

FINAL PROGRAM

*Scoliosis Research
Society Presents*

IMAST



20th International Meeting on
Advanced Spine Techniques

July 10-13, 2013
Vancouver, British Columbia
Canada



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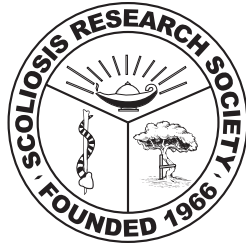
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GENERAL INFORMATION





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



FINAL PROGRAM

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Future Educational Events

48TH ANNUAL MEETING & COURSE

September 18-21, 2013
Lyon, France

SRS SPINE DEFORMITY SOLUTIONS: A HANDS-ON COURSE

October 3-5, 2013
Burr Ridge, ILL, USA

21ST INTERNATIONAL MEETING ON ADVANCED SPINE TECHNIQUES

July 16-19, 2014
Valencia, Spain

Worldwide Conferences

SARAJEVO, BOSNIA & HERZEGOVINA

November 1-2, 2013

BEIJING, CHINA

In Conjunction with COA and CSS Meetings
November 7, 2013

KOLKATA, INDIA

In Conjunction with ASSICON
January 23-24, 2014

Welcome

Dear Participant,

I want to personally welcome you to Vancouver, one of the most beautiful and diverse cities in the world, for what promises to be an innovative academic meeting. As a committee and Society, we continue to revolutionize the program to bring our delegates the newest and most ground-breaking topics in the spinal deformity field. This year, we increased the number of concurrent sessions to expand the Complication Series, increased the ever-popular Debates, and will introduce Two-Minute Point Presentations to accommodate yet another year of record-breaking abstract submissions. The program will also offer Instructional Course Lectures and Roundtable Case Discussions with an increasingly international and expansive faculty.

We estimate there will be more than 900 participants from around the world in attendance at the Vancouver Convention Center for the meeting where 185 podium and Two-Minute Point Presentations, over 100 E-Posters, and 30 concurrent sessions will be presented.

In between the very busy meeting schedule, I encourage you to enjoy the wonderful city of Vancouver. Vancouver is truly a unique city given its geographic location, nestled between the Pacific Ocean and the Coast Mountain Range, and its multicultural population making it a destination for award-winning international cuisine.

I am pleased to serve as your IMAST Chairman again this year. I want to thank those whose leadership and diligent efforts have created such a successful meeting, including Drs. Kamal Ibrahim, B. Stephen Richards III, Steven Glassman, John Dormans and the IMAST Committee. I look forward to another successful and inspiring meeting in the wonderful city of Vancouver.

With warmest personal regards,



Christopher I. Shaffrey, MD
IMAST Committee Chair



IMAST Mobile & Online App

A mobile and online app will be available to all delegates during the 20th IMAST. The app is designed to provide all the information about IMAST & Vancouver in one convenient location and can be accessed from any smart phone or computer with an internet connection. To download the app visit <http://eventmobi.com/imast2013> or scan the QR code below with your smart phone.

- Download all the abstracts and final program right from the app!
- A new offline mode will allow delegates to access all static content, including the agenda, speaker listing and info booth, on the app without an internet connection.
- A detailed IMAST agenda that allows delegates to create a personalized schedule.
- Exhibitor information including exhibit floor plan, company descriptions and the Hands-On Workshop schedule.
- An information booth featuring everything you need to know about IMAST, and its host city of Vancouver, including scientific and social program details, information on the hotels, as well as downtown Vancouver dining and attractions.
- Maps of the Vancouver Convention Center and meeting space.
- An alert system for real-time updates from SRS - program changes, tour and social event notifications, and breaking news as it happens.
- A complete list of IMAST faculty and podium presenters, including presentation titles, times, dates, and locations.

To learn more about the app or how to use the QR code, please refer to the insert in your registration bag or visit www.srs.org/imast/2013.

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



<http://eventmobi.com/imast2013>

Welcome

CME INFORMATION

CME certificates will be available to pre-registered delegates upon the opening of the meeting at www.srs.org/imast/2013/. Delegates who registered on-site may access their certificates after August 1, 2013. Delegates are REQUIRED to complete evaluations to obtain a CME certificate. These evaluations may be completed during the meeting by pre-registered delegates, using the link provided above. However, evaluations and certificates are NOT available to delegates registering on-site until August 1.

Delegates should log on to the website listed above and enter their last name and the ID# listed at the top of the IMAST 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 will generate a PDF certificate which may be printed or saved to the delegate's computer. Session attendance and evaluation information are saved in the database, and certificates may be accessed again, in the event the certificate is lost or another copy is required.

Please note that certificates will not be mailed or emailed after the meeting. The online certificate program is the only source for this documentation. Please contact SRS at meetings@srs.org for any questions. SRS asks that all CME certificates be claimed no later than November 1, 2013.

INSTRUCTIONAL COURSE LECTURES (ICLS)

There will be three (3) ICL sessions highlighting the latest in surgical techniques and technologies. Each session will feature four (4) concurrent didactic sessions, programmed around thematic areas and will include a balanced discussion of multiple products, techniques and advances relevant to that topic.

DEBATES

The Debates will continue this year with three (3) sessions featuring multiple debates per session. Expert faculty will be assigned to different treatment options available for specific conditions for each debate. Debate topics and faculty are listed in the Meeting Agenda, beginning on p. 35.

COMPLICATIONS SERIES

The Complication Series presents a variety of illustrative case presentations, demonstrating the most common and worst complications encountered, as well as strategies to prevent and manage them. Interaction between faculty and participants will focus on treatment options with an emphasis on reducing further morbidity and improving eventual outcomes. Complication topics and faculty are listed in the Meeting Agenda, beginning on p. 35.

NEW! – TWO-MINUTE POINT PRESENTATIONS

This year, Two-Minute Point Presentations have been added to the abstract portion of the program. These three (3) lightning rounds were selected from the abstracts submitted to the 2013 meetings. The sessions will follow a similar format to the traditional podium presentations however, with a limited number of slides and time.

E-POSTERS

There are over 100 E-Posters available for your review on the E-Poster kiosks inside the Exhibit Hall. The E-Posters are also available on the CD-ROM included with your registration materials.

E-Poster CD-ROMs are supported, in part, by a grant from K2M.

EXHIBITS & HANDS-ON SESSIONS

Many new spinal systems and products are on display in the Exhibit Hall. We encourage you to visit the exhibits throughout the meeting to learn more about the technological advances. *Beverages will be available throughout the Exhibit Hall.

IMAST is pleased to continue the Hands-On Workshops (HOWs) introduced in 2011. Each one-hour workshop is supported and programmed by a single-supporting company and will feature presentations on topics and technologies selected by the Corporate Supporter. Breakfast, lunch, or cocktails, and snacks will be served just outside the HOWs, as noted in the program. Please note that HOWs are Non-CME sessions.

