
Secretary-Elect	Theodore R. Waugh, Jr.
Treasurer	James H. Hardy
Past President	Paul R. Harrington
Directors	Gordon W.D. Armstrong R. Kirklin Ashley Wilton H. Bunch

10th Annual Meeting

Sept 10-12, 1975 – Louisville, KY, USA

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Directors	R. Kirklin Ashley Wilton H. Bunch Ronald L. DeWald

Past Meetings and Officers

11th Annual Meeting

Sept. 4-6, 1976 – Ottawa, ON, CANADA

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President-Elect	Louis A. Goldstein
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Treasurer	James H. Hardy
Treasurer-Elect	Wilton H. Bunch
Past President	Kenton D. Leatherman
Directors	Ronald L. DeWald Robert B. Winter

12th Annual Meeting

Oct. 24-27, 1977 – HONG KONG

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President (9/76-10/76)	Louis A. Goldstein
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Treasurer	Wilton H. Bunch
Past President	Edward H. Simmons
Directors	Jesse H. Dickson Kenton D. Leatherman Marr P. Mullen

13th Annual Meeting

Sept. 13-15, 1978 – Boston, MA, USA

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Secretary	Theodore R. Waugh, Jr.
Secretary-Elect	Allen S. Edmonson
Treasurer	Wilton H. Bunch
Past President	Edward H. Simmons
Directors	Marr P. Mullen Clyde L. Nash, Jr.

14th Annual Meeting

Sept. 11-14, 1979 – Seattle, WA, USA

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Secretary	Allen S. Edmonson
Treasurer	Wilton H. Bunch
Past President	R. Kirklin Ashley
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15th Annual Meeting

Sept. 17-19, 1980 – Chicago, IL, USA

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Treasurer	Wilton H. Bunch
Treasurer-Elect	John C. Brown
Past President	David B. Levine
Directors	James E. Holmblad Donald A. Jones

16th Annual Meeting

Sept. 16-18, 1981 – Montreal, QC, CANADA

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President-Elect	Theodore R. Waugh, Jr.
Secretary	Allen S. Edmonson
Treasurer	John C. Brown
Past President	William J. Kane
Directors	James E. Holmblad Gordon L. Engler David S. Bradford

17th Annual Meeting

Sept. 22-25, 1982 – Denver, CO, USA

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President-Elect	Clyde L. Nash, Jr.
Secretary	Allen S. Edmonson
Secretary-Elect	Robert N. Hensinger
Treasurer	John C. Brown
Past President	Gordon W.D. Armstrong
Directors	Gordon L. Engler David S. Bradford Morris A. Duhaime Harold K. Dunn

18th Annual Meeting

Sept. 28-Oct. 1, 1983 – New Orleans, LA, USA

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President-Elect	David S. Bradford
Secretary	Robert N. Hensinger
Treasurer	John C. Brown
Past President	Theodore R. Waugh, Jr.
Directors	Morris A. Duhaime Harold K. Dunn Edgar G. Dawson John P. Kostuik

Past Meetings and Officers

19th Annual Meeting

Sept. 19-22, 1984 – Orlando, FL, USA

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President-Elect	Allen S. Edmonson
Secretary	Robert N. Hensinger
Treasurer	John C. Brown
Treasurer-Elect	Gordon L. Engler
Past President	Clyde L. Nash, Jr.
Directors	Edgar G. Dawson John P. Kostuik Thomas I. Lowry

20th Annual Meeting

Sept. 17-20, 1985 – San Diego, CA, USA

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President-Elect	Wilton H. Bunch
Secretary	Robert N. Hensinger
Treasurer	Gordon L. Engler
Past President	David S. Bradford
Directors	Thomas I. Lowry Marc A. Asher L. Ray Lawson Albert B. Schultz

21st Annual Meeting

Sept. 21-25, 1986 – Hamilton, BERMUDA

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Secretary	Robert N. Hensinger
Secretary-Elect	William P. Bunnell
Treasurer	Gordon L. Engler
Past President	Allen S. Edmonson
Directors	Marc A. Asher L. Ray Lawson Robert Gillespie John E. Lonstein

22nd Annual Meeting

Sept. 15-19, 1987 – Vancouver, BC, CANADA

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President-Elect	Ronald L. DeWald
Secretary	William P. Bunnell
Treasurer	Gordon L. Engler
Past President	Wilton H. Bunch
Directors	Robert Gillespie Rae R. Jacobs John E. Lonstein Stuart L. Weinstein

23rd Annual Meeting

Sept. 21-25, 1988 – Baltimore, MD, USA

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President-Elect	Robert N. Hensinger
Secretary	William P. Bunnell
Treasurer	Gordon L. Engler
Treasurer-Elect	Edgar G. Dawson
Past President	John P. Kostuik
Directors	Ralph W. Coonrad Denis S. Drummond Rae R. Jacobs Stuart L. Weinstein

24th Annual Meeting

Sept. 17-22, 1989 – Amsterdam, NETHERLANDS

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President-Elect	Jesse H. Dickson
First Vice President	John E. Lonstein
Secretary	William P. Bunnell
Treasurer	Edgar G. Dawson
Past President	Ronald L. DeWald
Directors	Daniel R. Benson Ralph W. Coonrad Denis S. Drummond Thomas S. Renshaw

25th Annual Meeting

Sept. 23-27, 1990 – Honolulu, HI, USA

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President-Elect	John E. Lonstein
First Vice President	Daniel R. Benson
Secretary	William P. Bunnell
Secretary-Elect	Vernon T. Tolo
Treasurer	Edgar G. Dawson
Past President	Robert N. Hensinger
Directors	Robert W. Gaines, Jr. Thomas S. Renshaw Susan M. Swank Stephen J. Tredwell

26th Annual Meeting

Sept. 24-27, 1991 – Minneapolis, MN, USA

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President-Elect	Daniel R. Benson
First Vice President	John C. Brown
Secretary	Vernon T. Tolo
Treasurer	Edgar G. Dawson
Past President	Jesse H. Dickson
Directors	Alvin H. Crawford Robert W. Gaines, Jr. Stanley D. Gertzbein Stephen J. Tredwell

Past Meetings and Officers

27th Annual Meeting

Sept. 23-26, 1992 – Kansas City, MO, USA

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President-Elect	John C. Brown
First Vice President	Gordon L. Engler
Secretary	Vernon T. Tolo
Treasurer	Edgar G. Dawson
Treasurer-Elect	Courtney W. Brown
Past President	John E. Lonstein
Directors	Alvin H. Crawford Stanley D. Gertzbein Donald P.K. Chan Susan W. Swank

28th Annual Meeting

Sept. 18-23, 1993 – Dublin, IRELAND

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President-Elect	Gordon L. Engler
First Vice President	Edgar G. Dawson
Past President	Daniel R. Benson
Secretary	Vernon T. Tolo
Treasurer	Courtney W. Brown
Directors	Donald P.K. Chan Susan W. Swank Behrooz A. Akbarnia John A. Herring

29th Annual Meeting

Sept. 21-24, 1994 – Portland, OR, USA

President	Gordon L. Engler
President-Elect	Edgar G. Dawson
First Vice President	Vernon T. Tolo
Past President	John C. Brown
Secretary	Harry L. Shufflebarger
Treasurer	Courtney W. Brown
Directors	Behrooz A. Akbarnia John A. Herring William A. Carr Dennis R. Wenger

30th Annual Meeting

Sept. 13-16, 1995 – Asheville, NC, USA

President	Edgar G. Dawson
President-Elect	Vernon T. Tolo
First Vice President	Marc A. Asher
Past President	Gordon L. Engler
Secretary	Harry L. Shufflebarger
Treasurer	Courtney W. Brown
Directors	William A. Carr Dennis R. Wenger Thomas F. Kling, Jr. Jack K. Mayfield

31st Annual Meeting

Sept. 25-28, 1996 – Ottawa, ON, CANADA

President	Vernon T. Tolo
President-Elect	Marc A. Asher
First Vice President	Donald P.K. Chan
Past President	Edgar G. Dawson
Secretary	Harry L. Shufflebarger
Treasurer	Courtney W. Brown
Treasurer-Elect	William A. Carr
Directors	Thomas F. Kling, Jr. Jack K. Mayfield Keith H. Bridwell Thomas R. Haher

32nd Annual Meeting

Sept. 25-27, 1997 – St. Louis, MO, USA

President	Marc A. Asher
President-Elect	Donald P.K. Chan
First Vice President	Courtney W. Brown
Past President	Vernon T. Tolo
Secretary	Harry L. Shufflebarger
Secretary-Elect	Denis S. Drummond
Treasurer	William A. Carr
Directors	Keith H. Bridwell Thomas R. Haher R. Mervyn Letts Michael G. Neuwirth

33rd Annual Meeting

Sept. 16-20, 1998 – New York, NY, USA

President	Donald P.K. Chan
President-Elect	Courtney W. Brown
First Vice President	Harry L. Shufflebarger
Past President	Marc A. Asher
Secretary	Denis S. Drummond
Treasurer	William A. Carr
Directors	R. Mervyn Letts Michael G. Neuwirth John B. Emans James W. Ogilvie

34th Annual Meeting

Sept. 23-25, 1999 – San Diego, CA, USA

President	Courtney W. Brown
President-Elect	Harry L. Shufflebarger
First Vice President	Alvin H. Crawford
Past President	Donald P.K. Chan
Secretary	Denis S. Drummond
Treasurer	William A. Carr
Directors	John B. Emans James W. Ogilvie John V. Banta Thomas G. Lowe

Past Meetings and Officers

35th Annual Meeting

Oct. 18-21, 2000 – Cairns, AUSTRALIA

President	Harry L. Shufflebarger
President-Elect	Alvin H. Crawford
First Vice President	Denis S. Drummond
Past President	Courtney W. Brown
Secretary	John B. Emans
Treasurer	William A. Carr
Treasurer-Elect	Behrooz A. Akbarnia
Directors	John V. Banta Thomas G. Lowe John P. Lubicky George H. Thompson

36th Annual Meeting

Sept. 19-22, 2001 – Cleveland, OH, USA

President	Alvin H. Crawford
President-Elect	Denis S. Drummond
First Vice President	Keith H. Bridwell
Past President	Harry L. Shufflebarger
Secretary	John B. Emans
Treasurer	Behrooz A. Akbarnia
Directors	John P. Lubicky George H. Thompson Stewart I. Bailey Thomas S. Whitecloud, III

37th Annual Meeting

Sept. 18-21, 2002 – Seattle, WA, USA

President	Denis S. Drummond
President-Elect	Keith H. Bridwell
First Vice President	James W. Ogilvie
Past President	Alvin H. Crawford
Secretary	John B. Emans
Treasurer	Behrooz A. Akbarnia
Directors	Stewart I. Bailey Thomas S. Whitecloud, III Randal R. Betz Howard A. King

38th Annual Meeting

Sept. 10-13, 2003 – Quebec City, Canada

President	Keith H. Bridwell
President-Elect	James W. Ogilvie
First Vice President	Randal R. Betz
Past President	Denis S. Drummond
Secretary	John B. Emans
Secretary-Elect	Thomas R. Haher
Treasurer	Behrooz A. Akbarnia
Treasurer-Elect	Richard E. McCarthy
Directors	Howard A. King Hubert H.L. Labelle John P. Dormans David W. Polly, Jr.

39th Annual Meeting

Sept. 6-9, 2004 – Buenos Aires, Argentina

President	James W. Ogilvie
President-Elect	Randal R. Betz
First Vice President	Behrooz A. Akbarnia
Past President	Keith H. Bridwell
Secretary	Thomas R. Haher
Treasurer	Richard E. McCarthy
Directors	John P. Dormans David W. Polly Oheneba Boachie-Adjei Michael A. Edgar

40th Annual Meeting

Oct. 27-30, 2005 – Miami, FL, USA

President	Randal R. Betz
President-Elect	Behrooz A. Akbarnia
Vice President	George H. Thompson
Past President	James W. Ogilvie
Secretary	Thomas R. Haher
Treasurer	Richard E. McCarthy
Directors	Oheneba Boachie-Adjei Michael A. Edgar Steven M. Mardjetko Mark Weidenbaum

41st Annual Meeting

Sept. 13-16, 2006 – Monterey, CA, USA

President	Behrooz A. Akbarnia
President-Elect	George H. Thompson
Vice President	Thomas G. Lowe
Secretary	Thomas R. Haher
Treasurer	Richard E. McCarthy
Past President	Randal R. Betz
Past President	James W. Ogilvie
Past President	Keith H. Bridwell
Directors	Steven M. Mardjetko Mark Weidenbaum Paul D. Sponseller Nobumasa Suzuki

Past Meetings and Officers

42nd Annual Meeting

Sept. 5-8, 2007 – Edinburgh, SCOTLAND

President	George H. Thompson
President-Elect	Oheneba Boachie-Adjei
Vice President	Richard E. McCarthy
Secretary	Thomas R. Haher
Treasurer	Steven M. Mardjetko
Secretary-Elect	David W. Polly, Jr.
Past President	Behrooz A. Akbarnia
Past President	Randal R. Betz
Past President	James W. Ogilvie
Directors	Paul D. Sponseller Nobumasa Suzuki Lawrence G. Lenke B. Stephens Richards

44th Annual Meeting

Sept. 23 – 26, 2009 – San Antonio, TX, USA

President	Oheneba Boachie-Adjei
President-Elect	Richard E. McCarthy
Vice President	Lawrence G. Lenke
Secretary	David W. Polly, Jr.
Treasurer	Steven M. Mardjetko
Past President	George H. Thompson
Past President	Behrooz A. Akbarnia
Past President	Randal R. Betz
Directors	Azmi hamzaoglu James W. Roach Kamal Ibrahim Kenneth MC Cheung

43rd Annual Meeting

Sept. 10-13, 2008 – Salt Lake City, UT, USA

President	George H. Thompson
President-Elect	Oheneba Boachie-Adjei
Vice President	Richard E. McCarthy
Secretary	David W. Polly, Jr.
Treasurer	Steven M. Mardjetko
Past President	Behrooz A. Akbarnia
Past President	Randal R. Betz
Past President	James W. Ogilvie
Directors	Azim Hamzaoglu Lawrence G. Lenke B. Stephens Richards James W. Roach

SRS Committees

BOARD OF DIRECTORS

Richard E. McCarthy, President.....	2010
Lawrence G. Lenke, President Elect.....	2010
B. Stephens Richards, Vice President.....	2010
David W. Polly, Jr., Secretary.....	2010
Hubert Labelle, Secretary Elect.....	2010
Steven M. Mardjetko, Treasurer.....	2010
Oheneba Boachie-Adjei, Past President I.....	2012
George H. Thompson, Past President II.....	2011
Behrooz A. Akbarnia, Past President III.....	2010
Kamal N. Ibrahim, Director.....	2010
Kenneth MC Cheung, Director.....	2010
J. Abbott Byrd, Director.....	2010
Serena S. Hu, Director.....	2010

ADULT DEFORMITY COMMITTEE

Frank J. Schwab, Chair.....	2010
Mark Weidenbaum, Past Chair.....	2010
Christopher I. Shaffrey.....	2010
Jacob Buchowski (C).....	2010
Brian O'Shaughnessy (C).....	2010
Richard Hostin (C).....	2010
Sigurd H. Berven.....	2011
Clifford B. Tribus, Chair-Elect.....	2011
Mark B. Dekutoski.....	2012
Hossein Mehdiian.....	2012
Jeffrey D. Coe.....	2013
Christopher DeWald.....	2013

Council: Research

Board Liaison: Oheneba Boachie-Adjei

Staff Liaison: Megan Kelley

Back-up: Katie Agard

ADVOCACY AND PUBLIC POLICY COMMITTEE

Daniel W. Green, Chair.....	2010
Mark A. Lorenz, Past Chair.....	2010
Marco Brayda-Bruno.....	2010
Richard G. Fessler (C).....	2010
Michael D. Daubs (C).....	2010
William C. Lauerman.....	2011
John P. Lubicky, Chair-Elect.....	2011
Richard Holt.....	2012
Vishwas Talwalkar.....	2012
Jose Herrera-Soto.....	2013
Brian G. Smith.....	2013

Joseph P. O'Brien, advisory

Stanley E. Sacks, advisory

RAPID RESPONSE TEAM

George Thompson, Chair Daniel Green

Oheneba Boachie-Adjei Richard McCarthy

Steven Glassman David Polly

Lawrence Lenke

Council: Governance

Board Liaison: David W. Polly

Staff Liaison: Courtney Kissinger

Back-up: Katie Agard

AWARDS & SCHOLARSHIP COMMITTEE

Jeffrey L. Stambough, Chair.....	2010
K. Daniel Riew, Past Chair.....	2010
Peter F. Sturm (Global Outreach).....	2010
Noriaki Kawakami (Program).....	2010
Michael J. Yaszemski (Program).....	2010
Nancy Hadley Miller (Research).....	2010
Hilali H. Noordeen.....	2010
Dennis Crandall.....	2010
Michael P. Grevitt (C).....	2010
Vincent Arlet.....	2011
Andrew M. Casden.....	2011
Ensor E. Transfeldt, Chair Elect.....	2011
Yongjung Kim.....	2012
Stephen J. Lewis.....	2012
Preston J. Phillips.....	2012

Council: Education

Board Liaison: Steven M. Mardjetko

Staff Liaison: Courtney Kissinger, Back-up: Nilda Toro

SRS Committees

BYLAWS & POLICIES COMMITTEE

Robert J. Huler, Chair	2010
J. Abbott Byrd, Past Chair	2010
Mohammed Mossaad (C).....	2010
James W. Roach	2011
Michael C. Albert, Chair Elect.....	2012
Jose Herrera-Soto	2013