INTERNET ACCESS

Wireless Internet access is available throughout the meeting space on the East Convention Level and East Meeting Level of the Vancouver Convention Center (VCC).

To log on select . . .

Network = IMAST2013

Password = spine2013

*** Note: Internet cookies must be enabled to connect

Wireless Internet is supported, in part, by a grant from Medtronic.

Delegates without laptops may access complimentary Internet kiosks inside the Exhibit Hall.

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

General Meeting Information

MEETING DESCRIPTION

IMAST gathers leading spine surgeons, innovative researchers, and the most advanced spine technologies for all areas of spine (cervical, thoracic and lumbar), most spinal conditions (degenerative, trauma, deformity and tumor), and a variety of treatment techniques. The IMAST program will include didactic presentations, panel discussions, papers and posters on current research, Roundtable Case Discussions, Debates, Complication Series and Instructional Course Lectures, all lead by an international and multidisciplinary faculty. IMAST is sponsored by the Scoliosis Research Society (SRS).

LEARNING OBJECTIVES

Upon completion of IMAST, participants should be able to:

- Assess recent advances in surgical techniques for the treatment of spinal disorders, compare them with traditional treatments and determine if and/or when to use them for optimal patient care.
- Analyze indications and potential complications for various procedures and approaches related to spinal surgery, including spinal arthroplasty, dynamic stabilization, minimally invasive techniques and lateral transposas procedures, and apply that analysis to treatment decisions.
- Compare and contrast treatment options for various spinal disorders in order to present the full range of non-operative and operative interventions to patients to allow informed choices for optimal care and improved outcomes.
- Present a variety of new objective cost and outcome analyses of operative and non-operative interventions to better understand the cost effectiveness and cost/utility related to treatment options in both the short and intermediate time periods.

TARGET AUDIENCE

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

ACCREDITATION STATEMENT

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

CREDIT DESIGNATION

The Scoliosis Research Society (SRS) designates this live activity for a maximum of 15 *AMA PRA Category 1 Credit(s)*[™]. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

DISCLOSURE OF CONFLICT OF INTEREST

It is the policy of SRS to insure balance, independence, objectivity and scientific rigor in all of their educational activities. In accordance with this policy, SRS identifies conflicts of interest with instructors, content managers, and other individuals who are in a position to control the content of an activity. Conflicts are resolved by SRS to ensure that all scientific research referred to, reported, or used in a CME activity conforms to the generally accepted standards of experimental design, data collection and analysis. Complete faculty disclosures are included in this Final Program on page 9.

FDA STATEMENT (UNITED STATES)

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

INSURANCE/LIABILITIES AND DISCLAIMER

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

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

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

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

General Meeting Information

LANGUAGE

Presentations and course materials will be provided in English.

NO SMOKING POLICY

Smoking is not permitted during any IMAST activity or event.

ATTIRE

Business (suits) or business casual (polo or dress shirts, sport coats) are appropriate for IMAST sessions. Cocktail attire is recommended for the Course Reception.

DELEGATE SERVICES INFORMATION DESK - TOURISM VANCOUVER

East Convention Lobby

Tourism Vancouver, the official Conventions & Visitors Bureau of Vancouver, will be present in the East Convention Lobby across from registration to answer all of delegates' questions regarding Vancouver. Stop by to pick up your guide and city maps!

Hours:

Thursday, July 11	9:00 – 16:00
Friday, July 12	9:00 – 16:00
Saturday, July 13	9:00 – 12:00

Tourism Vancouver Offices

200 Burrard St

Vancouver, BC V6C 3L6

+1 604-682-2222

**Across the street from the Pan Pacific!*

SHOW YOUR BADGE- VANCOUVER!

Show your conference badge at participating businesses for discounts offered exclusively to convention attendees. Please note some offers below are only available when booked in person at Tourism Vancouver's Visitor Centers. Visit the 20th IMAST Mobile App or http://www.tourismvancouver.com/includes/content/images/media/docs/show_your_badge3.pdf for a list of participating businesses.

PRESENTATION UPLOAD AREA

Location: East Ballroom AB, East Convention Level

Presenters may upload their PowerPoint presentations in the Presentation Upload Area, located at the back of the general session room, East Ballroom AB, East Convention Level. ****New this year: presentations may not be uploaded in individual rooms but must be uploaded in the Presentation Upload Area.****

Hours:

Wednesday, July 10	14:00 – 19:30 (during Welcome Reception)
Thursday, July 11	7:00 – 16:30
Friday, July 12	7:00 – 16:00
Saturday, July 13	7:00 – 9:00

Please upload presentations no later than 24 hours before the session is scheduled to begin.

VIDEO ARCHIVES

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

Social Events

WELCOME RECEPTION

Wednesday, July 10, 2013

17:00-19:30

Exhibit Hall A

All registered delegates and registered guests are invited to pick up their registration materials and to attend the IMAST Welcome Reception on Wednesday, July 10 from 17:00-19:30. The reception will be hosted in the Exhibit Hall (Exhibition Hall A) at the Vancouver Convention Center, where beverages and hors d'oeuvres will be served. There is no charge for registered delegates, though a ticket should be requested at the time of registration. Registered guests may purchase a Welcome Reception ticket for \$20 USD at the time of registration. Dress for the Welcome Reception is business casual.

The Welcome Reception is supported, in part, by a grant from Medtronic.

COURSE RECEPTION

Friday, July 12, 2013

19:00-23:00

Vancouver Convention Center- West Pacific Terrace and Ballroom

IMAST delegates and registered guests are invited to take part in a closing reception on the terrace of the Vancouver Convention Center on Friday, July 12 from 19:00-22:00. The terrace offers stunning views of the harbor, mountains and is home to the 2010 Winter Olympic Torch. Tickets are \$25 each for registered delegates and \$30 each for registered guests, and should be purchased at the time of registration. A limited number of tickets may be available onsite, but organizers strongly encourage delegates to purchase tickets in advance. Cocktail dress is appropriate for the Course Reception, but please keep in mind, portions of the event will be held outside.

OPTIONAL TOURS

SRS is proud to be partnering with local tour companies for the 20th IMAST. Please visit their websites, to view special tours and pricing for IMAST delegates. Registration for all tours will be handled through the individual companies. Please note: SRS is unable to assist with tour reservations.

Please visit www.srs.org/imast/2013/tours for more information regarding tours and registration.

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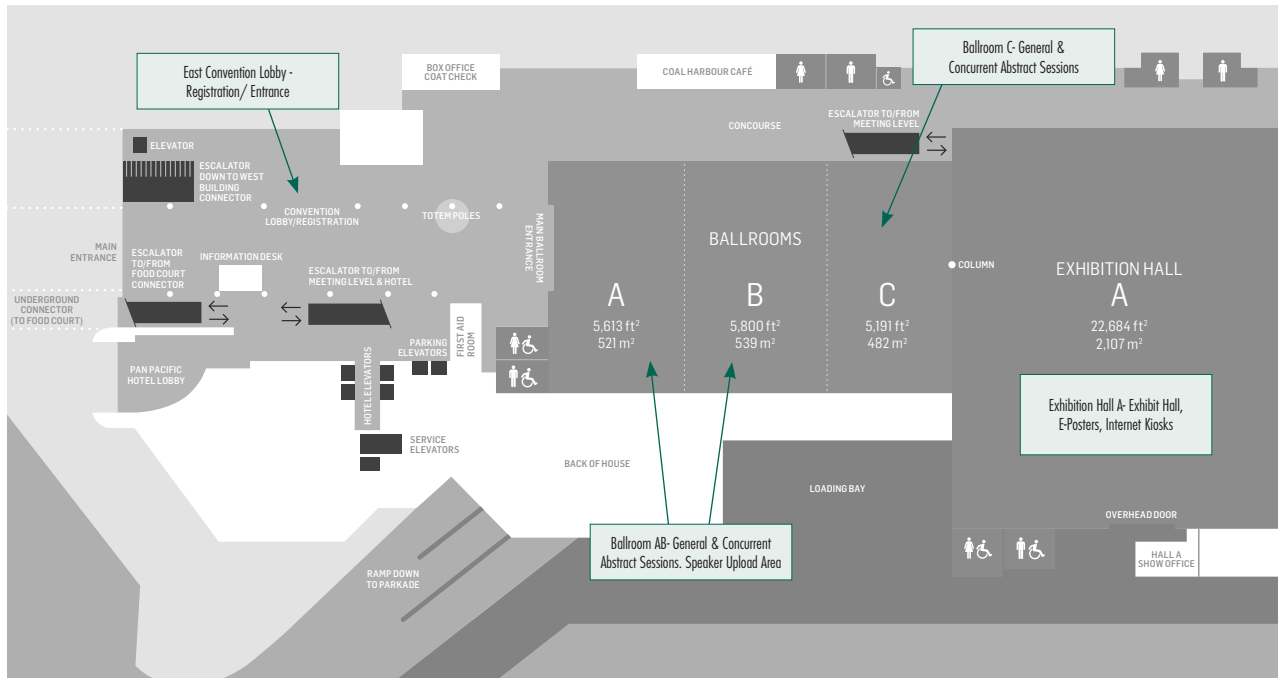
Meeting Overview

Wednesday, July 10, 2013	
8:00-15:00	Board of Directors Meeting Exhibit Set-Up
14:00-19:30	Registration Open
15:00-17:00	*Hands-On Workshops with Beverages, Snacks
17:00-19:30	Welcome Reception
Thursday, July 11, 2013	
7:00-16:30	Exhibits Open Registration Open
7:00-7:40	Breakfast & Exhibit Viewing *Hands-On Workshop with Breakfast
7:40-9:10	General Session
9:10-9:25	Walking Break
9:25-10:25	Concurrent Roundtable Sessions 1A-D
10:25-10:35	Refreshment Break
10:35-11:50	Concurrent Abstract & Debate Sessions
12:00-13:00	Exhibit Viewing with Lunch *Hands-On Workshops with Lunch
13:10-14:10	Concurrent Abstract & Complication Series
14:10-14:20	Refreshment Break
14:20-15:20	Instructional Course Lectures 1A-D
15:20-15:30	Walking Break
15:30-16:30	*Hands-On Workshops with Beverages, Snacks
*Denotes Non-CME Session	

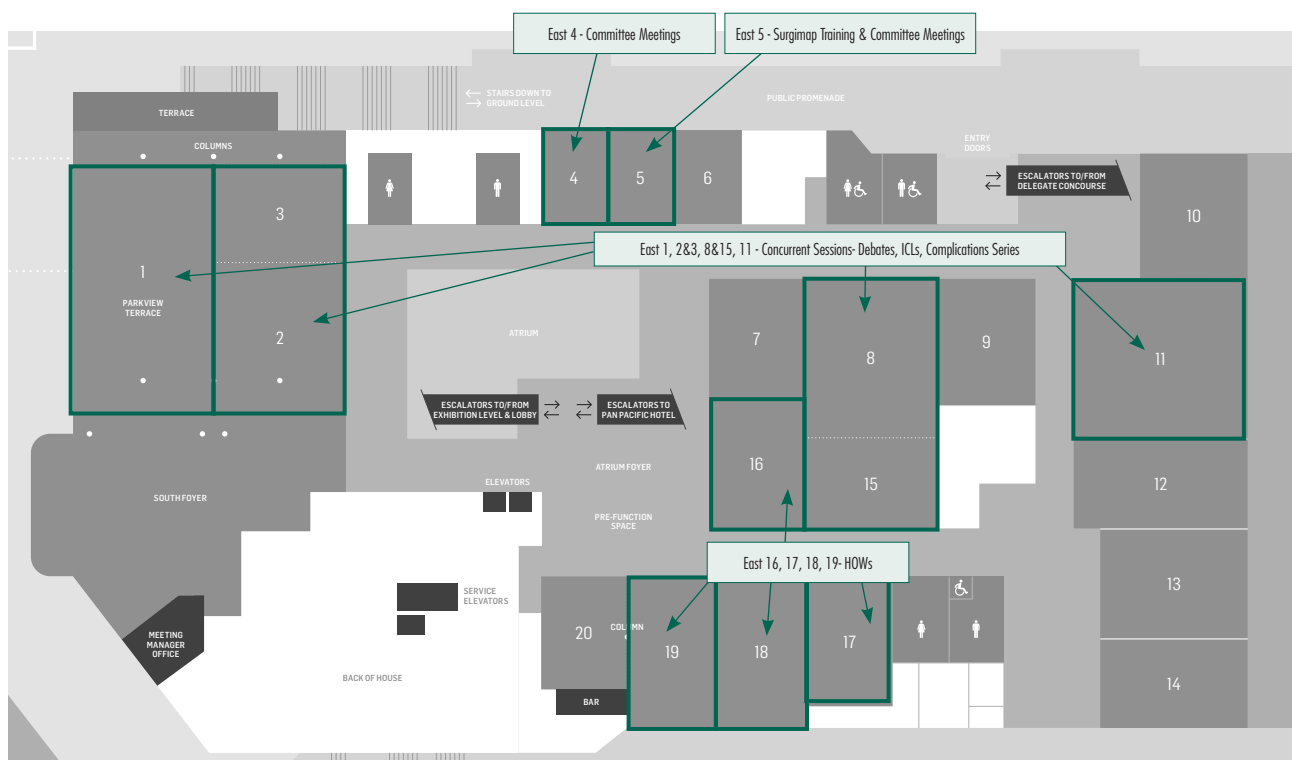
Friday, July 12, 2013	
7:00-16:00	Exhibits Open Registration Open
7:00-7:45	Breakfast & Exhibit Viewing *Hands-On Workshop with Breakfast
7:45-8:45	Concurrent Abstract and Debate Sessions
8:45-9:15	Refreshment Break
9:15-10:15	Concurrent Roundtable Sessions 2A-D
10:15-10:25	Walking Break
10:25-11:50	Concurrent Abstract & Complication Series
12:00-13:00	Exhibit Viewing with Lunch *Hands-On Workshops with Lunch Member Information Session
13:10-14:10	Concurrent Roundtable Sessions 3A-D
14:10-14:20	Refreshment Break
14:20-15:20	Instructional Course Lectures 2A-D
15:20-15:30	Walking Break
15:30-16:30	*Hands-On Workshop with Beverages, Snacks
19:00-22:00	Course Reception
Saturday, July 13, 2013	
7:00-12:15	Registration Open Exhibits Closed
7:00-7:45	Breakfast
7:45-8:45	Instructional Course Lectures 3A-D
8:45-9:00	Walking Break
9:00-10:30	Concurrent Abstract and Debate Sessions
10:30-10:45	Refreshment Break
10:45-12:15	Concurrent Abstract and Complications Series
12:15	Meeting Adjourns
*Denotes Non-CME Session	