Council: Governance

Board Liaison: Behrooz A. Akbarnia

Staff Liaison: Nilda Toro, Back up: Tressa Goulding

CME COMMITTEE

Lawrence G. Lenke, Chair.....	2010
Behrooz A. Akbarnia, PP III.....	2010
Allen W. Carl (Education PCh)	2010
Peter O. Newton (Program PCh).....	2010
George H. Thompson, PP II.....	2011
Noriaka Kawakami (Program Ch).....	2011
Michael J. Yaszemski (Program Ch).....	2011
Andrew A. Merola (Website).....	2011
Steven D. Glassman (Ed. Council Chair).....	2011
Joseph H. Perra (Education).....	2011
Kamal N. Ibrahim (WWC, Education ChE)	2012
Laurel Blakemore (Program ChE).....	2012
John F. Sarwark (Website ChE)	2012
Todd J. Albert (IMAST).....	2012
Oheneba Boachie-Adjei, PPI and Past Chair	2012
Richard E. McCarthy, Past Chair.....	2013
B. Stephens Richards (Vice President) Chair-Elect.....	2014

Council: Education

Board Liaison: Oheneba Boachie-Adjei

Staff Liaison: Tressa Goulding

Back-up: Courtney Kissinger

CODING COMMITTEE

Barton L. Sachs, Chair	2010
James T. Bennett, Past Chair.....	2010
R. Shay Bess (C).....	2010
N. Harshavardhana (C).....	2010
Jeffrey B. Neustadt, Chair Elect.....	2011
R. Dale Blasier	2012
Christopher DeWald	2013

Council: Governance

Board Liaison: George H. Thompson

Staff Liaison: Nadine Couto

Back-up: Megan Kelley

EDUCATION COMMITTEE

Joseph H. Perra, Chair	2010
Allen W. Carl, Past Chair.....	2010
Noriaki Kawakami (Program).....	2010
Michael J. Yaszemski (Program).....	2010
Lawrence L. Haber	2010
Phillip S. Anson (C).....	2010
Adam Wollowick (C).....	2010
Sean Molloy (C).....	2010
Ahmet Alanay	2011
Kamal N. Ibrahim, Chair Elect.....	2011
Mark Dekutoski	2012
Eric T. Jones.....	2012
Paul D. Sponsor	2013
John R. Dimar	2013

Council: Education

Board Liaison: Behrooz A. Akbarnia

Staff Liaison: Courtney Kissinger

Back-up: Nadine Couto

ENDOWMENT COMMITTEE

Frances A. Farley, Chair	2010
Baron S. Lonner, Past Chair.....	2010
Behrooz A. Akbarnia, PP3.....	2010
Eldin Karaikovic	2010
James Mooney	2010
George H. Thompson, PP2.....	2011
Alvin H. Crawford, Chair Elect.....	2011
Matthew B. Dobbs	2011
Karl E. Rathjen	2011
Oheneba Boachie-Adjei, PP1	2012
Thomas E. Bailey.....	2012
John R. Dimar	2012
Kirkham Wood	2012

Council: Finance

Board Liaison: Richard E. McCarthy

Staff Liaison: Nilda Toro

Back up: Nadine Couto

E-TEXT COMMITTEE

James W. Ogilvie, Chair.....	2012
Denis S. Drummond	2010
Todd J. Albert	2012
John P. Dormans.....	2013
Lawrence G. Lenke, Chair Elect	2014
Praveen Mummaneni	2015

Council: Education

Board Liaison: Lawrence G. Lenke

Staff Liaison: Katie Agard

Back up: Courtney Kissinger

SRS Committees

ETHICS COMMITTEE

Dennis S. Drummond (E), Chair	2010
Marc A. Asher, Past Chair	2010
Bettye A. Wright (E)	2011
Michael A. Edgar, Chair Elect	2012
Michael Bolesta	2013
J. Abbott Byrd	2014
James W. Roach	2014

Council: Governance

Board Liaison: B. Stephens Richards.

Staff Liaison: Tressa Goulding

Back up: Nilda Toro

EVIDENCE BASED OUTCOMES COMMITTEE

James O. Sanders, Chair	2010
Douglas C. Burton, Past Chair	2010
Reginald Q. Knight, Past Chair	2010
Dale V. Hoekstra	2010
Nancy Hadley Miller (Research)	2010
James V. Raso (Assoc)	2010
Gregory M. Mundis (C)	2010
Richard E. Bowen, Chair Elect	2011
Robert B. Campbell	2011
William A. Phillips	2011
Dilip K. Sengupta	2011
J. Bradley Williamson	2012

Council: Research

Board Liaison: Kenneth M.C. Cheung

Staff Liaison: Nadine Couto

Back up: Megan Kelley

FELLOWSHIP COMMITTEE

Mark Weidenbaum, Chair	2010
J. Abbott Byrd, Past Chair	2010
Serena S. Hu, Chair Elect	2011
Carlos Tello	2012
Laurel C. Blakemore	2013

Council: Governance

Board Liaison: Steven M. Mardjetko

Staff Liaison: Nilda Toro

Back up: Tressa Goulding

FINANCE COMMITTEE

Steven M. Mardjetko, Chair	2011
Oheneba Boachie-Adjei	2010
Richard E. McCarthy	2011
Lawrence G. Lenke	2012
B. Stephens Richards	2013
Tressa Goulding, Executive Director	Ad Hoc
Dan Nemeč, Accounting Director	Ad Hoc

Council: Finance

Board Liaison: Richard E. McCarthy

Staff Liaison: Tressa Goulding

Back up: Megan Kelley

GLOBAL OUTREACH COMMITTEE

Peter F. Sturm, Chair	2010
Charles T. Mehlman, Past Chair	2010
Linda P. d'Andrea	2010
Federico P. Girardi	2010
Kamal N. Ibrahim (Worldwide Course)	2010
Hani Mhaidli (C)	2010
Sanjeev Suratwala (C)	2010
Hazem Elsebaie (C)	2010
David H. Clements	2011
Hossein Mehdián	2011
Theodore A. Wagner, Chair Elect	2011
Kenneth J. Paonessa	2012
Anthony S. Rinella	2012
Yousry MK El-Hawary	2012

Council: Education

Board Liaison: J. Abbott Byrd

Staff Liaison: Katie Agard

Back up: Nadine Couto

GROWING SPINE COMMITTEE

Laurel C. Blakemore, Chair	2010
Francisco S. Perez-Grueso, Past Chair	2010
Alain Dimeglio (H)	2010
Vincent F.X. Deeney	2010
Amer Samdani (C)	2010
Hazem Elsebaie (C)	2010
John Tis (C)	2010
Lawrence I. Karlin, Chair Elect	2011
Behrooz A. Akbaria	2011
Carlos A. Tello	2011
Bruce L. Gillingham	2012
Eric T. Jones	2012
Suken Shah	2012
Michael C. Ain	2013
Michael J. Mendelow	2013
Ernesto Bersusky	2013

Council: Research

Board Liaison: George H. Thompson

Staff Liaison: Nadine Couto

Back up: Katie Agard

HISTORICAL COMMITTEE

Nathan H. Lebowhl, Historian	2011
Behrooz A. Akbaria, PP3, Chair Elect	2012
Daniele A. Fabris-Monterumici	2010
Paul Huddleston (C)	2010
John J. Grayhack	2011
David H. Clements	2012
Azmi Hamzaoglu	2013

Council: Governance

Board Liaison: Behrooz A. Akbaria

Staff Liaison: Katie Agard

Back up: Nilda Toro

SRS Committees

IMAST COMMITTEE

Todd J. Albert, Chair	2012
Lawrence G. Lenke, Past Chair	2010
Khaled Kebaish (C)	2010
Yutaka Sasao (C)	2010
Kamal Ibrahim (Education ChE)	2011
B. Stephens Richards	2011
Michael F. O'Brien	2012
Praveen Mummaneni	2013
Daniel J. Sucato	2013

Council: Education

Board Liaison: Lawrence G. Lenke

Staff Liaisons: Megan Kelley

Back up: Nadine Couto

INDUSTRY RELATIONS COMMITTEE

Oheneba Boachie-Adjei, Chair	2010
George H. Thompson, Past Chair	2010
J. Bradley Williamson	2010
Peter O. Newton (Res Council)	2010
Kamal N. Ibrahim (WWC)	2010
Steven M. Mardjetko (Treas)	2011
Richard E. McCarthy, Chair Elect	2011
Vincent Arlet	2011
John P. Dormans	2011
Hansen A. Yuan	2011
Lawrence G. Lenke (Pres Elect)	2012
Todd J. Albert (IMAST)	2012
B. Stephens Richards (VP)	2013
Howard M. Place	2013

Council: Governance

Board Liaison: Behrooz A. Akbarnia

Staff Liaison: Tressa Goulding

Back up: Megan Kelley

LONG RANGE PLANNING COMMITTEE

Oheneba Boachie-Adjei, Chair	2010
George H. Thompson, Past Chair	2011
Behrooz A. Akbarnia, PP3	2010
Peter F. Sturm (Global Outreach)	2010
Kamal N. Ibrahim (Worldwide Course)	2010
Todd J. Albert (IMAST)	2012
Richard E. McCarthy, Chair Elect	2013

Council: Finance

Board Liaison: Lawrence G. Lenke

Staff Liaison: Tressa Goulding

Back up: Megan Kelley

MORBIDITY & MORTALITY COMMITTEE

D. Raymond Knapp, Chair	2010
Joseph H. Perra, Past Chair	2010
Hilali H. Noordeen	2010
Christopher P. Ames (C)	2010
Justin S. Smith (C)	2010
Sigurd H. Berven	2011
Michael J. Goytan, Chair Elect	2011
Paul A. Broadstone	2012
Theodore J. Choma	2012
Michael S. Roh	2013
Yongjung Kim	2013

Council: Research

Board Liaison: Steven M. Mardjetko

Staff Liaison: Nilda Toro

Back up: Katie Agard

NEWSLETTER COMMITTEE

Vicki Kalen, Chair & Editor	2010
Kathy Blanke (A)	2010
Marinus de Kleuver	2010
John Tis (C)	2010
John P. Lubicky	2011
Eric Buchl (A)	2012

Council: Governance

Board Liaison: Serena S. Hu

Staff Liaison: Katie Agard

Back up: Nadine Couto

NOMINATING COMMITTEE

Oheneba Boachie-Adjei, Chair	2010
Denis S. Drummond	2010
Steven D. Glassman	2010
Munish C. Gupta	2010
Steven M. Mardjetko	2010

Council: Reports to Board

Board Liaison: George Thompson

Staff Liaison: Tressa Goulding

Back up: Nilda Toro

SRS Committees

NON-OPERATIVE MANAGEMENT COMMITTEE

Brian G. Smith, Chair	2010
D. Raymond Knapp, Jr, Past Chair.....	2010
Jeffrey D. Thomson.....	2010
Dmytro Petrenko (C).....	2010
Anatolii Levvyskyi (C)	2010
Richard H. Gross.....	2011
John G. Thometz, Chair Elect.....	2011
Nigel J. Price.....	2012
Paul D. Sponseller.....	2012

Joe P. O'Brien - Advisory

Council: Research

Board Liaison: George H. Thompson

Staff Liaison: Nadine Couto

Back up: Katie Agard

PATIENT EDUCATION COMMITTEE

Ram Mudiyaam, Chair	2010
John T. Killian, Past Chair.....	2010
Vishwas R. Talwalkar	2010
Connie Poe-Kochert (Assoc).....	2010
Toni Cawley (Assoc).....	2011
Walter F. Krengel.....	2011
Jay Shapiro, Chair Elect	2011
Glen M. Ginsberg	2012
Christopher Bergin.....	2012
Michael C. Albert.....	2012

Joe P. O'Brien – Advisory

Stanley E. Sacks – Advisory

Council: Education

Board Liaison: David W. Polly, Jr.

Staff Liaison: Katie Agard

Back up: Courtney Kissinger

PEDIATRIC DEVICE TASK FORCE

Michael G. Vitale, Chair
 Akbarnia, Behrooz A.
 Blakemore, Laurel C.
 Campbell, Robert M. Jr.
 Richard E. McCarthy
 David W. Polly, Jr.
 B. Stephens Richards
 Brian D. Snyder

PROGRAM COMMITTEE

Noriaka Kawakami, Co-Chair.....	2010
Michael J. Yaszemski, Co-Chair.....	2010
Peter O. Newton, Past Chair	2010
Lawrence G. Lenke (IMAST Past Chair)	2010
Patrick J. Connolly.....	2010
Peter S. Rose (C).....	2010
Laurel C. Blakemore, Chair Elect	2011
Andrew M. Casden	2011
Marinus de Kleuver	2011
Todd J. Albert (IMAST Chair).....	2012
R. Haluk Berk.....	2012
William F. Donaldson, III.....	2012
Daniel J. Sucato.....	2012

Council: Education

Board Liaison: Richard E. McCarthy

Staff Liaison: Megan Kelley

Back up: Nadine Couto

Program Reviewers

Eric Buchl (A) 2010	Paul Glazer 2011
Akesen Burak (C) 2010	Henry Iwinski 2011
Michael Daubs (C) 2010	Steve Richards (I) 2011
Ujjwal Debnath (C) 2010	Timothy Kuklo (I) 2011
Mark Dekutoski 2010	Hawart Singh 2011
Brian Hsu (C) 2010	Brian Smith 2011
Paul Huddleston (C) 2010	Joseph Verska 2011
Khaled Kebaish (C) (I) 2010	Todd Albert (I) 2012
Lawrence G. Lenke (I) 2010	Elizabeth Ames 2012
Sean Molloy (C) 2010	Stephen Lewis 2012
Greg Mundis (C) 2010	Michael O'Brien (I) 2012
Brian O'Shaughnessy (C) 2010	Kenneth Paonessa 2012
Yutaka Sasao (C) (I) 2010	Michael Roh 2012
Michael Ain 2011	Suken Shah 2012
Michael Albert 2011	P. Mummaneni (I) 2013

PUBLIC RELATIONS COMMITTEE

Alan Moskowitz, Chair	2010
Dennis G. Crandall	2010
Paul A. Glazer.....	2011
Michael O. LaGrone, Chair Elect.....	2011
Ian Bruce McPhee	2012
Andrew G. King	2012

Compelling Stories Task Force

John M. (Jack) Flynn, Chair
 Richard E. McCarthy
 Charles E. Johnston
 Robert (Matt) Bernstein
 Alan Moskowitz
 Dennis G. Crandall
 Baron S. Lonner

Council: Governance

Board Liaison: Steven M. Mardjetko

Staff Liaison: Nadine Couto

Back up: Courtney Kissinger

SRS Committees

RESEARCH GRANT COMMITTEE

Nancy Hadley Miller, Chair.....	2010
Kit M. Song, Past Chair.....	2010
Benjamin A. Alman.....	2010
Cathleen L. Raggio.....	2010
Brian Hsu (C).....	2010
Srinivasa Vidyadhara (C).....	2010
Dilip K. Sengupta, Chair Elect.....	2011
Peter P. Masso.....	2011
Matthew B. Dobbs.....	2011
Federico P. Girardi.....	2012
John M. (Jack) Flynn.....	2012
Siavash Haghghi.....	2012
Kirkham B. Wood.....	2013
Lori Dolan.....	2013
Jonathan H. Phillips.....	2013

Council: Research

Board Liaison: Kenneth M.C. Cheung

Staff Liaison: Courtney Kissinger; Back up: Nilda Toro

SRS / SPINE LIAISON COMMITTEE

Allen W. Carl, Chair (Education Past Chair).....	2010
Paul D. Sponseller, Past Chair (Program Past Ch).....	2010
Munish C. Gupta.....	2010
John A I Ferguson (C).....	2010
Joseph W. Perra, Chair Elect (Education Chair).....	2011
Kamal N. Ibrahim (Education Chair elect).....	2012
Frank J. Schwab.....	2012

Keith H. Bridwell – Spine Liaison

Council: Education

Board Liaison: Serena Hu

Staff Liaison: Courtney Kissinger

Back up: Megan Kelley

3D SCOLIOSIS

Hubert Labelle, Chair.....	2010
Carl Eric Aubin, Co-Chair.....	2010
Lawrence G. Lenke.....	2010
Roger P. Jackson.....	2010
Peter O. Newton.....	2010
Stefan Parent (C).....	2010
Pierre Roussouly.....	2010
Ian A.F. Stokes.....	2010

Ad Hoc Members

Mark F. Abel.....	2010
Kenneth M.C. Cheung.....	2010
Howard A. King.....	2010
Richard E. McCall.....	2010
Michael J. Mendelow (C).....	2010
Reinhard D. Zeller.....	2010

Council: Research

Board Liaison: Lawrence G. Lenke

Staff Liaison: Nadine Couto; Back up: Nilda Toro

WEBSITE COMMITTEE

Andrew A. Merola, Chair.....	2010
Dale E. Rowe.....	2010
Ram Mudiyaam (Patient Ed).....	2010
Joseph H. Perra (Education).....	2010
Paul Huddleston (C).....	2010
Ron El-Hawary (C).....	2010
John F. Sarwark, Chair Elect.....	2011
Michael F. O'Brien.....	2011
Kit M. Song.....	2011
Nathan H. Lebowohl (Historian).....	2011
Matthew Geck.....	2012
Anthony S. Rinella.....	2012
Michael Roh.....	2013
Ross Moquin.....	2013