Vancouver Convention Center Floorplans

EAST CONVENTION LEVEL



EAST MEETING LEVEL



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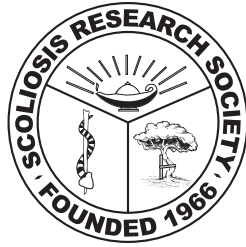
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(f) Salary, Contractual Services (g) Other Financial Or Material Support (royalties, patents, etc.)

Meeting Agenda





The Scoliosis Research Society gratefully acknowledges Medtronic for their support of the General Session, Wireless Internet, Internet Kiosks, IMAST E-Newsletter and Welcome Reception.



Medtronic

Meeting Agenda—Wednesday, July 10 and Thursday, July 11

WEDNESDAY, JULY 10, 2013

14:00 – 19:30	Registration Open <i>East Level Convention Lobby</i>
15:00 – 17:00	*Hands-On Workshops <i>(See “Exhibits and Hands-On Workshops” (HOW) section on page 193 for more information.)</i>
17:00 – 19:30	Welcome Reception <i>Exhibit Hall A</i>

THURSDAY, JULY 11, 2013

7:00 – 16:30	Registration and Exhibits Open <i>East Level Convention Lobby Exhibit Hall A</i>
7:00 – 7:40	Breakfast & Exhibit Viewing and *Hands-On Workshops <i>Exhibit Hall A *Beverages available throughout the day in the Exhibit Hall Hands-On Workshops with Breakfast - East 16-19 (See “Exhibits and Hands-On Workshops” (HOW) section on page 193 for more information.)</i>
7:40 – 9:10	General Session: Whitecloud Award Nominees <i>The general sessions are supported, in part, by a grant from Medtronic</i> <i>Room: East Ballroom AB</i> <i>Moderators: B. Stephens Richards, III, MD and Todd J. Albert, MD</i> 7:40-7:45 Welcome Address <i>Christopher I. Shaffrey, MD IMAST Committee Chair</i> 7:45-7:49 † Paper #1: A Prospective, Randomized Clinical Investigation of the PCM Cervical Disc: Five-Year Results From US IDE Study <i>Frank M. Phillips, MD; Kye Gilder, PhD; Kelli M. Howell, MS; Fred H. Geisler, MD, PhD; Christopher D. Chaput, MD; John G. DeVine, MD; Christopher J. Reah, PhD; Paul C. McAfee, MD, MBA</i> 7:49-7:53 † Paper #2: Laminoplasty versus Laminectomy and Fusion to Treat Cervical Spondylotic Myelopathy: Outcomes of the Prospective Multi-Center AOSpine International CSM Study <i>Michael G. Fehlings, MD, PhD; Branko Kopjar; Helton L. Defino, MD; Giuseppe Barbagallo; Ronald H. Bartels, MD, PhD; Paul Arnold; Mehmet Zileli, MD; Gamaliel Tan, MBBS; Yasutsugu Yukawa, MD; Massimo Scerrati, Head of Neurosurgery, Ancona; Tomoaki Toyone, MD, PhD; Qiang Zhou, PhD</i>

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Meeting Agenda—Thursday, July 11

THURSDAY, JULY 11, 2013

- 7:53-7:57 †Paper #3: The Clinical, Functional, and Occupational Outcomes of Smokers Versus Non-Smokers Undergoing Spinal Arthrodesis: Diagnosis Related Results
Dennis Crandall, MD; Jan Revella, RN; Kurt Crandall; Michael S. Chang, MD
- 7:57-8:04 Discussion
- 8:04-8:08 †Paper #4: Surgical Treatment of Pathological Loss of Lumbar Lordosis (Flatback) in the Setting of Normal Sagittal Vertical Axis (SVA) Achieves Similar Clinical Improvement as Surgical Treatment for Elevated SVA
Manish Singh, MD; Justin S. Smith, MD, PhD; Eric Klineberg, MD; Christopher I. Shaffrey, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Vedat Deviren, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group
- 8:08-8:12 †Paper #5: Convex Instrumented Hemiepiphysiodesis with Concave Distraction: A New Treatment Modality for Long Sweeping Congenital Curves
Gokhan H. Demirkiran; Ozgur Dede, MD; Mehmet Ayzav, MD; Ahmet Alanay, MD; Muharrem Yazici, MD
- 8:12-8:16 †Paper #6: Comparison of Radiographic Results After Minimally Invasive (MIS), Hybrid (HYB) and Open (OPEN) Surgery for Adult Spinal Deformity (ASD): A Multi-Center Study of 184 Patients
Raqeeb Haque, MD; Gregory M. Mundis, MD; Yousef M. Ahmed, BS; Tarek Y. El Ahmadi, MD; Michael Y. Wang, MD; Praveen V. Mummaneni, MD; Juan S. Uribe, MD; David O. Okonkwo, MD, PhD; Neel Anand, MD; Adam S. Kanter, MD; Frank La Marca, MD; Virginie Lafage, PhD; Jamie S. Terran, BS; Vedat Deviren, MD; Richard G. Fessler, MD, PhD; International Spine Study Group
- 8:16-8:23 Discussion
- 8:23-8:27 Paper #7: Mechanical Versus Chemical Prophylaxis for Deep Venous Thrombosis in Patients Undergoing Lumbar Spinal Fusion: Comparative Effectiveness and Cost-Benefit
Saniya S. Godil, MD; Michael C. Dewan, MD; Scott L. Parker, MD; Clinton J. Devin, MD; Matthew J. McGirt, MD
- 8:27-8:31 Paper #8: Evaluation of the Alarm Criteria of Transcranial Electrical Stimulation Muscle Evoked Potential in Scoliosis Surgery: Multi-Institution Survey by the Monitoring Committee of the Japanese Society for Spine Surgery and Related Research
Kei Yamada, MD, PhD; Sho Kobayashi, PhD; Nobuaki Tadokoro, MD; Kanichiro Wada; Akio Muramoto, MD; Hiroshi Iwasaki, MD; Tsukasa Kanchiku; Shoji Seki, MD, PhD; Muneharu Ando; Yujiro Hirao; Atsuko Saruwatari, MD; Ryo Ohta; Yukihiko Matsuyama, MD
- 8:31-8:35 Paper #9: A Prospective Randomized Study Comparing Neurophysiologic Monitoring with Total Intravenous Anesthesia and Inhalational Anesthesia in the Treatment of Adolescent Idiopathic Scoliosis
Walter P. Samora, MD; Allan Beebe; Jan Klamar, MD; David P. Martin, MD
- 8:35-8:42 Discussion
- 8:42-8:47 Introduction of SRS President
*Steven D. Glassman, MD
President-Elect*
- 8:47-9:02 Keynote Address
*Kamal N. Ibrahim, MD, FRCS(C), MA
Scoliosis Research Society (SRS) President*
- 9:02-9:05 Preview of 48th Annual Meeting & Course — Lyon, France
Suken A. Shah, MD - Program Committee Chair
- 9:05-9:08 Preview of 21st IMAST — Valencia, Spain
Christopher I. Shaffrey, MD - IMAST Committee Chair

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Meeting Agenda—Thursday, July 11

THURSDAY, JULY 11, 2013

9:10 – 9:25 **Walking Break**

9:25 – 10:25 **Concurrent Roundtable Sessions 1A-D**

1A: Early-Onset Scoliosis

Moderator: John P. Dormans, MD

Room: East 8&15

Case Presenters:

09:25 – 09:40 Richard E. McCarthy, MD

09:40 – 09:55 Paul D. Sponseller, MD

09:55 – 10:10 Muharrem Yazici, MD

10:10 – 10:25 Ahmet Alanay, MD

1B: Adolescent Idiopathic Scoliosis

Moderator: Lawrence G. Lenke, MD

Room: East 2&3

Case Presenters:

09:25 – 09:40 Peter O. Newton, MD

09:40 – 09:55 Toshiaki Kotani, MD, PhD

09:55 – 10:10 David S. Marks, FRCS

10:10 – 10:25 Marinus De Kleuver, MD, PhD

1C: Adult Degenerative Scoliosis

Moderator: Frank J. Schwab, MD

Room: East 1

Case Presenters:

09:25 – 09:40 Henry F.H. Halm, MD

09:40 – 09:55 David W. Polly, Jr., MD

09:55 – 10:10 Steven D. Glassman, MD

10:10 – 10:25 Steven M. Mardjetko, MD, FAAP

1D: Cervical Trauma

Moderator: Alexander R. Vaccaro, III, MD, PhD

Room: East 11

Case Presenters:

09:25 – 09:40 Vincent Traynelis, MD

09:40 – 09:55 Marcel F. Dvorak, MD, FRCSC

09:55 – 10:10 F. Cumhur Oner, MD, PhD

10:10 – 10:25 Jens R. Chapman, MD

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Meeting Agenda—Thursday, July 11

THURSDAY, JULY 11, 2013

10:25 – 10:35 Refreshment Break

Refreshments available in the South Foyer, East Meeting Level

10:35 – 11:50 Concurrent Abstract and Debate Sessions (A – C)

Concurrent Abstract Session A: Whitecloud Basic Science Award Nominees & Top Scoring Abstracts

Room: East Ballroom AB

Moderators: Kenneth M.C. Cheung, MD & Michael J. Yaszemski, MD, PhD

10:35-10:39 *Paper #10: Effect of Intermittent Administration of Teriparatide(PTH1-34) on BMP Induced Bone Formation in a Rat Spinal Fusion Model

Tokimitsu Morimoto; Takashi Kaito, MD, PhD; Yohei Matsuo; Tsuyoshi Sugiura; Hirotsugu Honda; Masafumi Kashii, MD, PhD; Motoki Iwasaki, MD, DMSc; Hideki Yoshikawa

10:39-10:43 *Paper #11: The Effect of Increasing Pedicle Screw Diameter on Thoracic Spinal Canal Dimensions: An Anatomic Study

Samuel K. Cho, MD; Young Lu; Branko Skovrlj, MD; John Caridi, MD; Lawrence G. Lenke, MD

10:43-10:47 *Paper #12: Biomechanical Demands on Posterior Fusion Instrumentation During Lordosis Restoration Procedures

Calvin C. Kuo, MD; Audrey Martin; Connor J. Telles, MD; Jeremi M. Leasure, MSME; Christopher P. Ames, MD; Dimitriy Kondrashov, MD

10:47-10:54 Discussion

10:54-10:58 *Paper # 13: The Influences of Rod Contouring on Rod Strength and Stiffness of Different Spinal Constructs

Satoru Demura; Hideki Murakami; Satoshi Kato, MD; Katsuhito Yoshioka; Hiroyuki Hayashi; Hiroyuki Tsuchiya

10:58-11:02 *Paper # 14: The Utility of an Allograft Tendon for Scoliosis Correction via the Costotransverse Foramen in a Porcine Model

Richard E. McCarthy, MD; Dong Sun, PhD; Michael H. McCarthy, BA

11:02-11:06 *Paper # 15: Comparison of an Oxysterol Molecule and rhBMP2 Fusion Rates in a Rabbit Posterolateral Lumbar Spine Model

Trevor P. Scott, MD; Kevin Phan; Akinobu Suzuki, MD, PhD; Scott R. Montgomery, MD; Michael D. Daubs, MD; Farhad Parhami, PhD, MBA; Jeffrey C. Wang, MD

11:06-11:13 Discussion

11:13-11:17 Paper #16: International Variations in the Clinical Presentation and Management of Cervical Spondylotic Myelopathy: One Year Outcomes of the AOSpine Multi-Center Prospective CSM-I Study

Michael G. Fehlings, MD, PhD; Branko Kopjar; Helton L. Defino, MD; Giuseppe Barbagallo; Ronald H. Bartels, MD, PhD; Paul Arnold; Mehmet Zileli, MD; Gamaliel Tan, MBBS; Yasutsugu Yukawa, MD; Massimo Scerrati; Tomoaki Toyone, MD, PhD; Qiang Zhou, PhD

11:17-11:21 Paper #17: C2 Nerve Root Transection During C1 Lateral Mass Screw Fixation: Does it Affect Functionality and Quality of Life?