Council: Education

Board Liaison: Behrooz Akbarnia

Staff Liaison: Courtney Kissinger

Back up: Katie Agard

WORLDWIDE CONFERENCE COMMITTEE

Kamal N. Ibrahim, Chair.....	2010
Joseph H. Perra (Education).....	2010
Peter F. Sturm (Global Outreach).....	2010
Norbert Passuti.....	2010
Khalil Kharrat.....	2010
Carlos Tello.....	2010
John A I Ferguson (C).....	2010
Wael Koptan (C).....	2010
Alpaslan Senkoylu (C).....	2010
Ahmet Alanay, Chair Elect.....	2011
William C. Horton.....	2011
Victor Rositto.....	2011
Charles E. Johnston II.....	2011
Christopher L. Hamill.....	2012
Suken A. Shah.....	2012
Ensor E. Transfeldt.....	2012
Muharrem Yazici.....	2012
Munish C. Gupta.....	2013
Youssry El Hawary.....	2013
Scott D. Hodges.....	2013
Koki Uno.....	2013

Council: Education

Board Liaison: Kamal N. Ibrahim

Staff Liaison: Tressa Goulding

Back up: Courtney Kissinger

SRS Committees

GLOBAL AFFAIRS ADVISORY BOARD

Kenneth Cheung (Asia), Chair.....	2010
Oheneba Boachie-Adjei, Past Chair.....	2010
Osmar Avanzi (The Americas, Co-Chair)	2012
Ernesto Bersusky (The Americas).....	2012
Dietrich Schlenzka (Europe).....	2012
Michael Ruf (Europe).....	2012
Kenneth Cheung (Asia).....	2012
Hee Kit Wong (Asia).....	2012
Khalil Kharrat (Middle East/Africa).....	2012
Mohammed Mossaad (Middle East/Africa).....	2012

Council: Governance

Board Liaison: Oheneba Boachie-Adjei

Staff Liaison: Nilda Toro

Back Up: Katie Agard

EARLY ONSET SCOLIOSIS TASK FORCE

Richard E. McCarthy, Chair
 Michael G. Vitale, Co-Chair
 Behrooz A. Akbarnia
 Laurel C. Blakemore
 Robert M. Campbell, Jr.
 Peter O. Newton
 Brian D. Snyder

DIRECTED RESEARCH TASK FORCE

Lawrence G. Lenke, Chair
 Kenneth MC Cheung, Co-Chair
 Randal R. Betz
 Steven D. Glassman
 B. Stephens Richards
 James O. Sanders
 Frank J. Schwab
 Kit M. Song

BOS Representatives

Oheneba Boachie-Adjei (Presidential Line).....	2010
Richard E. McCarthy (Communications).....	2010
Lawrence G. Lenke (Health Policy).....	2011
Peter O. Newton (Research).....	2011
Steven D. Glassman (Education).....	2012
Tressa Goulding (Executive Director).....	indefinite

FOSA Representatives

Kamal N. Ibrahim	March 2011
Allen W. Carl	Mar. 10-Feb. 11
Joseph H. Perra.....	Mar. 10-Feb.11

Hibbs Society Liaison

Robert W. Gaines.....	2009
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Education Council – Steven D. Glassman, Chair – 2011

Awards & Scholarship	Jeffrey L. Stambough
CME	Lawrence G. Lenke
E-Text.....	James W. Ogilvie
Education	Joseph H. Perra
Global Outreach.....	Peter F. Sturm
IMAST	Todd J. Albert
Patient Education	Ram Mudiya
Program Co-Chair.....	Noriaki Kawakami
Program Co-Chair.....	Michael J. Yaszemski
SRS/Spine Liaison	Allen W. Carl
Website	Andrew A. Merola
Worldwide Conference.....	Kamal N. Ibrahim

Staff Liaison: Megan Kelley
Back-up: Courtney Kissinger

Finance Council – Steven M. Mardjetko, Chair

Endowment	Frances A. Farley
Finance.....	Steven M. Mardjetko
Long Range Planning	Oheneba Boachie-Adjei

Staff Liaison: Tressa Goulding
Back up: Megan Kelley

Governance Council – David W. Polly, Jr., Chair

Advocacy & Public Policy.....	Daniel W. Green
Bylaws & Policies	Robert J. Huler
Coding.....	Barton L. Sachs
Ethics.....	Denis S. Drummond
Fellowship.....	Mark Weidenbaum
Historical	Nathan H. Leibold
Industry Relations.....	Oheneba Boachie-Adjei
Marketing & PR.....	Alan Moskowitz
Newsletter.....	Vicki Kalen
Global Affairs Advisory Board.....	Kenneth Cheung

Staff Liaison: Tressa Goulding
Backup: Nilda Toro

Research Council – Peter O. Newton, Chair – 2010

Chair Elect: Kenneth M C Cheung	
Adult Deformity.....	Frank J. Schwab
Evidence Based Outcomes.....	James O. Sanders
Growing Spine.....	Behrooz A. Akbarnia
Morbidity & Mortality.....	D. Raymond Knapp
Non-Operative Management.....	Brian G. Smith
Research Grant.....	Nancy Hadley Miller
3D Scoliosis	Hubert Labelle

Staff Liaison: Courtney Kissinger
Backup: Nadine Couto

Previous SRS Award & Research Grant Recipients

Exhibit Awards

1982	Ronald L. DeWald, Mary Faut Rodts, James S. Fister <i>The Management of Unstable Burst Fractures of the Thoracic and Lumbar Spine</i>
1984 (Blount)	R. Mervyn Letts and G.J.Gouw <i>Scoliosis in the Head Injured Child</i>
1985 (Blount)	Kiyoshi Kaneda, Tomoyuki Hashimoto, Shigenobu Satoh, Kuniyoshi Abumi <i>Late Progressive Neurologic Deficit Following Thoracolumbar Spine Fractures</i>
1986 (Blount)	Greg Houghton, Anne McInerny, Tony Tew <i>Compliance Monitoring System for Spinal Braces</i>
1987	Jeffrey H. Owen, Keith H. Bridwell <i>Motor (MEPs) and Somatosensory Evoked Potentials (SEPs) in Animals and Humans: Sensitivity and Specificity</i>
1991	Ian A.F. Stokes, Mack Gardner-Morse, Jeffrey P. Laible <i>The Biomechanics of Surgical Derotation</i>
1992	Tali Siegal, Tzony Siegal <i>Neoplastic Spinal Cord Compression: Manipulation of Vasogenic Edema by Ketanserin, a 5-HT₂ Receptor Blocker</i>
1993	Kristian Høy, S.M. Jespersen, E.S. Hansen, K.Ø. Christensen, B.E. Lindblad, S.Z. He, C. Bungler <i>Hemodynamics of the Spinal Cord, Cauda Equina, Nerve Roots and the Dural Sac During Exercise - An Experimental Study</i>
1994 (Moe)	Kirkham B. Wood, Timothy A. Garvey, Cooper Gundry, Kenneth Heitoff <i>Thoracic MRI Evaluation of Asymptomatic Individuals</i>
1995 (Moe)	Michael P. Chapman, Christopher L. Hamill, Keith H. Bridwell, Lawrence G. Lenke, Kathy Blanke, Christy Baldus <i>Can We Lordose the Spine with Zielke Instrumentation Anteriorly?</i>
1996 (Moe)	Sakae Sato, Marc A. Asher <i>Comparison of Lamina Hook to Pedicle Screw Anchors for Correction of Double Structural Adolescent Idiopathic Scoliosis</i>
1997 (Moe)	Tatsuto Takeuchi, Kuniyoshi Abumi, Itaru Oda, Yasuhiro Shono, Kiyoshi Kaneda <i>Biomechanical Evaluation of Thoracic Spinal Stability: A Significance of Costovertebral Joints in Providing Stability</i>
1998 (Moe)	Itaru Oda, Bryan W. Cunningham, Charles J. Haggerty, Kiyoshi Kaneda, Paul C. McAfee <i>An In-Vitro Study Investigating the Stability of Reconstruction Methods Following Total Spondylectomy</i>
1999 Moe - Basic Science	Edward P. Southern, Howard S. An, Charles E. Edmiston, Jr., Larry Newman, Michael Goheen, Dawn Zuelke, Sharon Sinski, Gary Seabrook <i>A Microbiology and Lint Study in the Orthopaedic Surgery Operating Room</i>
1999 Goldstein Clinical	Christian Fras, Twee Do, Stephen Burke, Bernard Rawlins, Roger Widmann, Oheneba Boachie-Adjei <i>Routine Preoperative MRI in Adolescent Idiopathic Scoliosis: A Prospective Study of 327 Patients</i>
2000 Moe – Basic Science	R.K. Wilcox, T.O. Boerger, R.M. Hall, D.C. Barton, D.L. Limb, R.A. Dickson <i>Canal Pressure Measurements and Video Recording of Thoracolumbar Burst Fractures</i>
2000 Goldstein Clinical	Makoto Tokunaga, Shohei Minami, Hiroshi Kitahara, Yoshinori Nakata, Hideshige Moriya <i>Neurologic Complications in Scoliotic Patients with Syringomyelia</i>
2001 Moe – Basic Science	P.C. McAfee, B.W. Cunningham, A.E. Dmitriev, N. Shimamoto, J.C. Sefter, I.L. Fedder <i>General Principles of Porous Ingrowth Total Disk Replacement Arthroplasty Compared to Diarthrodial Total Joint Arthroplasty. A Non-Human Primate Model – Part 1</i>
2001 Goldstein Clinical	Mohammed J. Al-Sayyad, Charles T. Mehlman, Alvin H. Crawford <i>Effectiveness of Spinal Release and Halo-Femoral Traction in the Management of Severe Spinal Deformity</i>

Previous SRS Award & Research Grant Recipients

2002 Moe – Basic Science	Andrew A. Merola, Michael F. O'Brien, Amit Lamba, Gregorio Chejfec, Thomas R. HaHer, Andrew Castro, Franco Givna, Sameer Mathur, Mario Brkavic, David A.B. Smith, James M. Eule, N. Joseph Espat, Thomas G. Lowe, Thomas F. Dwyer <i>Attenuation of Cillary Neurotrophic Factor (CNTF) in Acute Spinal Cord Injury (ASCI) Treated with Intravenous Methylprednisolone (MP)</i>
2002 Goldstein Clinical	Behrooz A. Akbarnia, David S. Marks, Oheneba Boachie-Adjei, Marc A. Asher, Alistair G. Thompson, Richard C. Rooney, Chatupon Chotigavanichaya <i>Dual Rod Posterior Instrumentation Without Fusion for the Treatment of Progressive Early Onset Scoliosis: A Multicenter Study</i>
2003 Moe – Basic Science	William W. Lu, Kenneth M.C. Cheung, Keith D.K. Luk, John C.Y. Leong <i>A Novel Sr-HA Bioactive Bone Cement for Vertebroplasty</i>
2003 Goldstein Clinical	Athanasios I. Tsirikos, Freeman Miller, Wei-Ning Chang, Kirk W. Dabney, Joseph Glutting <i>Life Expectancy in Pediatric Patients with Cerebral Palsy and Neuromuscular Scoliosis who Underwent Spinal Fusion</i>
2004 Moe – Basic Science	Vikas V. Patel, Li Zhao, Pamela Wong, Ben Bhupendra Pradhan, Linda Kanim, Hyun W. Bae, Rick B. Delamarter <i>Controlling BMP-Simulated Bone Growth Using Fibrin Glue</i>
2004 Goldstein Clinical	André van Ooij, F. Chumhur Oner, Ab J. Verbout <i>Complications of Artificial Disc Replacement: A Report of 45 Patients with an Unconstrained Disc Prosthesis</i>
2005 Goldstein Clinical	Gene Cheh, Lawrence G. Lenke, Keith H. Bridwell, Young-Jung J. Kim <i>"Decompression Alone vs. Decompression and Limited Fusion for the Treatment of Degenerative Lumbar Scoliosis"</i>
2005 Moe – Basic Science	Cathy Xiao Xi Guo, Kenneth McCheung, Danny Chan, Michael Irwin <i>"Comparison of the Effect of Non-Selective NSAID and Cyclooxygenase-2 (COX-2) Selective NSAID on Bone Formation – Implications for Spinal Fusion"</i>
2006 Goldstein Clinical	Clayton L. Dean, Josue P. Gabriel, Michael J. Bolesta, Ezequiel Cassinelli, Henry H. Bohlman <i>Degenerative Spondylolisthesis of the Cervical Spine. A Long Term Follow-up Study</i>
2006 Moe – Basic Science	Nancy Hadley Miller, Beth Marosy, Marie Helene Roy-Gagnon, Kimberly F. Doheny, Elizabeth W. Pugh, Alexander F. Wilson, Cristina M. Justice <i>Familial Idiopathic Scoliosis: Defining Genomic Loci on Chromosomes 9 and 16 Utilizing Custom SNP Panels</i>
2007 Moe – Basic Science	Jonathan G. Schoenecker, Nicholas Mignemi, Heidi Hamm, Herbert Schwartz, Ginger Holt, Gregory Mencio <i>Aprotinin Inhibits Bone Formation In Vitro</i>
2007 Goldstein – Clinical	Mark J. Sokolowski, Timothy A. Garvey, John Perl, Amir A. Mehbod, Burak Akesen, Margaret S. Sokolowski, Ensor E. Transfeldt <i>Prospective Study of Post-Operative Lumbar Epidural Hematoma: Does Size Really Matter?</i>
2008 Moe – Basic Science	Chi Wai Gene Man; Hiu Yan Yeung, PhD; Wei Jun Wang, MPHIL; Kwong Man Lee, PhD; Bobby KW Ng, MD; Vivian W. Hung; Yong Qiu, MD; Jack Chun Yiu Cheng, MD <i>A Study on the Effect of Melatonin Toward the Proliferation and Differentiation of Osteoblasts in Adolescent Idiopathic Scoliosis</i>
2008 Goldstein - Clinical	Daniel J. Sucato, MD, MS; Timothy R. Kuklo, MD, JD; Mohammad Diab, MD; B. Stephens Richards, III, MD; Charles E. Johnston, MD; Lawrence G. Lenke, MD; Spinal Deformity Study Group <i>Risk Factors for Critical Intraoperative Neuromonitoring Changes During AIS Surgery</i>
2009 Moe – Basic Science	Hong Zhang; Daniel J. Sucato, MD, MS <i>Quantitative Histology of the Neurocentral Synchronosis in a Growing Animal Scoliosis Model</i>
2009 Goldstein - Clinical	Jean-Marc Mac-Thiong; Stefan Parent; Benoit Poitras; Hubert Labelle <i>Neurological Outcome Associated with Severely Misplaced Pedicle Screws: A Case Report</i>

Previous SRS Award & Research Grant Recipients

Best Discussor

1984	Harold K. Dunn, MD
1985	Dennis R. Wenger, MD
1986	Vernon T. Tolo, MD
1988	Thomas F. Kling, Jr., MD
1989	J. Andy Sullivan, MD
1991	John E. Hall, MD
1992	Gordon L. Engler, MD

1988

Steve K. Salzman, A.A. Mendez, A.S. Fonseca, E.B. Ingersol, G.M. Freeman, I.H. Choi
Effects of Anesthesia on Outcome After Experimental Spinal Trauma: Halothane has a Protective Effect

1989

Rick B. Delamarter, Henry H. Bohlman, D. Bodner, C. Biro
Urologic Function Following Experimental Cauda Equina Compression: Cystometrograms vs. Cortical Evoked Potentials

Hibbs Award for Best Basic Science Presentation

1980	Kazuhiko Satomi, Jens Axelgaard <i>Effects of Selective Cord Transections on Spinal Evoked Potentials</i>
1981	Ensor E. Transfeldt, Edward H. Simmons <i>Functional and Pathological Biomechanics of the Spinal Cord: An In Vivo Study</i> John A. Herring <i>Early Complications of Segmental Spinal Instrumentation</i>
1982	R.G. Burwell, J.J. James, F. Johnson, J.K. Webb, Y.G. Wilson <i>Standardized Trunk Asymmetry Scores: A New Method and a Study of Normality</i> Roger P. Jackson, E.J. Simmons, D. Stripinis <i>Structural Changes Correlating with Back Pain in Scoliosis</i>
1983	Robert Barrack <i>Proprioception in Idiopathic Scoliosis</i>
1984	Cohen, Solomons, Lowe <i>Altered Platelet Calmodulin Activity in Idiopathic Scoliosis</i> D. Hoppenfeld, Gross and Andrews <i>The Ankle Clonus Test</i>
1985	Thomas F. Kling, Jr, P.M. Spargo, Robert N. Hensinger, P.R. Knight III <i>The Effect of Nitroglycerin Induced Hypotension With and Without Spine Distraction on Canine Spinal Cord Blood Flow</i>
1986	William C. Schrader, Daniel Bethem, Vladimir Scerbin <i>The Chronic Local Effects of Sublaminar Wires - An Animal Model</i>
1987	Jeffrey H. Owen, John Laschinger, Keith Bridwell, Shelle Shimon, Carl Nielsen, Janet Dunlap <i>Sensitivity and Specificity of Somatosensory and Neurogenic-Motor Evoked Potentials in Animals and Humans</i>

1990

Steven K. Salzman, Michael A. Puniak, Zhongjun Liu, Richard P. Maitland-Heriot, Gina M. Freeman, Cynthia A. Agresta, Laura Van Newkirk
Pharmacological Treatment of Acute Spinal Trauma I: Mechanisms of Action of the Serotonin Antagonist Mianserin

1991

Dale Dalenberg, Marc A. Asher, Gopal Jayaraman, Ralph Robinson
The Effect of a Stiff Spinal Implant and Its Loosening on Bone Mineral Content in Canines

1992

Sanford E. Emery, Mark S. Brazinski, Anuradah Koka, Jay S. Bensusan, Sharon Stevenson
The Biological and Biomechanical Effects of Irradiation on Anterior Spinal Bone Grafts - A Canine Model

1993

Stephen D. Cook, Thomas S. Whitecloud, Jeanette E. Dalton, D.C. Rueger
In Vivo Evaluation of Recombinant Human Osteogenic Protein (rhOP-1) as a Bone Graft Substitute for Spine Fusions

1994

Jeffrey H. Schimandle, Scott D. Boden, W.C. Hutton
Experimental Spine Fusion with Recombinant Human Bone Morphogenetic Protein (rhBMP-2)

1995

Douglas M. Petraco, Jeffrey M. Spivak, Joseph G. Cappadona, Frederick J. Kummer, Michael G. Neuwirth
An Anatomic Evaluation of L5 Nerve Stretch in Spondylolisthesis Reduction

1996

S.B. Tan, J.T.H. Chew, R. Fortune, H.H. Tan, K.P. Tan, R.T.H. Ng, I.C. Song
Allograft Vertebral Disc Transplantation in a Porcine Model

1997

Keith M. Bagnall, Cian O'Kelly, Marc Moreau, James Raso, Xiaoping Wang
Scoliosis Development Following Pinealectomy in Young Chickens, Rats and Hamsters

Previous SRS Award & Research Grant Recipients

1998	John R. Dimar II, Steven Glassman, George Raque, Y. Ping Zhang, Christopher Shields <i>The Influence of Canal Narrowing and Timing of Decompression on Neurological Recovery Following Spinal Cord Contusion in the Rat Model</i>	2007	Kenneth J. Hunt, John T. Braun, Bryt A. Christensen <i>The Effect Of Two Clinically Relevant Fusionless Scoliosis Implant Strategies On The Health of the Intervertebral Disc</i>
1999	Jeffrey C. Wang, Stephen Yoo, Linda E.A. Kanim, Paula L. McAllister, Scott D. Nelson, Edgar G. Dawson, Jay R. Lieberman <i>Gene Therapy for Spinal Fusion: Transformation of Marrow Cells with an Adenoviral Vector to Produce BMP-2</i>	2008	Hemal Mehta, MSc; Brian D. Snyder, MD, PhD; Stephen R. Baldassarri, BA; Melissa J. Hayward, MD; Michael J. Giuffrida, MD; Supriya P. Bansal, BS; Vahid Entezari, MD; Nipun D. Patel, MS; Andrew C. Jackson, PhD <i>VEPTR Improves Pulmonary Hypoplasia in a Postnatal Rabbit Model of Thoracic Insufficiency Syndrome</i>
2000	K.D. Riew, J. Lou, N.M. Wright, S.-L. Cheng, T. Bae, L.V. Avioli <i>Thoracoscopic Intradiscal Spine Fusion Using Gene Therapy</i>	2009	Francis Shen; Qing Zeng; Gary Balain <i>Influence of GDF-5 on Osteogenic Differentiation of Adipose-Derived Stromal Cells in a Three-Dimensional Microsphere Matrix (Plaga)</i>
2001	M. Darryl Antonacci, Manu Nothias, Catherine Humphreys, Richard Frisch, Marion Murray <i>Axonal Regeneration Using Transplants of Genetically Engineered Fibroblasts in Spinal Cord Injury</i>	Hibbs Awards for Best Clinical Presentation	
2002	Kohei Goshi, Oheneba Boachie-Adjei, Bernard A. Rawlins, Ronald G. Crystal, Chisa Hidaka <i>Genetically Modified Marrow Cells Enhance Spine Fusion</i>	1981	John A. Herring, Dennis R. Wenger <i>Early Complications of Segmental Spinal Instrumentation</i>
2003	M. Darryl Antonacci, Jean Nothias, Tom Parks, Richard Fritsch, Chris Cawley, Marion Murray <i>Human Marrow Stromal Cell Transplants in a Collagen Matrix Support Axonal Regeneration of Descending Pathways Across Complete Spinal Cord Transections</i>	1982	Roger P. Jackson, Edward H. Simmons, D. Stripinis <i>Structural Changes Correlating with Back Pain in Scoliosis</i>
2004	William C. Horton, Chaiwat Kraiwattanapong, Tomoyuki Akamaru, Akihito Minamide, Moon-Soo Park, William Hutton <i>The Role of the Sternum, Costosternal Articulations, Intervertebral Disc, and Facets in Thoracic Sagittal Plane Biomechanics and Deformity Correction: A Comparison of Three Different Sequences of Surgery</i>	1984	Hoppenfeld, Gross and Andrews <i>The Ankle Clonus Test</i>
2005	Brian K. Kwon, Jie Liu, Clarrie Lam, Loren W. Oschipok, Armin Blesch, Wolfram Tetzlaff <i>"Brain Derived Neurotrophic Factor Gene Transfer with Adeno-Associated Viral and Lentiviral Vectors Prevents Rubrospinal Neuronal Atrophy and Stimulates Regeneration Associated Gene Expression after Acute Cervical Spinal Cord Injury"</i>	1985	Bert Mandelbaum, Vernon Tolo, Paul McAfee, Peggy Buresh <i>Nutritional Deficiencies After Staged Anterior and Posterior Spinal Surgery</i>
2006	Howard S. An, Kei Miyamoto, Jesse G. Kim, Nozomu Inoue, Koji Akeda, Gunnar Andersson, Koichi Masuda <i>An Intradiscal Injection of Osteogenic Protein-1 Restores the Viscoelastic Properties of Degenerated Intervertebral Discs in the Rabbit Anular Puncture Model</i>	1986	Paul D. Sponseller, Mark S. Cohen, John E. Hall, Alf L. Nachemson <i>Long-Term Follow-Up of Adult Scoliosis Treated Surgically</i>
		1987	Christine S. O'Donnell, William P. Bunnell, Randal R. Betz, Cynthia R. Tipping <i>Electrical Stimulation in the Treatment of Idiopathic Scoliosis</i>
		1988	John E. Lonstein, Robert B. Winter <i>Milwaukee Brace Treatment of Adolescent Idiopathic Scoliosis - Review of 939 Patients</i>
		1989	J.P. Thompson, Ensor E. Transfeldt, David Bradford, Oheneba Boachi-Adjei <i>Evaluation of Spinal Imbalance and Shoulder Elevation Following Cotrel-Dubousset Instrumentation with Special Reference to Uncoupling</i>

Previous SRS Award & Research Grant Recipients

- 1990 David M. Apel, G. Marrero, W.D. Goldie, J. King, Vernon T. Tolo, George S. Bassett
Avoiding Paraplegia During Anterior Spinal Surgery: The Role of SSEP Monitoring During Temporary Occlusion of Segmental Spinal Arteries
- 1991 Lawrence G. Lenke, Keith H. Bridwell, Christy Baldus, Kathy Blanke
Preventing Decompensation in King Type II and III Curves Treated with Cotrel-Dubouset Instrumentation (CDI): 24 to 64 Month Follow-Up
- D. Holte, Robert Winter, John Lonstein, Francis Denis
Hemivertebra Excision and Wedge Resection in the Surgical Treatment of Patients with Congenital Scoliosis
- 1992 Shanti S. Upadhyay, P. Sell, B. Sell, M.J. Saji, E.K.W. Ho, J.Y.C. Leong
Seventeen Year Prospective Study of Surgical Management of Tuberculosis of the Spine: A Controlled Trial Comparing Anterior Debridement with Hong Kong Radical Operation
- 1993 Mark Goldberg, Nancy Mayo, Benoit Poitras, Susan Scott, James Hanley
The Ste-Justine Adolescent Idiopathic Scoliosis (AIS) Cohort Study I & II: Description of the Cohort Health Outcomes and Back Pain
- 1994 Thomas Maher, R. Zipnick, D. Manor, Andrew Merola, John Gorup, J. Dryer, R. Nucci, J. Orchowski, C. Kaufmann
Meta-Analysis of Surgical Outcome in Scoliosis: A Thirty One Year Review of Eleven Thousand Patients
- 1995 Howard H. Ginsburg, L. Goldstein, P. William Haake, Shannon Perkins, K. Gilbert
Longitudinal Study of Back Pain in Postoperative Idiopathic Scoliosis: Long-Term Follow-Up, Phase IV
- 1996 James O. Sanders, David G. Little, B. Stephens Richards
Prediction of the Crankshaft Phenomenon by the Peak Growth Age
- 1997 John P. Kostuik
The Development of a Preoperative Scoring Assessment System of Metastatic Spine Disease
- 1998 Stuart L. Weinstein, Lori Dolan, Kevin Spratt, Kirk Peterson, Mark Spoonamore
Natural History of Adolescent Idiopathic Scoliosis: Back Pain at 50-Year Follow-Up
- 1999 Marc A. Asher, Sue Min Lai, Douglas C. Burton
Further Development and Validation of the SRS Outcomes Instrument
- 2000 Hiroshi Taneichi, Kiyoshi Kaneda, Kuniyoshi Abumi, Manabu Ito
Radiological Differentiation Between Benign and Malignant Vertebral Body Collapse
- 2000 R. Jhanjee, K. Wood, G. Buttermann, T. Garvey, R. Kane, V. Sechrest, A. Mehbod
Operative Vs. Nonoperative Treatment of Thoracolumbar Burst Fractures without Neurological Deficit: A Randomized, Prospective Study
- 2001 – TIE Aina J. Danielsson, I. Wiklund, K. Pehrsson, Alf L. Nachemson
Health-Related Quality of Life in Patients with Adolescent Idiopathic Scoliosis – A Matched Follow-Up at Least Twenty Years After Treatment with Brace or Surgery
- Harry L. Shufflebarger, Cynthia Clark
The Posterior Approach for Lumbar and Thoracolumbar Adolescent Idiopathic Curves: Posterior Shortening and Pedicle Screws
- 2002 C. Barrios, C. Pérez-Encinas, J.I. Maruenda, P. Renovell, N. de Bernardo, L. García del Moral, J.A. Martín-Benlloch, M. Laguía
Significant Ventilatory Functional Restriction in Adolescents with Mild or Moderate Scoliosis During Maximal Exercise Tolerance Test
- 2003 Eric J. Wall, Donita Bylski-Austrow, Ronald Kolata, Alvin H. Crawford
Endoscopic Mechanical Spinal Hemiepiphysiodesis Modifies Spine Growth
- 2004 Christopher Hulen, H. Temple, Allaaddin Mollobashy, Frank Eismont
Oncological and Functional Outcome Following Sacrectomy for Sacral Tumors
- 2005 Ilkka Helenius, Tommi Lamberg, Kalevi Österman, Dietrich Schlenzka, Timo Yrjönen, Seppo Seitsalo, Mikko Poussa, Ville Remes
"Posterolateral, Anterior or Circumferential Fusion In-Situ for High-Grade Spondylolisthesis in Young Patients: A Long-Term Evaluation using SRS Questionnaire"
- 2006 Joshua D. Auerbach, Daniel M. Schwartz, Denis S. Drummond, Kristofer J. Jones, John M. Flynn, Yaser El-Gazzar, Thomas McPartland, J. Andrew Bowe, Samuel Laufer, Peter D. Pizzutillo, J. Richard Bowen, John P. Dormans
Detection Of Impending Neurologic Injury During Surgery For Adolescent Idiopathic Scoliosis: A Comparison Of Transcranial Motor And Somatosensory Evoked Potential Monitoring In 1121 Consecutive Cases

Previous SRS Award & Research Grant Recipients

- 2007 Lawrence G. Lenke; Brenda A. Sides; Linda Koester; Marsha Hensley; Kathy Blanke
Posterior Vertebral Column Resection (VCR) for Severe Pediatric and Adult Spinal Deformity: Indications, Results, and Complications of 43 Consecutive Cases
- 2008 Michael D. Daubs, MD; Alpesh Patel, MD; Darrel S. Brodke, MD
Clinical Instinct vs. Standardized Questionnaire: The Spinal Surgeon's Ability to Detect Psychological Distress
- 2009 Justin Smith; Christopher I. Shaffrey; Steven D. Glassman; Sigurd Berven; Christopher Hamill; William C. Horton; Stephen L. Ondra; Frank Schwab; Charles A. Sansur; Keith H. Bridwell
Risk-Benefit Assessment of Surgery for Adult Scoliosis: An Analysis Based on Patient Age

Walter P. Blount Humanitarian Award

- 1987 Marc A. Asher, MD
1989 Howard and Barbara Schulman
1992 Laura Gowen
1996 David B. Levine, MD
1997 Albert E. Sanders, MD
1998 L. Ray Lawson, MD
2001 Charles F. Heinig, MD
2002 James E. Holmblad, MD
2006 Oheneba Boachie-Adjei, MD
2007 Professor John CY Leong
2008 Behrooz A. Akbarnia, MD
2009 Robert M. Campbell, MD

Lifetime Achievement Awards

- 2008 John E. Hall, MD
Jacqueline Perry, MD, DSc
2009 Marc A. Asher, MD
David B. Levine, MD

SRS Travelling Fellows

- 1970 John D. King, California
Jen Fang Wang, Taiwan
1971 Donald P.K. Chan, Vermont
Gourish R. Palekaar, India
1993 **Medtronic Sofamor Danek Traveling Fellows**
Robert B. Winter, MD, Senior Fellow
George S. Bassett, MD, Junior Fellow
J. Kenneth Burkus, MD, Junior Fellow
Ensor E. Transfeldt, MD, Junior Fellow

- 1995 **Medtronic Sofamor Danek Traveling Fellows**
John E. Hall, MD, Senior Fellow
Howard S. An, MD, Junior Fellow
Hubert H.L. Labelle, MD, Junior Fellow
Lawrence G. Lenke, MD, Junior Fellow
1997 **Medtronic Sofamor Danek Traveling Fellows**
Ronald L. DeWald, MD, Senior Fellow
Vincent Arlet, MD, Junior Fellow
Allen L. Carl, MD, Junior Fellow
Michael F. O'Brien, MD, Junior Fellow
1999 **Medtronic Sofamor Danek Traveling Fellows**
Clyde L. Nash, MD, Senior Fellow
Serena S. Hu, MD, Junior Fellow
Joseph Y. Margulies, MD, PhD, Junior Fellow
Rolando M. Puno, MD, Junior Fellow
Kirkham B. Wood, MD, Junior Fellow
2000 **DePuy AcroMed International Traveling Fellows**
Ufuk Aydinli, MD, Turkey
Henry F.H. Halm, MD, Germany
Yutaka Hiraizumi, MD, PhD, Japan
2001 **Medtronic Sofamor Danek Traveling Fellows**
John P. Kostuik, MD, Senior Fellow
Peter O. Newton, MD, Junior Fellow
Richard M. Schwend, MD, Junior Fellow
Edward P. Southern, MD, Junior Fellow
2002 **DePuy AcroMed International Traveling Fellows**
Bruce F. Hodgson, FRACS, New Zealand
Jin-Hyok Kim, MD, Korea
Muharrem Yazici, MD, Turkey
(Note: Tamás Illés, MD, Hungary, was originally selected but unable to participate)
2003 **Medtronic Sofamor Danek Traveling Fellows**
Courtney W. Brown, MD, Senior Fellow
Timothy R. Kuklo, MD, Junior Fellow
Daniel J. Sucato, MD, Junior Fellow
Alexander R. Vaccaro, MD, Junior Fellow
2004 **DePuy Spine International Traveling Fellows**
Ahmet Alanay, MD, Turkey
Kenneth M.C. Cheung, MD, Hong Kong
Ulf R. Liljenqvist, MD, Germany
2005 **Medtronic Sofamor Danek Traveling Fellows**
Donald P.K. Chan, MD, Senior Fellow
Matthew B. Dobbs, MD, Junior Fellow
Charles T. Mehlman, MD, Junior Fellow
Suken Shah, MD, Junior Fellow
2006 **DePuy Spine International Traveling Fellows**
Theodoros B. Grivas, MD, Greece
Ashok Johari, MD, India
Reinhard D. Zeller, MD, France

Previous SRS Award & Research Grant Recipients

- 2007** **Medtronic Traveling Fellows**
James Ogilvie, MD, Senior Fellow
Youngjung Kim, MD, Junior Fellow
Praveen Mummaneni, MD, Junior Fellow
Jean Ouellet, MD, Junior Fellow
- 2008** **DePuy Spine International Traveling Fellows**
Kyu-Jung Cho, MD, South Korea
Kan Min, MD, Switzerland
Avraam Ploumis, MD, Greece
- 2009** **Medtronic Spine International Traveling Fellows**
Alvin H. Crawford, MD - Senior Traveling Fellow
Jacob Buchowski, MD, MS
Frank LaMarca, MD
Francis Shen, MD

Research Grant Recipients

In the last ten years, SRS, in conjunction with OREF and the Cotrel Foundation have provided more than \$1.8 million for spinal deformity research projects. The following are previous SRS Research Grant recipients:

1998

Nancy Hadley Miller, MD

Genetic Analysis of Etiologic Factors of AIS
\$50,000 – 2 years

John A. Szivek, PhD

Monitoring Spinal Fusion in Scoliosis Patients: A Biomechanical & In Vivo Study
\$54,000 – 2 years

Jack Engsberg, PhD

Comparison of Outcome Measures in Adult Scoliosis Patients Undergoing an Extended Spinal Fusion to L5 or Sacrum or Revision of Previous Long Spinal Deformity Fusion
\$80,308 – 3 years

William A. Vannah

Longitudinal Study of Balance & Other Factors in AIS
\$10,887.50 – 2 years

1999

Jack C.Y. Cheng, MD

The Loss of Synchronous Coupling of Endochondral and Membranous Ossification in AIS: The Morphological and Biological Evidences
\$35,400 – 1 year

James O. Sanders, MD

A Determination of Maturity in Girls with Idiopathic Scoliosis: A Pilot Study
\$48,252 - 2 years

2000

Keith Bagnall, PhD

The Relationship Between Serum Melatonin & Growth Hormone in Pinealectomy Model
\$14,250 – 2 years

Oheneba Boachie-Adjei, MD w/ Dr. Raymond Clarke

Developmental Basis of the Klippel-Feil Syndrome
\$60,000 – 3 years

Frances Farley, MD

Prediction of Curve Progression in Congenital Scoliosis Using a Mouse Model
\$44,926 – 2 years