Michael C. Dewan, MD; Saniya S. Godil, MD; Clinton J. Devin, MD; Matthew J. McGirt, MD

11:21-11:25 Paper #18: When is it Safe to Return to Driving Following Cervical and Lumbar Spinal Surgery?

Trevor P. Scott, MD; William Pannell, BS; David Savin, MD; Stephanie S. Ngo, MPH; Jeffrey C. Wang, MD; Michael D. Daubs, MD

11:25-11:32 Discussion

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Meeting Agenda—Thursday, July 11

THURSDAY, JULY 11, 2013

- 11:32-11:36 **Paper #19: Prospective Analysis of Risk Factors for Proximal Junctional Failure in Adult Deformity Patients**
Robert A. Hart, MD; D. Kojo Hamilton, MD; Jayme R. Hiratzka, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Virginie Lafage, PhD; Praveen V. Mummaneni, MD; Justin S. Smith, MD, PhD; Eric Klineberg, MD; Ian McCarthy, PhD; Douglas C. Burton, MD; Richard Hostin, MD; International Spine Study Group
- 11:36-11:40 **Paper #20: Short Segment Anterior Fusion with Interbody Spacers and Anterior Instrumentation for Moderate, Flexible, Functionally Restrictive, Painful Scheuermann's Kyphosis**
Jwalant S. Mehta, FRCS(Orth); Kan Min, MD; Robert W. Gaines, MD
- 11:40-11:44 **Paper #21: Clinical Results and Functional Outcomes After Direct Intralaminar Screw Repair of Spondylolysis**
Emmanuel N. Menga, MD; Khaled Kebaish, MD; Amit Jain, MD; John A. Carrino, MD, MPH; Paul D. Sponseller, MD
- 11:44-11:50 **Discussion**
- 10:35-11:50 **Concurrent Abstract Session B: Early Onset Scoliosis**
- Room: East Ballroom C*
Moderators: Stefan Parent, MD, PhD & Muharren Yazici, MD
- 10:35-10:39 **Paper #22: Early Experience with Use of Phenix Magnetic Distraction Device in Treatment of EOS**
Joseph I. Krajchich, MD
- 10:39-10:43 **Paper #23: Reducing Radiation Exposure in Early-Onset Scoliosis Patients: Novel use of Ultrasonography to Measure Lengthening in Magnetically-Controlled Growing Rods. Prospective Validation Study and Assessment of Clinical Algorithm**
Oliver M. Stokes, MBBS, MSc, FRCS(Tr&Orth); Elizabeth J. O'Donovan; Dino Samartzis, DSc, PhD (C), MSc; Bow H. Cora; Keith D. Luk, MD; Kenneth M. Cheung, MBBS(UK), FRCS(England), FHKCOS, FHKAM(ORTH)
- 10:43-10:47 **Paper #24: The Classification for Early Onset Scoliosis (C-EOS) Identifies Patients at Higher Risk for Complications at Five Years of Follow-Up**
Howard Y. Park, BA; Hiroko Matsumoto, MA; Tricia St. Hilaire, MPH; Jeff Pawelek; John M. Flynn, MD; David L. Skaggs, MD, MMM; David P. Roye, MD; Michael G. Vitale, MD, MPH
- 10:47-10:54 **Discussion**
- 10:54-10:58 **Paper #25: Early Onset Scoliosis with Intraspinous Anomalies: Management with Growing Rod**
Ankur Goswami, MS(Orth); Pankaj Kandwal, MS(Orth); Ashok Kumar Jaryal; Upendra Bidre, MS; Ankit Gupta, MBBS, MS; Arvind Jayaswal, MS(Orth)
- 10:58-11:02 **Paper #26: Modified Growing Rod Technique for the Treatment of Early-Onset Idiopathic Scoliosis**
Cagatay Ozturk, MD; Bekir Y. Uçar, MD; Meric Enercan; Sinan Kahraman; Alauddin Kochai; Azmi Hamzaoglu, MD
- 11:02-11:06 **Paper #27: One Stage Posterior Osteotomy with Short Segmental Fusion and Dual Growing Rod Technique for Severe Rigid Early Onset Congenital Scoliosis: A Hybrid Technique**
Zhang Jianguo, MD
- 11:06-11:13 **Discussion**
- 11:13-11:17 **Paper #28: Five to Sixteen-Year Results of 201 Growing Rod Patients: Is There a Difference Between Etiologies?**
Behrooz A. Akbarinia, MD; Nima Kabirian, MD; Jeff Pawelek; George H. Thompson, MD; John B. Emans, MD; Paul D. Sponseller, MD; David L. Skaggs, MD, MMM; Growing Spine Study Group

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Meeting Agenda—Thursday, July 11

THURSDAY, JULY 11, 2013

- 11:17-11:21 **Paper #29: Comparison Between 44 Early Fusion and 31 Growing Rod Graduates for Early Onset Scoliosis**
Koki Uno, MD, PhD; Teppei Suzuki; Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Morio Matsumoto, MD; Kota Watanabe; Haruhisa Yanagida, MD; Katsushi Takeshita, MD; Toru Hirano; Manabu Ito, MD, PhD
- 11:21-11:25 **Paper #30: The Effect of Rib-Based Distraction Surgery on Spine Growth**
Ron El-Hawary, MD, MSc, FRCSC; Michael G. Vitale, MD, MPH; Amer F. Samdani, MD; John A. Heflin, MD; Melissa Smith; Joshua W. Klatt, MD; John T. Smith, MD
- 11:25-11:32 **Discussion**
- 11:32-11:36 **Paper #31: The Use of Rib-Based Distraction in Dysplastic Early Onset Scoliosis Associated with Neurofibromatosis**
John T. Smith, MD; John A. Heflin, MD; Michael G. Vitale, MD, MPH; Ron El-Hawary, MD, MSc, FRCSC; Randal R. Betz, MD
- 11:36-11:40 **Paper #32: Proximal Rib Anchors Have 77% Less Risk of Rod Breakage Than Proximal Spine Anchors In Distraction-Based Growing Rods**
Kent T. Yamaguchi, BA; David L. Skaggs, MD, MMM; Shaun Mansour, BA; Karen S. Myung, MD, PhD; Muharrem Yazici, MD; Charles E. Johnston, MD; George H. Thompson, MD; Paul D. Sponseller, MD; Behrooz A. Akbarnia, MD; Michael G. Vitale, MD, MPH; Growing Spine Study Group
- 11:40-11:44 **Paper #33: Peri-Operative Neurological Injury Associated with VEPTR Surgery**
Ron El-Hawary, MD, MSc, FRCSC; Luke Gauthier, MD; Amy L. McIntosh, MD; Yousef Mandourah, BSc; John M. Flynn, MD
- 11:44-11:50 **Discussion**