Carol A. Wise, PhD

Localization of a Gene for Susceptibility To Idiopathic Scoliosis
\$36,066.50 – 2 years

Nancy Hadley Miller, MD

Genetic Linkage of Familial Idiopathic Scoliosis – A Complex Orthopaedic Disorder
\$50,000 – 2 years

Thomas Lowe, MD

Platelet Calmodulin Levels in AIS: A Predictor of Curve Progression and Severity
\$42,070 – 2 years

2001

Jack C.Y. Cheng, MD

Relationship between Postural Balance, Somatosensory Evoked Potential and the Progression of Scoliotic Deformity in the AIS
\$70,800 – 2 years

2002

Carol Wise, PhD

Localization & Analysis of Candidate Genes of Idiopathic Scoliosis
\$36,666.50 – 2 years

2003

Jack C.Y. Cheng, MD

Are VDR, Era and PTHR1 Genes Associated With The Occurrence as well As Abnormality In Bone Growth And Sexual Maturation In Adolescent Idiopathic Scoliosis
\$70,800 – 2 years

John Kostuik, MD

Adult Onset of Scoliosis: Relationship between Osteoporosis and Deformity
\$30,000 – 2 years

Matthew Dobbs, MD

Idiopathic Scoliosis: Gene Mapping Identification
\$47,177 – 2 years

Previous SRS Award & Research Grant Recipients

2004

Philip Giampietro, MD, PhD

Mutation Analysis in Human Congenital Scoliosis and Vertebral Malformations
\$77,077 – 2 years

Carol Wise, PhD

Localization and Analysis of Candidate Genes for Idiopathic Scoliosis
\$50,000 – 2 years

Ralph Marcucio, PhD

A Comparison of the Expressions of Malatonin, Calmodulin and 5-HT4 in Paravertebral Muscle and Platelets of Patients with our without Adolescent Idiopathic Scoliosis
\$50,000 – 2 years

2005

Kenneth Cheung, MD

Surface Modification of Nitinol by Plasma Immersion ION Implantation
\$100,000 – 2 years

Robin Patel, MD

Biofilms and Spinal Instrumentation
\$99,850 – 2 years

Alf Nachemson, MD, PhD

A Continuation of the "SRS Study for Brace Treatment of Adolescent Idiopathic Scoliosis" – Follow-up of the Swedish Patients at Least 10 Years After Maturity
\$47,020 – 2 years

Brian Snyder, MD, PhD

How does VEPTA Affect Pulmonary Function: An In-vivo Assessment using the Rabbit Scoliosis Model
\$34,408 – 1 year

Stefan Parent, MD, PhD

Analysis of Local 3-D Measurements of the Curve as Predictive Factors for Curve Progression in AIS
\$25,000 – 1 year

Francis Shen, MD

Can We Eliminate the Need for Autologous Bone Graft Harvest? The Use of Multipotential Adipose-derived Stromal Cells in an Activated Matrix for Posterolateral Spinal Fusions
\$25,000 – 1 year

Andrew Merola, MD

Association between an Aggrecan Gene Polymorphism and AIS
\$10,000 – 1 year

Anthony Florschutz, MD

Experimental Scoliosis Using Vertebral Body Implanted Magnets in an Immature Goat Model
\$10,000 – 1 year

Stefan Parent, MD, PhD

Growth Modulation of the Chest Case in a Pre-Natal Ovine Model: A Preliminary Study
\$10,000 – 1 year

Andrew Mahar, MS

How Does Increasing Curve Magnitude in Scoliotic Deformity Affect the Biomechanics of the Spine with Implications Toward Curve Correction?
\$10,000 – 1 year

Donita Bylski-Austrow, PhD

Mechanobiology of Growth: In-Vivo Growth Plate Pressures
\$10,000 – 1 year

Felix Breden, BA, MSc, PhD

The Guppy 'Curveback' Mutant as a Model for Spinal Deformity
\$10,000 – 1 year

Jack C.Y. Cheng, MD

Abnormal Differential Longitudinal Growth of Vertebral Column and Spinal Cord in AIS – A Morphological and Functional Study
\$77,000

Brian K. Kwon, MD, PHD, FRCSC

Neuroprotection for Acute Spinal Cord Injury: The Preclinical Evaluation of Drugs That Are Currently Used in Human Non-Spinal Applications
\$24,881.60 – 2 years

2006

Carol Wise, PhD

Identification of Genetic Susceptibility in Idiopathic Scoliosis
\$19,000 – 2 years

Shane Burch, MD FRCSC

The Role of Hypoxic Stress on the Vertebral Growthplates of the Developing Spine and its Potential Role in Pathogenesis of Scoliosis
\$10,000 – 1 year

Vedat Deviren, MD

The Minimal Clinically Important Difference (MCID) for Spinal Disorders: Finding the Threshold of Clinically Significant Change
\$24,996 – 1 year

2007

Jeffrey Shilt, MD; Peter Apel, MD

Temporary Unilateral Paraspinal Muscle Paralysis on the Prevention and Progression of Scoliosis: Investigation in a Chicken Model
\$9,740 - 1 year

Previous SRS Award & Research Grant Recipients

Mohammad Diab, MD

Comparison of Extended-Release Epidural Morphine, Patient-Controlled Epidural Analgesia and Patient-Controlled Intravenous Analgesia for Postoperative Pain after Posterior Spinal fusion in Adolescents
\$24,245 – 2 years

Frank Schwab, MD

Adult Deformity: Development of an Effective Treatment Algorithm Based upon Outcomes Analysis
\$50,000 – 2 years

John Lonstein, MD

Long-term Function Outcomes of Early Fusions for Congenital Scoliosis
\$75,450 – 2 years

Michael Vitale, MD

CT Analysis of Pedicle Screw Placement in Pediatric Patients
\$20,595 – 1 year

Vidyadhar Upasani, MD

The Effect of Increasing Construct Rigidity on Intervertebral Disc Health: A Pilot Study in a Porcine Anterior Spinal Growth Modulation Model
\$10,000 – 1 year

Xudong Li, MD

Nucleus Pulposus Regeneration with Genetically Engineered Fat-derived Stem Cells
\$50,000 – 2 years

Josh Auerbach, MD

An in vivo Porcine Animal Model to Detect Spinal Cord Vascular Flow in Spinal Deformity Surgery using Transcranial Motor Evoked Potential Monitoring
\$10,000 – 1 year

2008

David Aronsson, MD

The Contribution of Asymmetric Growth and Vertebral Remodeling to Apical Wedging
\$41,829 – 2 years

Sigurd Berven, MD

Impact of Spinal Disorders on Health Related Quality of Life
\$5,000 – 1 year

Andrew Briggs, MD

Measurement of Vertebral Subregional Bone Mineral Density using Lateral-Projection DXA: Establishing Concurrent and Predictive Validity
\$10,000 – 1 year

Shane Burch, MD

Monitoring of Nerve Root Injury Using Transcranial Motor-Evoke Potentials in a Pig Model
\$23,255 – 2 years

Qian Chen, PhD

The Potential Role of Fibronectin in the Pathogenesis of Congenital Scoliosis
\$25,000 – 1 year

Daniel Y.T. Fong, MD

Single-Blind Comprehensive Cohort Study Incorporating A Randomized Controlled Design on Bracing in AIS: A Feasibility Study
\$25,000 – 2 years

Safdar Khan, MD

Utilizing a Novel MRI-based (Dense-FSE) Technique to Characterize Spatial Strain Distributions in an Established Model of Intervertebral Disc Degeneration: Implications for Tissue Engineering
\$10,000 – 1 year

Hubert Labelle, MD

Towards a 3D Classification of Adolescent Idiopathic Scoliosis
\$49,600 – 2 years

Carol Wise, PhD

Identification of Genetic Susceptibility in Idiopathic Scoliosis
\$60,000 – 1 year

2009

Kirkham Wood, MD

Correlation of Adjacent Segment Degeneration and Quality of Life Outcome: Application an In-Vivo Biomechanics to Assess the Effect of Fusion in AIS
\$50,000 - 2 years

Hongbo Liu, MD

United States' Trends and Regional Variations in Lumbar Spine Surgery for Children with Spondylolysis and Spondylolisthesis
\$10,000 - 1 year

SRS Bylaws

Bylaws of Scoliosis Research Society

(An Illinois Not-For-Profit Corporation)

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SRS Bylaws

Bylaws of Scoliosis Research Society

(An Illinois Not-For-Profit Corporation)

ARTICLE I

NAME

The name of this corporation shall be the "Scoliosis Research Society" (hereinafter referred to as the "Society"). The Society is a nonstock, not-for-profit corporation organized under the Illinois Revised Statutes.

ARTICLE II

OBJECTIVES, PURPOSES AND POWERS

Section 2.1 Objectives and Purposes. The Society has been organized, and shall at all times be operated, exclusively for charitable, educational and scientific purposes within the meaning of section 501(c)(3) of the Code (as defined in Section 20.3, below), which purposes shall include, but not be limited to, the fostering, promotion, support, augmentation, development and encouragement of (a) investigative knowledge of the causes, cures and prevention of Scoliosis and related spinal deformities; (b) standardization of medical terminology in Scoliosis and related spinal deformities; (c) basic research in the field of Scoliosis and related spinal deformities; (d) the teaching and education of the same by developing, publishing and copyrighting educational material and providing specialized training for orthopaedic surgeons, neurosurgeons, and other members of the medical profession; and (e) education of the public with respect to the recognition and prevention of Scoliosis and related spinal deformities.

Section 2.2 Powers. The Society shall possess all powers which a corporation organized under the General Not-For-Profit Corporation Act of the State of Illinois, as the same from time to time may be amended shall possess; all powers which are not in conflict with said purposes; provided, however, the Society shall not engage in any business which would disqualify it from being exempt from taxation under Sections 501(a) or (c) (3) of the Code.

Section 2.3 Prohibited Practices. Notwithstanding anything in these Bylaws or the Society's Articles of Incorporation to the contrary, the Society shall exercise only those powers or engage in or carry on only those activities permitted to be exercised, engaged in or carried on by an organization exempt from federal income tax under Sections 501(c) (3) and 509(a) (1) of the Code and by an organization contributions to which are deductible under Section 170(c) (2) of the Code. The Society shall not engage in any activities which would result in the imposition of federal tax under Sections 4941 through 4945, inclusive, of the Code. No part of the net earnings of the Society shall inure to the benefit of any private individual, except that the Society shall be authorized and empowered to pay reasonable compensation for services rendered and to make payments and distributions in furtherance of the exempt purposes set forth in Section 2.1 of these Bylaws. No substantial part of the activities of the Society shall consist of carrying on propaganda or otherwise attempting to influence legislation, except as otherwise provided in subsection 501(h) of the Code, and the Society shall not participate or intervene in, including the publication or distribution of statements, any political campaign on behalf of or in opposition to any candidate for public office. In the pursuit of its purposes and the exercise of its powers, the Society shall make its services and activities available to the community that it serves regardless of, and shall not discriminate on the basis of, race, color, gender, sexual orientation, creed, religion or national origin.

ARTICLE III

OFFICES

Section 3.1 Principal and Business Offices. The Society may have such principal and other business offices as the Board of Directors may designate. The current principal offices are located at 555 East Wells Street, 11th Floor, Suite 1100, Milwaukee, Wisconsin 53202.

Section 3.2 Registered Agent. The Society shall maintain a registered agent as required by the Illinois Revised Statutes whose address may be, but need not be, identical with the principal office of the Society. The name and address of the registered agent may be changed from time to time by the Board of Directors.

Section 3.3 Records. The Board of Directors may keep the books of the Society in such place or places, including, without limitation, an authorized agent, as they may from time to time determine in accordance with the Illinois Revised Statutes.

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ARTICLE IV

CLASSES OF FELLOWSHIP

Section 4.1 Identification of Fellow Classes. The Society shall have members, which shall hereinafter be referred to as "Fellows." There shall be six (6) classes of membership (such term herein after referred to as "Fellowship") in the Society, namely, Candidate, Active, Inactive, Associate, Emeritus, and Honorary. Any reference to Fellows in these Bylaws refers to all six (6) classes of Fellowship, unless otherwise specified. Only Active Fellows shall have the right to vote on matters submitted to a vote of the members of the Society, hold office or serve on the Board of Directors. Otherwise, Fellows of any class shall have the same rights and responsibilities including the right to attend meetings and serve on Committees or Councils. Fellowship status in any class shall be a privilege, not a right, and is dependent upon the applicant for any class of Fellowship demonstrating compliance with the requirements for such Fellowship as defined in the Bylaws and otherwise as determined by the Board of Directors of the Society.

The Board of Directors may from time to time, in its sole discretion, establish membership criteria, rules and procedures applicable to Fellowship in any class in order to implement and carry out the provisions of this Article IV, including, without limitation, specific membership criteria, requirements and procedures for application to Fellowship in any class, and procedures and requirements for transfer between such classes of Fellowship; provided, however, that no such criteria, rules or procedures shall be established which alter the membership criteria and/or classifications set forth in these Bylaws. All determinations whether an individual has met the requirements for or otherwise qualified for membership of any class shall be made by the Board of Directors in its sole discretion after receiving and taking into account the recommendation of the Fellowship Committee (as defined in Section 9.3, below).

Section 4.2 Candidate Fellowship. The following individuals shall be eligible to be Candidate Fellows of the Society: (a) orthopaedic surgeons and neurosurgeons in active clinical practice who have a demonstrated interest and involvement in, and commitment to, the field of Scoliosis and related spinal deformities; and (b) scientists in a field related to Scoliosis and/or related spinal deformities who have a demonstrated interest and involvement in, and commitment to, scientific research and investigation in the field of Scoliosis and/or related spinal deformities. A Candidate Fellow shall be eligible to be considered for Active Fellow status after five (5) years of membership as a Candidate Fellow in good standing.

Section 4.3 Active Fellowship. Individuals who have been Candidate Fellows in good standing for five (5) years shall be eligible to become Active Fellows of the Society upon application made by such individual.

Section 4.4 Inactive Fellowship. Any Active Fellow who has become disabled by sickness or accident or otherwise becomes incapacitated for a period of more than fifteen (15) consecutive calendar months and who is unable to engage in his or her normal professional activities that give rise to his or her eligibility for Active Fellow status may apply to the Board of Directors for a transference to Inactive Fellow status. Individuals whose applications for Inactive Fellow status are approved shall be Inactive Fellows, in which event any rights and privileges accorded to any such individual as Active Fellow shall be suspended for such period as such individual is an Inactive Fellow. An individual who is an Inactive Fellow may apply to the Board of Directors for resumption of Active Fellow status as the case may be, once such individual resumes his or her normal professional activities which qualified him or her as an Active Fellow.

Section 4.5 Associate Fellowship. Individuals engaged in professional, scientific or academic activities and/or allied health specialties who:

- (a) have a demonstrated interest and involvement in, and commitment to, the field of Scoliosis and related spinal deformities but who are not otherwise eligible for Candidate Fellow or Active Fellow status; or
- (b) are eligible for Candidate Fellow or Active Fellow status but do not desire to become, Candidate Fellows or Active Fellows shall be eligible to be Associate Fellows of the Society.

Section 4.6 Emeritus Fellowship. An Active Fellow or Associate Fellow who has retired from the active conduct of his or her profession or vocation regardless of age or who has otherwise reached the age of sixty-five (65) shall be eligible to apply to the Board of Directors for a transfer to Emeritus Fellowship status. Membership dues shall be waived for Emeritus Fellows.

Section 4.7 Honorary Fellowship. Honorary Fellowship may be conferred, upon the recommendation of the Fellowship Committee and approval by the Board of Directors by a two-thirds (2/3) vote thereof, upon an individual who has contributed significantly to, or is otherwise preeminent in, the field of Scoliosis and/or related spinal deformities. Honorary Fellows shall not be required to pay dues. Honorary Fellows may be issued a certificate, in the discretion of the Board of Directors, signifying their admission as Honorary Fellows.

Section 4.8 Annual Meeting. The annual meeting of the Society shall be held at such time and place each year as may be determined by the Board of Directors from time to time (which time and place shall be specified in a notice of meeting), in

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order to elect new directors and officers, conduct such scientific sessions and discussions as the Board of Directors may determine and transact such other business as shall come before such meeting.

Section 4.9 Special Meetings. Special meetings of the members may be called for any purpose by (a) the President; (b) the Board of Directors by majority vote thereof; or (c) the written petition of five percent (5%) of the number of Active Fellows delivered to the Secretary of the Society.

Section 4.10 Voting. Each Active Fellow in good standing, and only Active Fellows in good standing, shall be entitled to vote in person on all matters to be voted on by members of the Society, including, without limitation, electing directors and officers of the Society as provided herein. Any matter to be decided by a vote of the members of the Society shall, except as otherwise provided in the Illinois Revised Statutes or as expressly provided herein, be decided by a majority of Active Fellows voting in person at a duly held meeting of Active Fellows at which a quorum is present. Cumulative voting or placing all votes for a particular candidate or a particular issue is prohibited. Whenever within these Bylaws an individual is specified as an Ex-Officio member of a board or committee, said Ex-Officio member shall not have the right to vote as such unless otherwise expressly provided in these Bylaws.

Section 4.11 Quorum. The presence in person of not less than twenty percent (20%) of the total number of Active Fellows shall constitute a quorum for the transaction of business at any annual or special meeting of Active Fellows of the Society. If a quorum is not present at any such meeting, a majority of the Active Fellows present thereat may adjourn the meeting from time to time, without further notice. The Active Fellows present in person at a duly organized meeting at which a quorum is present may continue to transact business until adjournment, notwithstanding the withdrawal during the meeting of that number of Active Fellows whose absence would cause less than a quorum.

Section 4.12 Notice of Meetings. Written notice stating the place (which may be within or without the state of Illinois), day and time of any meeting of Active Fellows (including, without limitation, any annual meeting) shall be signed by the President or Secretary of the Society and shall be delivered either personally or by first class United States mail, electronic mail or facsimile, to each member entitled to vote at such meeting, not less than thirty (30) days nor more than sixty (60) days before the date of such meeting. In case of a special meeting or when otherwise required by Illinois Revised Statutes or by these Bylaws, such notice shall also include the purpose or purposes for which the meeting is called. In the case of a special meeting, no business other than that specified in the notice of such meeting shall be transacted at any such meeting. If mailed, the notice of meeting shall be deemed to be delivered when deposited in the United States mail addressed to the member at his or her address as it appears on the records of the Society, with postage thereon prepaid. If such notice is given by electronic mail or facsimile, such notice shall be deemed delivered upon receipt by the sender of confirmation of successful transmission of such notice to the member at his or her electronic mail address or facsimile telephone number, as the case may be.

Section 4.13 Induction of New Fellows. Induction of new Fellows of any class shall take place at each annual meeting.

ARTICLE V

MEMBER COVENANTS

Section 5.1 Confidential Information. Members, directors, officers, committee members and staff of the Society shall abide by such confidentiality policies relating to confidential information of the Society as the Board of Directors may establish from time to time.

Section 5.2 Conflicts of Interest/Disciplinary Process. The Board of Directors may establish from time to time such rules or policies with respect to the ethical conduct of its members, including without limitation, procedures and policies for dealing with conflicts of interest and the discipline of its members in the event of a breach of any rules or policies of the Society.

ARTICLE VI

BOARD OF DIRECTORS

Section 6.1 General Powers and Responsibilities. The Board of Directors shall have full responsibility for the management, direction and control of the business, policies and affairs of the Society, subject only to the limitations set forth in these Articles of Incorporation, these Bylaws, or by applicable law.

Section 6.2 Number, Tenure and Qualification. The Board of Directors shall, except as otherwise provided in this Section, consist of twelve (12) members and shall be composed of (a) the President, the President-Elect, the Vice President, the Secretary and the Treasurer; (b) the three most immediate Past Presidents; and (c) four (4) at-large directors. In years when there is a Treasurer-Elect and/or Secretary-Elect, as more fully described below, said officers shall also be directors and the number of directors comprising the Board of Directors shall be expanded accordingly. The President, President-Elect, Vice-President, Secretary, Treasurer, Treasurer-Elect and Secretary-Elect shall, by virtue of their positions as such, automatically be members of

SRS Bylaws

the Board of Directors for so long as they hold their respective offices. The above-referenced immediate Past-Presidents shall serve on the Board of Directors for terms of three (3) years each immediately after the completion of their respective terms as President, which terms shall not be renewable. At-large directors shall serve for terms of two (2) years, which terms shall be non-renewable. The terms of at-large directors shall be staggered so that, as nearly as possible, the terms of one-half of the at-large directors then in office expire each year. Only Active Fellows of the Society in good standing shall be eligible to be directors of the Society. At-large directors shall be nominated and elected in accordance with, and as part of, the procedure for electing officers of the Society as set forth in Section 7.2, below.

Section 6.3 Regular Meetings. Regular Meetings of the Board of Directors shall be held prior to or after but in conjunction with each annual meeting of the Society and/or at such other times as the President may designate for the transaction of such business that may come before the meeting. The Board of Directors may provide by resolution the time and place, either within or without the State of Illinois, for the holding of additional regular meetings of the Board of Directors without other notice than such resolution.

Section 6.4 Special Meetings. Special Meetings of the Board of Directors may be called by or at the request of the President or any two (2) other directors by delivering such request in writing to the Secretary, designating the time and place, either within or without of the State of Illinois, for such meeting to be held and stating the purpose for such meeting or the items to be considered. In the event the Secretary fails, neglects or refuses to distribute proper notice of such requested special meeting, the persons requesting the meeting may schedule or convene such meeting by proper notice to all directors then in office.

Section 6.5 Notice of Meetings. Notice of any Special Meeting of the Board of Directors shall be given at least 48 hours previous thereto by written notice delivered personally or sent by United States mail, electronic mail or facsimile to each director at his address as shown on the records of the Society. If mailed, such notice shall be deemed to be delivered when deposited in the United States mail in a sealed envelope so addressed with postage thereon prepaid. If notice is given by electronic mail or facsimile, such notice shall be deemed delivered upon receipt by the sender of confirmation of successful transmission of such notice to the director at his or her electronic mail address or facsimile telephone number, as the case may be. Any director may waive notice of any meeting. The attendance of a director at any meeting shall constitute a waiver of notice of such meeting, except where a director attends a meeting for the express purpose of objecting to the transaction of any business because the meeting is not lawfully called or convened. Neither the business to be transacted at, nor the purpose of, any regular or special meeting of the Board of Directors need be specified in the notice or waiver of notice of such meeting, unless specifically required by law or by these Bylaws.

Section 6.6 Quorum. A majority of the number of directors in office shall constitute a quorum for the transaction of business at any meeting of the Board of Directors. If the number of directors necessary to constitute a quorum shall fail to attend at the time and place fixed for any regular or special meeting of the Board of Directors, the directors in attendance may adjourn from time to time without notice or other announcement at the meeting until the requisite number of directors to constitute a quorum shall attend.

Section 6.7 Manner of Acting. The act of a majority of the number of directors present at a meeting at which a quorum is present shall be the act of the Board of Directors, except where otherwise provided by applicable law, the Articles of Incorporation of the Society, or by these Bylaws.

Section 6.8 Officers of the Board of Directors. The President of the Society shall serve as Chairman of the Board of Directors. The Secretary of the Society shall serve as the Secretary of the Board of Directors.

Section 6.9 Informal Action by Directors. Unless specifically prohibited by the Articles of Incorporation or by the Bylaws, any action required to be taken at a meeting of the Board of Directors, or any other action which may be taken at a meeting of the Board of Directors, may be taken without a meeting if a consent in writing, setting forth the action to be taken, shall be signed by all Directors entitled to vote with respect to the subject matter thereof. Any such consent signed by all directors shall have the same effect as a unanimous vote of the Board of Directors.

Section 6.10 Meetings by Electronic Means of Communication. Notwithstanding any place set forth in the notice for a meeting of the Board of Directors, any director may participate in such meeting by, or through the use of, any means of communication by which (a) all participants may simultaneously hear each other, such as by conference telephone; or (b) all communication is immediately transmitted to each participant, and each participant can immediately send messages to all other participants. Before the commencement of any business at a meeting at which any director participates by electronic means, all participating directors shall be informed that a meeting is taking place at which official business may be transacted.

Section 6.11 Executive Committee. There shall be established and maintained an Executive Committee which shall have and may exercise, when the Board of Directors is not in session, the powers of the Board of Directors in the management of

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the affairs of the Society, except action in respect to election or removal of officers and directors or the filling of vacancies in the Board of Directors or committees created pursuant to this Bylaw, or acts contrary to prior action adopted by the Board of Directors in proper session. The Executive Committee shall consist of the following individuals: the President, the Immediate Past-President, the President-Elect, the Vice President, the Secretary, the Treasurer and, when in office, the Secretary-Elect and the Treasurer-Elect. All members of the Executive Committee shall have voting rights thereon. The Executive Committee may meet from time to time between meetings of the Board of Directors at the discretion of the President and shall be authorized to conduct such business of the Society as may be necessary, subject to the Board of Directors' general direction and the obligation to report to the full Board of Directors. Notwithstanding the foregoing provision, the Executive Committee shall not be authorized to take any of the following actions on behalf of the Board of Directors: (a) elect directors or officers; (b) hire or terminate the executive director, if any; (c) amend these Bylaws; (d) dissolve the Society; or (e) authorize or contract any loan or indebtedness on behalf of the Society other than in accordance with these Bylaws. Meetings of the Executive Committee may be called by the President and shall be called upon written petition of two (2) other members of the Executive Committee. Notice of the time and place of each Executive Committee meeting shall be given in writing to each member of the committee not less than twenty-four (24) hours before such meeting. At any meeting of the Executive Committee, a majority of the number of Executive Committee members then in office shall constitute a quorum for the transaction of any business. The act of the majority of the Executive Committee members present at a meeting at which a quorum is present shall be the act of the Executive Committee.

Section 6.12 Director Vacancies. In case of any vacancy in a directorship for any reason, including, without limitation, the death, resignation or removal, before the expiration of the term of such directorship, the Nominating committee shall, as soon as practicable after such vacancy occurs, recommend to the Board of directors for its approval a qualified individual to fill such a vacancy. The Board of Directors shall as soon as practicable after such recommendation act on such approval. If such recommended individual is so approved, he or she shall serve for the unexpired portion of the term of the vacant directorship.

Section 6.13 Resignation/Removal of Directors. Any director may resign from the Board of directors at any time by giving written notice to the President. Any director may be removed from the Board of Directors with or without cause by the affirmative vote of at least two-thirds (2/3) of the Active Members present at a duly held meeting thereof.

ARTICLE VII OFFICERS

Section 7.1 Officers/Eligibility. The officers of the Society shall be as follows: President, President-Elect, Vice-President, Secretary, Secretary-Elect, Treasurer, and Treasurer-Elect. The President, President-Elect, Vice President, Secretary-Elect and Treasurer-Elect shall each serve for terms of one (1) year, which terms shall be non renewable, except as provided in Section 7.10 below. The Secretary and Treasurer shall, except as provided in Section 7.10 below, each serve for terms of four (4) years, which terms shall be non renewable (subject, however, to the proviso that individuals having previously served as Secretary and Treasurer respectively, shall be subject to returning to office as more fully described in Section 7.10, below, in the event of a vacancy in such office created by an immediate successor). The terms of the Secretary and Treasurer shall be staggered so that such terms alternatively expire every two (2) years. The President-Elect, the Vice President, the Secretary-Elect and the Treasurer-Elect shall each automatically succeed to the office of President, President-Elect, Secretary or Treasurer, as the case may be, upon the expiration of the term of the individual then serving in such office. Only Active Fellows who are then serving or who have previously served as at-large directors shall be eligible to be nominated as Vice President, Treasurer-Elect or Secretary-Elect.

Section 7.2 Election Procedure. At least sixty (60) days before each annual meeting of the Society, the Nominating Committee shall prepare, and submit for review to the Board of Directors, a list consisting of one individual recommended for each of the following offices: Vice-President, two (2) at-large directors and one (1) member of the Fellowship Committee. In the year immediately preceding any year in which the term of office of the Secretary or the Treasurer is to expire, the Nominating Committee shall also select one individual that it recommends for nomination to the office of Secretary-Elect or Treasurer-Elect, as the case may be. Should the Board of Directors have concerns about any individual on the proposed slate, those shall be conveyed to the Nominating Committee within twenty (20) days of receipt of the list. The Nominating Committee shall present a final slate of candidates to the SRS membership after investigation and review of any concerns. Candidates for the positions to which they were nominated shall be elected upon receiving a majority of the votes cast by Active Fellows at such annual meeting. The term of office for those individuals elected to a position at an annual meeting shall commence as of the close of such meeting.

Section 7.3 President. The President shall be the principal executive officer of the Society and shall, subject to the direction and control of the Board of Directors, supervise and be in charge of all the business affairs of the Society. The President shall

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preside at all general meetings of the Society and of the Board of Directors. The President may sign, with the Secretary or any other proper officer of the corporation authorized by the Board of Directors, any deeds, mortgages, bonds, contracts or other instruments which the Board of Directors has authorized to be executed, except in cases where the signing and execution thereof shall be expressly delegated to the Board of Directors or by these Bylaws with the approval of the Board of Directors and shall be Ex-Officio member of all Committees except the Fellowship and Nominating Committees. The President may fill any vacancies between annual meetings subject to the approval of the Board of Directors unless such vacancies are to be filled as otherwise specified. The President is authorized to act in the event of any contingency or emergency not covered by the Bylaws. The President shall, in general, perform all duties incident to the office of President and such other duties as may be prescribed by the Board of Directors from time to time. The President shall preside at all meetings of the Board of Directors and shall, except as otherwise provided under applicable law or these Bylaws, be responsible for scheduling all meetings of the Board of Directors and to determine the order of business to be conducted at meetings of the Board of Directors. The President shall serve for one (1) year term of office, except in circumstances outlined in Section 7.10.

Section 7.4 President-Elect. The President-Elect shall assume the duties of the President in the absence of the President or in the event of his/her death, inability or refusal to act and when so acting shall have the powers of and be subject to all the restrictions upon the President. The President-Elect shall perform such other duties and have such other powers as the Board of Directors may from time to time prescribe. In addition, the President-Elect shall, as the President-Elect of the Society, carry out such duties in such capacity as the President or the Board of Directors may from time to time determine. The President-Elect shall be an Ex-Officio member of all committees except the Fellowship and Nominating Committees. The President-Elect shall automatically succeed to the office of President at the close of the annual meeting at which the current President's term expires, or as otherwise provided in Section 7.10.

Section 7.5 Vice-President. The Vice President shall assume the duties of the President-Elect in the absence of the President-Elect and in the event of his or her death or inability or refusal to act, and when so acting, shall have all the powers of and be subject to all of the restrictions upon the President-Elect. The Vice President shall also assume the duties of President in the absence of both the President and the President-Elect and in the event of death or inability or refusal to act of both of them, and when so acting the Vice President shall have all of the powers of and be subject to all of the restrictions upon the President. The Vice President shall perform such other duties and have such other powers as the Board of Directors may from time to time prescribe. The Vice President shall be ex-officio member of all committees except the Fellowship and Nominating Committees. The Vice President shall automatically succeed to the office of President-Elect at the close of the annual meeting at which the current President-Elect's term expires, or as otherwise provided in Section 7.10 below.

Section 7.6 Secretary. The Secretary or its designee shall record the minutes of the meetings of the Society and of the Board of Directors and the Executive Committee; undertake to ensure that all notices of meetings are duly given in accordance with the provisions of these Bylaws or as required by applicable law; be custodian of the corporate records of the Society; and perform all duties incident to the office of Secretary. The Secretary shall be an Ex-Officio member of all committees except the Fellowship and Nominating Committees. The Secretary shall maintain a register of the post office address and electronic mail address of each Fellow of any class, which information shall be furnished to the Secretary by such Fellows. The Secretary shall maintain the correspondence of the Society and a record of the names of the Fellows, guests and visitors in attendance at any meeting of the Society.

Section 7.7 Secretary-Elect. The Secretary-Elect shall assume the duties of the Secretary in the absence of the Secretary or in the event of his or her death, inability or refusal to act. The Secretary-Elect shall perform the duties of the Secretary and when so acting shall have the power of and be subject to all the restrictions upon the Secretary. The Secretary-Elect shall automatically succeed to the office of Secretary at the close of the annual meeting at which the then-current Secretary's term of office expires, or as otherwise provided in Section 7.10 below. The Secretary-Elect shall perform such other duties as from time to time may be assigned to him or her by the President or the Board of Directors.

Section 7.8 Treasurer. The Treasurer shall be in charge and have custody of and be responsible for any and all funds, securities and other valuable assets of the Society and other assets of the Society and shall, at the request of the Board of Directors or as otherwise required by applicable law, post a bond at the expense of the Society for the faithful discharge of his or her duties in such sum and with such surety or sureties as the Board of Directors shall determine. The Treasurer shall oversee accurate accounts of the receipts and disbursements of the Board of Directors in books belonging to it. He or she shall ensure that all monies and other valuable effects are deposited in the name and to the credit of the Board of Directors in such accounts and in such depositories as may be designated by the Board of Directors. He or she shall check monthly the disbursements of funds of the Board of Directors in accordance with authority of the Board of Directors. The Treasurer shall render to the President and the Board of Directors whenever requested or otherwise required, a written detailed account of the transactions and of the financial condition of the Society, including a statement of all its assets, liabilities, and financial transactions. He or she

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shall perform such other duties as the Board of Directors, through the President, direct, and such other duties as usually pertain to the office of Treasurer. The Treasurer shall be relieved of all responsibility for any securities or monies or the disbursement thereof committed by the Board of Directors to the custody of any other person or the Society, or the supervision of which is delegated by the Board of Directors to any other officer, agent or employee, or for the performance of any other duties of the Treasurer delegated by the Board of Directors to any other officer, agent or employee, and he or she shall not be responsible for any actions of any other officer, agent or employee of the Board of Directors. The Treasurer shall be an Ex-Officio member of all committees except the Membership and Nominating Committees.

Section 7.9 Treasurer-Elect. The Treasurer-Elect shall assume the duties of the Treasurer in the absence of the Treasurer or in the event of his or her death, inability or refusal to act and when so acting shall have the power of and be subject to all restrictions upon the Treasurer. The Treasurer-Elect shall automatically succeed to the office of Treasurer at the close of the annual meeting at which the then-current Treasurer's term of office expires or as otherwise provided in Section 7.10 below. The Treasurer-Elect shall perform such other duties as from time to time may be assigned to him or her by the President or the Board of Directors.

Section 7.10 Vacancies. In the event of the President's death, resignation or removal while in office, the President-Elect shall succeed to the office of President for the remainder of such term and shall continue to serve as President for the immediately succeeding one-year term. In such event, the Vice President shall succeed to the office of President-Elect serving the remainder of such term and shall continue as President-Elect for the immediately succeeding one year term.

In the event of the President-Elect's death, resignation or removal while in office, the Vice President shall succeed to the office of President-Elect for the remainder of such term and shall continue to serve in such office for the immediately succeeding one-year term. The current President shall finish his/her term and will be asked to serve the term originally designated for the President-Elect.