Concurrent Session C: Debate Session 1

Room: East 1

Moderators: Shay Bess, MD and Michael G. Fehlings, MD, PhD, FRCSC, FACS

10:35 – 11:12 **Debate 1: Multilevel Cervical Spondylosis (>3 levels) With Straight Sagittal Alignment: Laminoplasty vs. Posterior Decompression and Instrumented Fusion**

Laminoplasty: Vincent Traynelis, MD

Posterior Fusion/Decomp: Regis W. Haid, Jr., MD

11:12 – 11:50 **Debate 2: Minimally Invasive vs. Open Technique for the Surgical Treatment of a Moderate Degenerative Lumbar Scoliosis**

MIS: Mark B. Dekutoski, MD

Open: Keith H. Bridwell, MD

11:50 – 12:00 **Walking Break**

12:00 – 13:00 **Exhibit Viewing and HOWs**

Exhibit Viewing with Lunch

*Hands-On Workshops with Lunch - East 16-19

(See "Exhibits and Hands-On Workshops" section on page ? for more information.)

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Meeting Agenda—Thursday, July 11

THURSDAY, JULY 11, 2013

13:00 – 13:10 **Walking Break**

13:10 – 14:10 **Concurrent Abstract Sessions and Complication Series (A- C)**

Concurrent Abstract Session A: Adolescent Idiopathic Scoliosis

Room: East Ballroom AB

Moderators: David H. Clements, III, MD and Daniel J. Sucato, MD, MS

13:10-13:14 **Paper #34: Minimum 20-Year Health Related Quality of Life and Subsequent Surgical Rates for Braced, Observed and Surgical Patients Treated for Adolescent Idiopathic Scoliosis in the US**

A. Noelle Larson, MD; David W. Polly, MD; Ali Ashraf, MD; Yaser M. Baghdadi, MD; Michael J. Yaszemski, MD, PhD

*** This presentation is the result of a project funded, in part, by an SRS Research Grant***

13:14-13:18 **Paper #35: Parameters Leading to a Successful Outcome Following Surgical Treatment for Lenke 2 Curves**

Heiko Koller, MD; Anna M. McClung, BSN, RN; Daniel J. Sucato, MD, MS

13:18-13:22 **Paper #36: Does Selective Thoracic Fusion Provide Satisfactory Outcomes in Adolescents with Chiari Malformation-Associated Scoliosis?**

Zhu Ze-zhang; Jiang Long; Qiu Yong, MD; Zhen Liu; Shifu Sha; Leilei Xu; Xu Sun, MD, PhD

13:22-13:29 **Discussion**

13:29-13:33 **Paper #37: Is Breast Asymmetry Present in Girls with Adolescent Idiopathic Scoliosis? Revisiting a Common Belief**

Joyce Ramsay; Julie Joncas, BSc; Isabelle Turgeon, BSc; Marjolaine Roy-Beaudry, MSc; Lama Seoud; Philippe Debanné, MASc; Isabelle Trop, MD, MPH; Farida Cheriet, PhD; Hubert Labelle, MD; Stefan Parent, MD, PhD

13:33-13:37 **Paper #38: Is Pelvic Incidence in Severe Adolescent Idiopathic Scoliosis Patients Different from General Population? Results of the Analysis of a Monocentric Cohort of 415-Adolescent Idiopathic Scoliosis Subjects**

Christophe Vidal, MD; Brice Ilharreborde, MD; Keyvan Mazda

13:37-13:41 **Paper #39: How Effective is Providence Nighttime Bracing for Adolescent Idiopathic Scoliosis?**

Daniel D. Bohl, MPH; Connor J. Telles, MD; Jonathan N. Grauer, MD; Peter A. DeLuca, MD

13:41-13:48 **Discussion**

13:48-13:52 **Paper #40: Prevalence of Spondylolisthesis and Concomitant Adolescent Idiopathic Scoliosis: A Matched Cohort Analysis**

Ronald A. Lehman, MD; Lawrence G. Lenke, MD; Daniel G. Kang, MD; Kathy Blanke, RN; Ensor E. Transfeldt, MD; Hubert Labelle, MD; Stefan Parent, MD, PhD

13:52-13:56 **Paper #41: Are Pedicle Screw Perforation Rates Influenced by Registered or Nonregistered Vertebrae in Multi-Level Registration Using CT-based Navigation System in the Setting of Scoliosis?**

Masayuki Shimizu; Jun Takahashi, MD; Hiroki Hirabayashi; Keijiro Mukaiyama; Shugo Kuraishi; Toshimasa Futatsugi; Hiroyuki Kato, MD, PhD

13:56-14:00 **Paper #42: Selective Thoracic Versus Non-Selective Fusion in Lenke 3 Curves**

Anuj Singla, MD; Amer F. Samdani, MD; Paul D. Sponseller, MD; James T. Bennett, MD; Joshua M. Pahys, MD; Michelle C. Marks, PT, MA; Baron S. Lonner, MD; Peter O. Newton, MD; Firoz Miyajji, MD, FRCSC; Randal R. Betz, MD; Patrick J. Cahill, MD

14:00-14:10 **Discussion**

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Meeting Agenda—Thursday, July 11