In the event that the Vice President ceases to serve in such office for any reason during his or her term, including, without limitation, by reason of death, resignation or succession to fill a vacancy of the President-Elect as described above, the Board of Directors may (taking into account any recommendations of the Nominating Committee as described in section 9.6 below) appoint a new Vice President to serve the remainder of that term who then becomes President-Elect at the Annual Meeting. In the event the Board of Directors does not appoint a qualified individual to replace the Vice President, a new Vice President shall be elected at the next annual meeting at which officers are elected in accordance with the procedures applicable to the election of officers generally.

In the event of the Secretary's death, resignation or removal while in office with less than six(6) months remaining before the expiration of the term, the immediate past Secretary will be asked to serve the balance of that term and one more additional year. The Secretary-Elect shall then succeed to the office of Secretary for the term for which he or she was originally slated. If the remaining term is greater than six months, then the Secretary-Elect will succeed to become Secretary as originally intended, and the additional year of service by the past Secretary will not be necessary.

In the event of the Secretary-Elect's death, resignation or removal while in office, the Board of Directors shall fill such vacancy as soon as practicable for the unexpired portion of that term and potentially one more year. The Secretary-Elect then becomes Secretary.

In the event of the Treasurer's death, resignation or removal while in office, the immediate past Treasurer will be asked to serve the balance of that term and then one additional year, if the remaining term is less than six months. If the remaining term is greater than six months, the one additional year will not be necessary. The Treasurer –Elect then succeeds to the office of Treasurer considering the above. Following succession of the Treasurer-Elect to the Treasurer, a new Treasurer-Elect is appointed by the Board of Directors as soon as practicable for the same time period.

In the event of the Treasurer-Elect's death, resignation or removal while in office, The Board of Directors will appoint a new Treasurer-Elect for the balance of that term and potentially one more year. This Treasurer-Elect will then become the Treasurer.

In the event of an At-Large Director's death, resignation or removal while in office, The Board of Directors will appoint a new Director in the appropriate category for the balance of that term.

Section 7.11 Resignation/Removal. Any officer may resign from such office at any time by giving written notice to the Secretary of the Society. Any officer may be removed from such office with or without cause by the affirmative vote of at least two-thirds (2/3) vote of the Active Fellows present at a meeting thereof.

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ARTICLE VIII COUNCILS

The Society shall establish and maintain four (4) Councils, namely, the Education Council, the Research Council, the Governance Council and the Finance Council, which Councils shall oversee the functions and operations of those committees placed under their respective jurisdiction from time to time by the President with the approval of the Board of Directors. Councils shall function in the same manner and be subject to the same procedures and restrictions as committees of the Society and as may be otherwise determined by the Board of Directors from time to time. The membership of each such Council shall be comprised of the chairpersons of the committees under the jurisdiction of such Council and the President, with the approval of the Board of Directors, shall appoint a chairperson for each such Council from among such Members. The Board of Directors may, at any time, by resolution, create, combine, consolidate and/or terminate any Council and change the composition, terms of membership and any other attribute or aspect of any Council as it deems appropriate in its discretion.

ARTICLE IX COMMITTEES

Section 9.1 Classification and Organization. There shall be established and maintained the following Standing Committees of the Society:

- (a) Education Committee;
- (b) Fellowship Committee;
- (c) Program Committee;
- (d) Bylaws and Policies Committee; and
- (e) Nominating Committee.

The President, with the approval of the Board of Directors, may from time to time designate other committees (including standing committees in addition to those described above, ad hoc committees and committees existing and operating under any Council), subcommittees, working groups and task forces. All Standing Committees and other committees, subcommittees, working groups and task forces (collectively referred to for purposes of this Article IX as "Committees") shall have the powers and duties as hereinafter set forth and/or other powers and duties delegated or assigned by the President, with the approval of the Board of Directors and shall make regular reports to President and the Board of Directors. All Committee chairpersons shall be appointed by the President, with the approval of the Board of Directors, except as otherwise provided in these Bylaws. Except for the Nominating Committee and the Fellowship Committee and as otherwise provided in these Bylaws, the President, with the approval of the Board of Directors, may determine the number of members to serve on each Committee and the eligibility requirements for same. Members of any such Committee shall be appointed by the President for such terms and on such terms as the President may determine from time to time, with the approval of the Board of Directors. The President, with the approval of the Board of Directors, shall establish such procedures for each Committee as he or she may determine in his or her discretion, with the approval of the Board of Directors. The Board of Directors may, at any time, by resolution, create, combine, consolidate or terminate any Committee (other than a Standing Committee described in subs. (a) through (e), above) as it deems appropriate in its discretion.

Section 9.2 Education Committee. The Education Committee shall be primarily responsible for the education of, dissemination of new information to, and public relations to promote a better understanding of Scoliosis and related spinal deformities including but not limited to availability of treatments and early symptoms of Scoliosis and related spinal deformities.

Section 9.3 Fellowship Committee. The Fellowship Committee shall be responsible for verifying the professional credentials and qualifications of the applicant for Fellowship in any class. All completed applications, except those for Honorary Fellowship, shall be forwarded by the Secretary of the Society to the Fellowship Committee. The Fellowship Committee shall conduct such investigation, personal interviews, or inquiries it deems necessary in order to determine the qualifications of an applicant for Fellowship in any class.

Section 9.4 Program Committee. The Program Committee shall be responsible for the initiation, organization, implementation and conduct of the annual meeting of the Society. The Program Committee shall be responsible to review all papers, exhibits and audiovisual materials to be used in connection with any program or event held in connection with any annual meeting of the Society, subject to such procedures as the Program Committee and the Board of Directors may establish from time to time.

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Section 9.5 Bylaws and Policies Committee. The Bylaws and Policies Committee shall be responsible for considering matters relating to the content of the Articles of Incorporation, the Bylaws and the policies and procedures of the Society, including amendments thereto, and to advise and make recommendations to the Board of Directors with respect to same.

Section 9.6 Nominating Committee. The Nominating Committee shall consist of five (5) Active Fellows, the Chairman of which shall be appointed by the President with the approval of the Board of Directors. The four (4) additional members shall be Active Members elected at each annual meeting of the Society by a majority of the Active Members present at such meeting. The term of each member of the Nominating Committee shall be one year, no Fellow may serve two (2) consecutive terms on the Nominating Committee. The Nominating Committee shall present to the Board of Directors a list of nominees as described in Section 7.2 and otherwise provide recommendations to the Board of Directors with respect to the filling of vacancies in any office or on the Board of Directors.

ARTICLE X Compensation

No director, officer, Council or Committee member or any other private individual shall receive at any time any of the net earnings or pecuniary profit from the operations of the Society; provided that this provision shall not prevent the payment to any such person of such reasonable compensation for services rendered to or for the Society in effecting any of its purposes. No such person or persons shall be entitled to share in the distribution of any of the corporate assets upon the dissolution of the Society. Notwithstanding the foregoing, no director, officer or Council or Committee member shall receive compensation from the Society for serving in such capacity; provided, however, the Society may reimburse expenses of such persons in attending meetings and conducting other activities on behalf of the Society. Upon such dissolution or winding up of the affairs of the Society, whether voluntary or involuntary, the assets of the Society, remaining in the hands of the Board of Directors after all debts have been satisfied shall be distributed, transferred, conveyed, delivered, and paid over exclusively to charitable and/or educational organizations which would then qualify under the provisions of Section 501(c)(3) of the Internal Revenue Code and its Regulations as they now exist or as they may hereafter be amended.

ARTICLE XI AMENDMENTS

Amendments to these Bylaws or to the Articles of Incorporation of the Bylaws may be proposed by the Executive Committee, the Board of Directors on its own motion or the written petition of at least four (4) Active Fellows. Any such proposal must be submitted to the Secretary of the Corporation not less than ninety (90) days before an annual meeting of the Society in order to be eligible for consideration of approval at such annual meeting. Such proposed amendment, once submitted to the Secretary, shall be submitted to the Bylaws and Policies Committee for review and consideration, which Committee shall then make a recommendation with respect to same to the Board of Directors. The Board of Directors shall then make a determination regarding whether to submit such proposed amendment to a vote of the Active Fellows. Any proposed amendment submitted to the Secretary for consideration at least ninety (90) days before an annual meeting of the Active Fellows of the Society which the Board of Directors has determined to be submitted to a vote of the Active fellows as described above shall be submitted to the Active Fellows at least 30 days prior to the Annual Meeting at which they will be voted on.

Any such proposed amendment submitted to the Secretary less than ninety (90) days before such annual meeting which the Board of Directors has determined to be submitted to a vote of the Active Fellows shall be eligible to be considered for approval by the Active Fellows at the next subsequent annual meeting or at the discretion of the Board of Directors at a special meeting of the Active Fellows of the Society. The Secretary shall include a copy of the proposed amendment with the notice of the meeting at which such proposed amendment is to be considered for approval, together with a statement that the Board of Directors recommends such amendment for adoption. Any amendment to these Bylaws or the Articles of Incorporation of the Society shall require approval of the Active Fellows by at least a two-thirds (2/3) majority of the Active Fellows present in person at a duly held meeting at which a quorum is present.

ARTICLE XII DUES

Section 12.1 Annual Dues. Annual Dues, in amounts to be determined by the Board of Directors, shall be paid by Candidate Fellows, Active Fellows and Associate Fellows in accordance with such procedures as the Board of Directors may from time to time establish.

Section 12.2 Exemption from Dues. The Board of Directors may, in its discretion, exempt a Fellow of any class from dues for good cause in any particular instance.

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ARTICLE XIII RULES OF ORDER

Except to the extent otherwise provided in these Bylaws, all meetings of the Society, the Board of Directors, the Councils or any Committee (as that term is defined in Section 9.1, above) shall, as and when determined by the presiding officer of such body, be governed by the parliamentary rules and usages set forth in the most current edition of Robert's Rules of Order.

ARTICLE XIV DISSOLUTION

The Board of Directors shall, after paying or making provisions for the payment of the Society's liabilities, if any, distribute the Society's net assets, to such Society(s), association(s), fund(s), and/or foundation(s) engaged in activities substantially similar to those of the Society as are designated by the Executive Committee and in such proportions as are determined thereby, subject to any order of court as provided by law, for charitable, educational or scientific purposes within the meaning of section 501(c)(3) of the Code. Notwithstanding any of the foregoing provisions of this Article, the distribution of any assets of the Society in liquidation shall be made in accordance with Illinois Revised Statutes.

ARTICLE XV CONTRACTS, CHECKS, DEPOSITS AND GIFTS

Section 15.1 Contracts. The Board of Directors may authorize any officers, agent or agents of the Society, in addition to the officers so authorized by these Bylaws, to enter into any contract or execute and deliver any instrument in the name of and on behalf of the Society and such authority may be general or confined to specific instances.

Section 15.2 Checks, Drafts, Etc. All checks, drafts, or other orders for the payment of money notes or other evidence of indebtedness issued to the name of the Society, shall be signed by such officer or officers, agent or agents of the Society and in such manner as shall be determined by action of the Board of Directors.

Section 15.3 Deposits. All funds of the Society shall be deposited to the credit of the Society in banks, trust companies, or other depositories as the Board of Directors may select.

Section 15.4 Gifts. The Board of Directors may accept on behalf of the Society any contribution, gift, bequest or device for the general purposes or for any special purpose of the Society.

ARTICLE XVI BOOKS AND RECORDS

The Society shall keep and maintain correct and complete books and records of account and shall also keep minutes of the proceedings of any meeting of the Active Members (including any business session), the Board of Directors and any Council or Committees, and shall keep and maintain at the principal office of the Society a record of the names and addresses of Fellows of any class.

ARTICLE XVII FISCAL YEAR

The fiscal year of the Society shall be as determined by the Board of Directors from time to time.

ARTICLE XVIII SEAL

The Society shall have no seal.

ARTICLE XIX INDEMNIFICATION

The Society shall, to the fullest extent provided by applicable law, indemnify every director, officer or Committee (as that term is defined in Section 9.1, above) or Council chair or member, and his or her heirs, executors and administrators who was or is a party or is threatened to be made a party to any threatened, pending or completed action, suit or proceeding, whether civil, criminal, administrative or investigative (other than an action by or in the right of the Society) by reason of the fact that he or she is or was a director, officer, employee or agent of the Society, or is or was serving at the request of the Society, partnership, joint venture, trust or other enterprise against expenses (including attorney's fees), judgments, fines and amounts paid in

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settlement actually and reasonably incurred by him or her in connection with such action, suit or proceeding if he or she acted in good faith and in a manner he or she reasonably believed to be in or not opposed to the best interests of the Society, and, with respect to any criminal action or proceeding, had no reasonable cause to believe his or her conduct was unlawful. The termination of any action, suit or proceeding by judgement, order, settlement conviction, or upon a plea of nolo contendere or its equivalent, shall not of itself, create a presumption that the person did not act in good faith and in a manner which he/she reasonably believed to be in or not opposed to the best interests of the Society, and with respect to any criminal action or proceeding, had no reasonable cause to believe that his or her conduct was unlawful.

ARTICLE XX **MISCELLANEOUS**

Section 20.1 Trademarks. No member may use the Society's name or trademarks for personal, commercial purposes or funding purposes without prior approval of the Board of Directors.

Section 20.2 Interpretation. In interpreting these Bylaws, whenever the context so requires, (a) the singular shall include the plural and the plural shall include the singular, and (b) any gender shall include all genders.

Section 20.3 Definition of "Code." All references in these Bylaws to sections of the "Code" shall be considered references to the Internal Revenue Code of 1986, as from time to time amended, and to the corresponding provisions subsequently enacted.

Section 20.4 Headings. The headings in these Bylaws are intended for convenience only and should not affect the meaning or interpretation hereof.

Section 20.5 Executive Director. An Executive Director may be employed directly or by contract by the Board of Directors. The Executive Director shall have general charge of the day-to-day operations and management of the Society. The Executive Director may sign in the name of or on behalf of the Society any contract or agreement authorized by the Board of Directors and shall do and perform such additional duties as may be assigned by the Board of Directors and/or otherwise expressed in a management agreement.

Approved September 6, 2007, Amended September 11, 2008



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ZERO TORQUE.
ZERO COMPETITION.



Final Locked 5.5 mm Rod Ø Final Locked 3.5 mm Rod Ø

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FELLOWSHIP DIRECTORY





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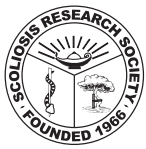
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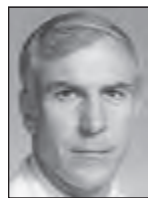
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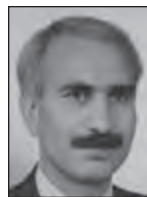
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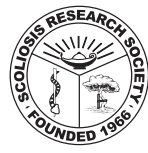
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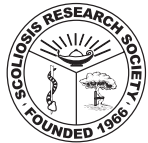
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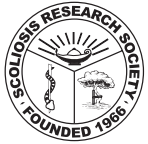
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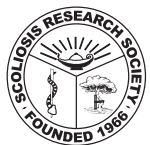
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Ashley, R. Kirklin	1996	Levine, Alan Marc	2009
Badger, Virginia M.	2009	Lovell, Wood W.	2008
Bernstein, Saul M.	2010	Lowe, Thomas G.	2007
• Bianco, Jr., Anthony J.	2004	Luque, Eduardo R.	2002
• Bickel, William H.	1982	MacKinnon, W. B.	1978
• Blount, Walter P.	1992	Makin, Mayer, FRCS.	2005
Bobechko, Walter P.	2007	Manning, Charles	1982
Boyd, Basil M., Jr.	1995	Martinez, Johnny H.	1990
Brown, Richard H.	2005	May, Virgil R.	2000
Brussatis, Friedrich	1990	• McKelvie, Allan M.	1994
Cakirgil, Gungor S.	1990	• Moe, John H.	1988
Cobb, John R.	1967	Murray, Horton L.	1993
Cockrell, B Randolph	1998	Nachemson, Alf L.	2006
Curtis, Burr H.	2001	Nadel, Charles I.	2000
Dawson, Edgar G.	2003	Nicastro, Joseph F.	2006
Daymond, Keith.	2000	Nickel, Vernon L.	1993
De Valderrama, Jose AF.	2006	• Noall, Lawrence	2001
Dholakia, T.K.	2008	Olsen, Gerner	1984
Doherty, John H.	1999	Parisini, Patrizio.	2008
Domnisse, George F.	2001	Peon-Vidales, Hector	2010
Donaldson, William F.	2006	Pickett, Justus C.	1990
Du Toit, Guillaume.	2006	Pinto, Waldemar Carvalho	2000
Dwyer, Allen F.	1975	Ponseti, Ignacio V.	2009
Eldridge, John C.	2004	• Riseborough, Edward J.	1985
Ferguson, Albert B., Sr.	1976	Risser, Joseph C.	1982
Flawn, Laura B.	2001	Roaf, Robert.	2007
Fontanetta, Michael	1979	Rogala, Eugene J.	1982
Garceau, George J.	1977	Sacks, Sidney	2002
Giannestras, Nicholas J.	1978	Savini, Romalo	1991
Gillespie, Robert.	2001	• Schmidt, Albert C.	1982
Godfrey, Joseph D.	1997	Scudese, Vincent A.	1992
Goldstein, Louis A.	1992	Simmons, Edward H.	2009
Graham, Jacob J.	2000	Snellman, Olai.	2004
• Harrington, Paul R.	1980	Stagnara, Pierre	1997
• Herndon, Charles H.	1997	Stauffer, E Shannon.	2002
Hillman, J. William	1970	Stelling, Frank H. III	2003
• Hollenberg, Charles	1996	Stewart, Steele F.	1978
Hopkins, Richard J.	1989	Swanson, Andrew Nicholas.	2009
Inoue, Shun-Ichi.	1987	Tatko, Robert W.	1993
Isaacson, Alvin	1997	Teuffer, Aurelio P.	1989
Jacobs, Rae R.	1988	Travaglini, Fiorenzo H.	2004
James, J.I.P.	2001	Veliskakis, Kostas P, MD	2005
• Keiser, Robert P.	1984	Vesely, David G.	1988
Kendig, Ronald J.	2005	VonLackum, William H.	1969
Kennedy, John C.	1983	Welply, W. R.	1970
Kilfoyle, Richard M.	2000	Whitecloud, Thomas S. III	2003
Kliscic, Predrag J.	1996	Wilber, R. Geoffrey.	1996
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Labelle, Pierre	1994	Wright, Alexander M.	2006
Lambert, Claude N.	1984	Wu, Zhikang	1998
LaRocca, S. Henry.	1973	Yamada, Kengo.	1990
• Larsen, Loren J.	2002	Zorab, Philip A.	1983
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Glossary of Spinal Deformity Biomechanical Terms

(Selected and adapted from White and Panjabi: Clinical Biomechanics of the Spine. Philadelphia: J. B. Lippincott, 1978).

Proposed by SRS Terminology Committee, 1999

Axes systems, etc. (See diagram)

Local, regional (spinal) and global axis systems (See Figure 1)

Vector - A quantity that possesses both a magnitude and a direction (e.g. force; velocity; displacement).

Loading

Force - An action that causes a body to displace or deform. (SI Unit of measure = Newton, i.e., N)

Tension Force - A force that tends to elongate a structure of material.

Compression Force - A force that tends to shorten a structure or material.

Moment or Torque - The sum of the forces applied to a structure multiplied by their perpendicular distance from a reference point or axis. (SI Unit of measure = Newton-metre, i.e., Nm)

Bending Moment at a point within a structure. (See Figure 2). The moment that tends to bend a structure. It is usually the sum of the moments due to several forces.

Couple - Two equal non-collinear forces producing a torque.

3-Point Bending (See Figure 3) - A structure is loaded in 3-point bending when a single force is applied on one side and two forces are applied on the other side acting in opposite directions.

4-Point Bending - (See Figure 3) - A long structure is loaded in 4-point bending when two transverse forces are applied on one side and two on the other.

Stress - The force per unit area of a structure and a measurement of the intensity of force (SI Units are Newtons/m²=Pascals. Hence 1 N/m² = 10⁶ N/mm² = 1 MPa).

Normal Stress - The intensity of force perpendicular to the surface on which it acts.

Shear Stress - The intensity of force parallel to the surface on which it acts.

Compressive Stress - A normal stress that tends to shorten a material.

Tensile Stress - A normal stress that tends to elongate a material.

Principal Stresses - The stresses normal to the principal planes of a material are called principal stresses.

Stress Concentration - A site of stress that is high compared to that of nearby sites in a structure or material. It is often caused by a sharp change in shape.

Center of Gravity - The point in a body in which the body mass is centered.

Displacement/Deformation

Absolute Motion - Motion of a rigid body relative to the global axis system.

Relative Motion - Motion of a rigid body relative to the local axis system of an adjacent body.

Rotation (Figure 4) - Motion of a rigid body in which a certain straight line within or adjacent to the body remains motionless. (That straight line is the axis of rotation)

Translation (Figure 4) - Motion of a rigid body in which a straight line in the body always remains parallel to itself.

Plane Motion - A motion of a rigid body in which the body moves in a single plane.

Degrees of Freedom (Figure 5) - The number of independent displacements that can occur in a mechanism (e.g. the spine and instrumentation) - total of possible displacements and rotations at all of the joints.

Instantaneous Axis of Rotation (Figure 5) - When a rigid body moves at every instant there is a line in the body or some hypothetical extension of it that does not move. For plane motion the axis of rotation becomes the center of rotation. Note: This applies to absolute motion of a single body, also to the relative motion of two bodies such as two vertebrae.

Bending - Deformation of a structure in response to a bending moment.

Neutral Axis - Line or axis within a beam or other structure about which bending occurs.

Strain - (Figure 6) Deformation divided by original length or thickness.

Normal Strain is defined as the change in length divided by the original length. Normal strain can be tensile or compressive.

Shear Strain - Shear deformation divided by the thickness perpendicular to the shear.

Plastic Deformation (Figure 7) - Deformation that remains after the deforming load is removed.

Load-Displacement, Stress-Strain Relationships Elastic Behavior:

Stiffness - Relationship between load and deformation – the force applied divided by the deformation it produces.

Modulus of Elasticity - Relationship between stress and strain. (e.g., Young's modulus = normal stress divided by normal strain)

Torsional Rigidity - The applied moment or torque divided by the rotational deformation (torsion) that it produces.

Glossary of Spinal Deformity Biomechanical Terms

Time Dependent Behavior:

Creep - Time dependent deformation of a material resulting from the application of a constant load.

Viscoelasticity - Material behavior in which the resistance to deformation depends on the amount of deformation (elastic) and the rate of deformation (viscous).

Failure

Yield Stress - (Figure 7) Magnitude of stress on the stress-strain curve at which appreciable deformation takes place without any appreciable increase in the stress.

Ductility - Property of a material in which there is a large amount of deformation possible after the yield point. This implies that a large amount of deformation energy is absorbed by the material before failure. (opposite of brittle)

Fatigue - Eventual failure after repeated cycles of sub-failure loading. This usually occurs as a result of the process of the growth of cracks in structures subjected to repetitive load cycles.

Equilibrium - State of a system in which all forces and moments are balanced, hence it does not displace.

Free Body Analysis (Figure 8) - Equilibrium analysis in which a system is split into real or imagined components (free bodies), in order to check that each part is in equilibrium. It is also used for determining the internal stresses in a structure subjected to external loads.

Statics - The branch of mechanics that deals with the equilibrium of bodies at rest or in motion with zero acceleration.

Dynamics - The branch of mechanics that deals with motion of systems in which the accelerations of masses have significant effect.

Kinematics - The branch of mechanics that deals with motion.

Stability - Behavior of a system whereby it returns to its equilibrium position after being disturbed.

Buckling - A kind of instability in which a structure suddenly bends and collapses when a certain critical load is applied. The stable equilibrium position is a position of minimum potential energy – any displacement of the structure requires a net input of energy. Although stiffness or rigidity of a structure can contribute to its stability, stiffness and stability are not the same thing. When referring to the rigidity of, for example an instrumentation construct, use the term stiffness or rigidity, not stability.

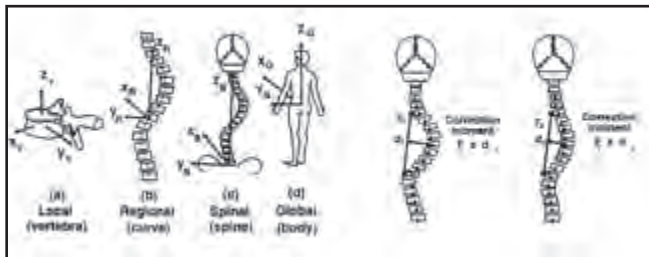


Figure 1. Local, regional (spinal) and global axis systems. Note: these are Cartesian systems, defined by three mutually perpendicular lines (axes).

Figure 2. Bending moment (produced here by the force in a Harrington rod) is the force multiplied by its perpendicular distance from a point in the structure (spine).

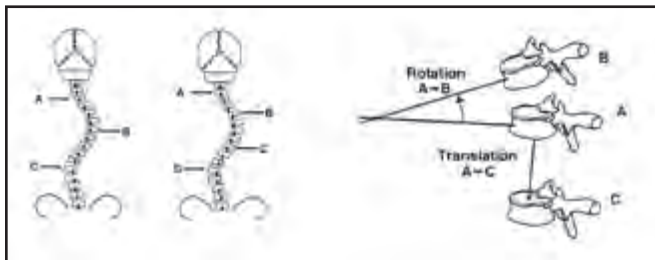


Figure 3. 3 and 4 point bending. For 3 point bending, the maximum bending moment is at point 'B'. For 4 point bending with four equal forces, the bending moment between forces 'B' and 'C' is uniform (constant).

Figure 4. Rotation and translation motion. The motion from A to B is a pure rotation, with an axis of rotation lying outside the vertebra. The motion from A to C is a pure translation.

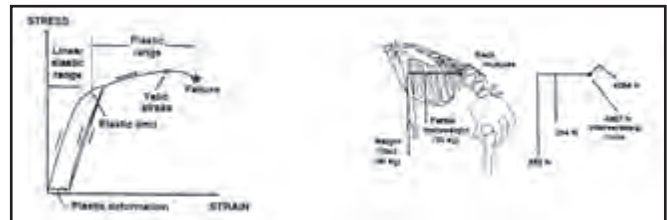


Figure 5. A motion segment has six degrees of freedom (i.e., six possible relative displacements of one vertebrae relative to its neighbor). The motion at any instant can be described as a translation along and a rotation about an instantaneous axis rotation.

Figure 6. Stress is the standardized measure of loading (force/unit area) and strain is the standardized measure of deformation (deformation divided by original length). (a) Normal stress and strain. (b) Shear stress and strain.

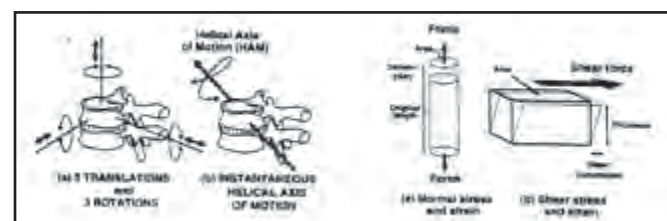
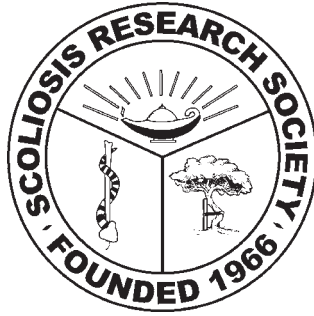


Figure 7. Stress-strain graph of a typical material. A sample was loaded past its elastic limit, unloaded to demonstrate plastic deformation, then loaded again to failure.

Figure 8. Simple static analysis (no motion occurring) of lifting mechanics to determine forces at the thoracolumbar junction. Here a free-body analysis is used. All forces acting on the upper part of the body must be in equilibrium (i.e., no net force or moment acting on the upper body) – otherwise it would be forced to accelerate.



Scoliosis Research Society

45th Annual Meeting & Course
September 21 - 24, 2010
Kyoto International Conference Center
Kyoto, Japan

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E-Mail: info@srs.org

Dear Dr. Polly:

Please change the listing of my name and address to read as follows:

Full Name: _____

Office Address: _____

City: _____ State: _____ Zip: _____

Country: _____

Telephone: _____ Fax: _____

E-mail: _____

Spouse's Name: _____



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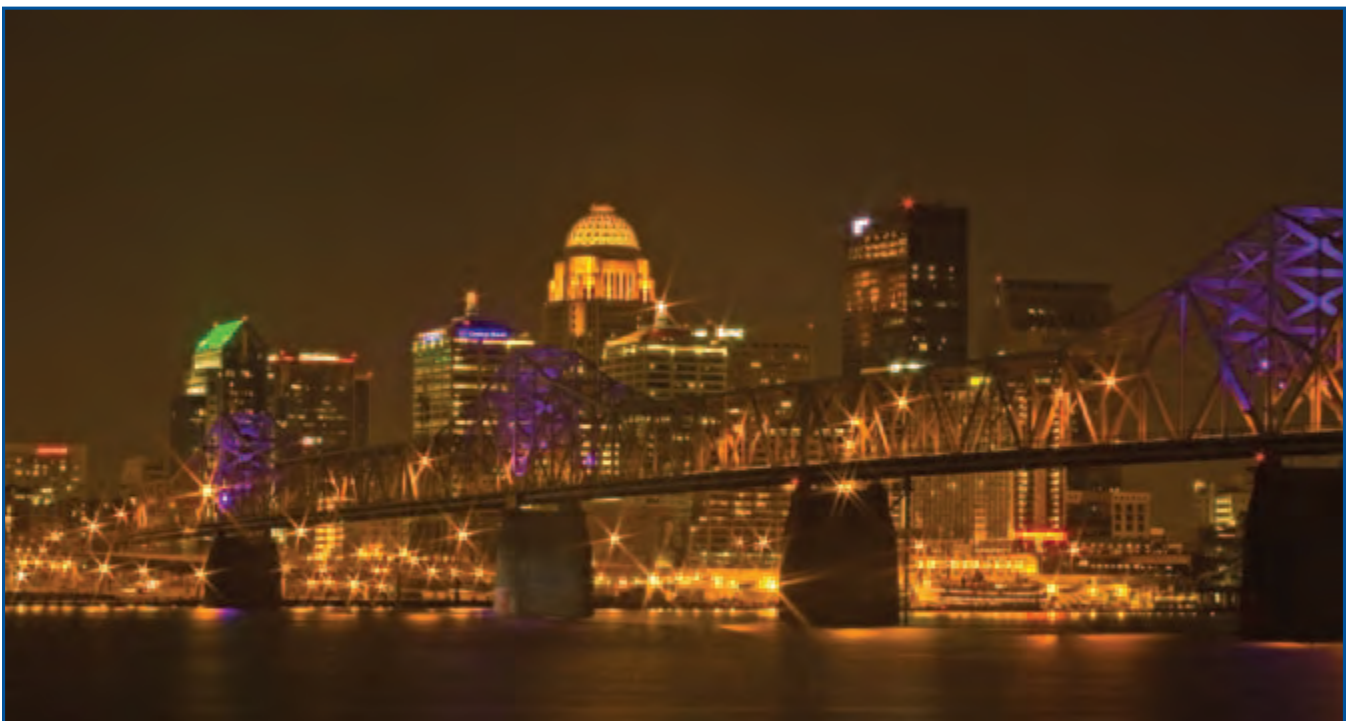
18th International Meeting on Advanced Spine Techniques

July 13-16, 2011 • Copenhagen, Denmark



46th Annual Meeting & Course

September 14-17, 2011 • Louisville, Kentucky, USA



Meeting at a Glance

Monday, September 20, 2010

07:00 – 17:00	Board of Directors Meeting	Room 560
11:00 – 17:00	Registration Open	Main Lounge
12:00 – 17:00	Hibbs Society Program	Room D
18:00 – 22:00	SRS Leadership Dinner (By invitation only)	Depart from Grand Prince Hotel

Tuesday, September 21, 2010

07:00 – 18:00	Registration Open	Main Lounge
08:00 – 18:00	Poster Set-Up by Authors	Sakura
08:00 – 18:00	Pre-Meeting Combined Course: Cervical Spine: A Multinational Approach	Main Hall
09:45 – 15:00	Nishiki Market and Japanese Cooking Class	Meet inside the main entrance at the ICCK
12:00 – 17:00	Kyoto World Heritage Tour	Meet inside the main entrance at the ICCK
12:35 – 13:35	Lunch Break	
12:45 – 13:30	Lunchtime Symposium: The Effect of Osteoporosis on Surgery in Adult Deformity Patients	Main Hall
18:00 – 19:00	Opening Ceremonies	Main Hall
19:00 – 21:00	Welcome Reception	Swan & Garden

Wednesday, September 22, 2010

06:30 – 16:00	Registration Open	Main Lounge
06:30 – 16:00	Poster & E-Posters, Internet Kiosks	Sakura
06:30 – 07:40	Members Business Meeting Breakfast	Annex Hall
06:30 – 07:40	Non-Members Continental Breakfast	Sakura
07:55 – 16:52	Scientific Sessions	Main Hall
08:30 – 16:30	Arashiyama and Saga Walking Tour	Meet inside the main entrance at the ICCK
09:00 – 18:00	Kyoto Day Tour	Meet inside the main entrance at the ICCK
12:00 – 16:00	Japanese Garden Tour	Meet inside the main entrance at the ICCK
12:20 – 13:10	Lunchtime Symposium: Navigation and Image Guidance Role in Spine Surgery	Main Hall
12:20 – 13:10	Lunchtime Symposium: Current Concepts: Is There Value in Scoliosis Screening in AIS?	Annex Hall

Thursday, September 23, 2010

06:30 – 13:00	Registration Open	Main Lounge
06:30 – 13:00	Poster & E-Posters, Internet Kiosks	Sakura
06:30 – 07:40	Members Business Meeting Breakfast	Annex Hall
06:30 – 07:40	Non-Members Continental Breakfast	Sakura
07:00 – 07:40	Non-Member Informational Session	Main Hall
07:55 – 12:30	Scientific Sessions	Main Hall
08:30 – 16:30	Arashiyama and Saga Walking Tour	Meet inside the main entrance at the ICCK
12:00 – 17:00	Kyoto World Heritage Tour	Meet inside the main entrance at the ICCK
12:00 – 17:30	Japanese Fushimi Sake Brewery Tour	Meet inside the main entrance at the ICCK
12:30 – 14:30	Instructional Course Lecture: Growing Spine Surgery: Options, Tips/Techniques and Results	Main Hall
18:00 – 23:00	Farewell Dinner	Westin Miyako Hotel, Mizu Ballroom

Friday, September 24, 2010

06:30 – 12:30	Registration Open	Main Lounge
06:30 – 12:30	Poster & E-Posters, Internet Kiosks	Sakura
06:30 – 07:40	Members Business Meeting Breakfast	Annex Hall
06:30 – 07:40	Non-Members Continental Breakfast	Sakura
08:00 – 12:25	Scientific Sessions	Main Hall
09:00 – 17:00	Nara Tour	Meet inside the main entrance at the ICCK
12:25	Meeting Adjourns	
12:30 – 16:00	Kyoto Handicraft Center	Meet inside the main entrance at the ICCK Shuttles depart at 12:45, 13:45 and 15:45
13:00 – 16:00	Board of Directors Meeting	Conference Room 104