THURSDAY, JULY 11, 2013

- 13:10-14:10 **Concurrent Abstract Session B: Complications/Infections**
- Room: East Ballroom C*
Moderators: Michael D. Daubs, MD and John R. Dimar, II, MD
- 13:10-13:14 **Paper #43: Safety of Instrumentation in Vertebral Osteomyelitis**
Sina Pourtaheri, MD; Arash Emami, MD; Eiman Shafa, MD; Mark J. Ruoff, MD; Kimona Issa, MD; Tyler Stewart, BS; Kumar Sinha, MD; Ki S. Hwang, MD
- 13:14-13:18 **Paper #44: Infection After Spinal Fusion for Neuromuscular Scoliosis: 30 Year Experience at a Single Institution**
Brandon A. Ramo, MD; David W. Roberts, MD; Dominick A. Tuason, MD; Anna M. McClung, BSN, RN; Harold G. Moore; Lauren Paraison; Scott Paradise; Daniel J. Sucato, MD, MS
- 13:18-13:22 **Paper #45: Comparative Effectiveness and Cost-Benefit Analysis of Topical Vancomycin Powder in Posterior Spinal Fusion for Spine Trauma and Degenerative Spine Disease**
Michael C. Dewan, MD; Saniya S. Godil, MD; Scott L. Zuckerman, MD; Stephen Mendenhall; David Shau; Scott L. Parker, MD; Clinton J. Devin, MD; Matthew J. McGirt, MD
- 13:22-13:29 **Discussion**
- 13:29-13:33 **Paper #46: Minimally Invasive Treatment of Adjacent Segment Degeneration via the Lateral Approach**
William B. Rodgers, MD; Jeffrey A. Lehmen, MD; Edward J. Gerber, PA-C; Jody A. Rodgers, MD, FACS
- 13:33-13:37 **Paper #47: Medially Misplaced Pedicle Screws in Patients Without Neurological Deficits Following Spinal Deformity Surgery: To Observe or to Remove?**
Ryo Sugawara; Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Tetsuya Ohara; Yoshitaka Suzuki; Toshiki Saito; Ayato Nohara; Kyotaro Ota; Kazuki Kawakami
- 13:37-13:41 **Paper #48: The Impact of Surgical Timing on Non-Neurological Outcomes Following Complete Traumatic Spinal Cord Injury**
Étienne Bourassa-Moreau, MD; Stefan Parent, MD, PhD; Debbie E. Feldman, PhD; Cynthia Thompson, PhD; Jean-Marc Mac-Thiong, MD, PhD
- 13:41-13:48 **Discussion**
- 13:48-13:52 **Paper #49: The Seattle Spine Team Approach to Adult Spinal Deformity: Significantly Reduced 30,60 and 90 Day Perioperative Complication Rates**
Rajiv K. Sethi, MD; Ryan P. Pong, MD; Jean-Christophe Leveque, MD; Vishal C. Gala, MD, MPH; Thomas C. Dean, MD; Stephen J. Olivar, MD; Stephen M. Rupp, MD
- 13:52-13:56 **Paper #50: Incidence and Risk Factors for Venous Thromboembolism after Spine Surgery**
Katsuhito Yoshioka, MD; Hideki Murakami; Satoru Demura; Satoshi Kato, MD; Takashi Ota; Kazuya Shinmura; Noriaki Yokogawa; Hiroyuki Tsuchiya
- 13:56-14:00 **Paper #51: Complications in Operative Scheuermann's Kyphosis: Do the Pitfalls Differ from Operative Adolescent Idiopathic Scoliosis?**
Baron S. Lonner, MD; Courtney Toombs, BS; Michael Guss, MD; Brian Braaksma, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Harry L. Shufflebarger, MD; Paul D. Sponseller, MD; Peter O. Newton, MD
- 14:00-14:10 **Discussion**

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Meeting Agenda—Thursday, July 11

THURSDAY, JULY 11, 2013

13:10-14:10 **Concurrent Session C: Complication Series 1 — My Worst Complication and Strategies to Prevent/Manage**

Room: *East 1*

Moderators: *Charles Gregory Fisher, MD, MHSc and Marcel Dvorak, MD, FRCS*

13:10 – 13:30 **Tumor**
Michael J. Yaszemski, MD, PhD

13:30 – 13:50 **Cervical Trauma**
Alexander R. Vaccaro, III, MD, PhD

13:50 – 14:10 **Pediatric Deformity**
John P. Dormans, MD

14:10 – 14:20 **Refreshment Break**

Refreshments available in South Foyer, East Meeting Level

14:20 – 15:20 **Instructional Course Lectures 1A-D and Two-Minute Point Presentations**

1A: Controversies in Physician and Industry Relationships

Room: *East 8&15*

Moderator: *Steven D. Glassman, MD*

14:20 – 14:30 **Physician-Industry Relationships Have Potential Ethical Concerns**
Peter S. Rose, MD

14:30 – 14:40 **Physician-Industry Relationships are Needed for Future Development in Spine Care**
William C. Horton, MD

14:40 – 14:50 **How Physician-Industry Collaboration has Resulted in Improvements in Spine Care**
Regis W. Haid, Jr., MD

14:50 – 15:00 **Managing Conflict in Physician-Industry Relationships**
Ed Crowe

15:00 – 15:20 **Discussion**

1B: Adult Deformity I: Clinical & Radiographic Evaluation

Room: *East 1*

Moderator: *Sigurd H. Berven, MD*

14:20 – 14:30 **Basics of Radiographic Assessment of Spino-Pelvic Alignment**
Christopher P. Ames, MD

14:30 – 14:40 **The SRS-Schwab Classification**
Frank J. Schwab, MD

14:40 – 14:50 **Assessment of Spinal Flexibility in the Pre-Operative Planning for Adult Spinal Deformity Surgery**
Benny T. Dahl, MD, PhD, DMSci

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Meeting Agenda—Thursday, July 11

THURSDAY, JULY 11, 2013

14:50 – 15:00 **The Role of Radiographic and Clinical Parameters in Determining Whether to Stop Instrumentation in the Lower Thoracic vs. the Upper Thoracic Spine**

Shay Bess, MD

15:00 – 15:20 **Discussion**

1C: Management of Primary Spine Tumors

Moderator: Michael J. Yazemski, MD, PhD

Room: East 11

14:20 – 14:30 **How Classification Impacts Surgical Decision Making for Resection**

Vedat Deviren, MD

14:30 – 14:40 **Surgical Resection Techniques for the Mobile Spine**

Charles Gregory Fisher, MD, MHS

14:40 – 14:50 **Decision Making for Sacrectomy vs. Partial Sacrectomy**

Ziya L. Gokaslan, MD

14:50 – 15:00 **Surgical Reconstruction Following Sacrectomy**

Patrick C. Hsieh, MD, MSc

15:00 – 15:20 **Discussion**

1D: AIS I: Clinical & Radiographic Evaluation

Moderator: Laurel C. Blakemore, MD

Room: East 2&3

14:20 – 14:30 **Role of 3D Classification in AIS**

Hubert Labelle, MD

14:30 – 14:40 **How the Lenke Classification Typically Guides Fusion Levels**

Marinus De Kleuver, MD, PhD

14:40 – 14:50 **When Can Stopping Short Predictably Give Good Results in AIS?**

Suken A. Shah, MD

14:50 – 15:00 **Evaluation and Management of Atypical Curve Patterns**

Amer Samdani, MD

15:00 – 15:20 **Discussion**

1E: Two-Minute Point Presentations

Moderators: Praveen V. Mummaneni, MD and Mark Weidenbaum, MD

Room: East Ballroom C

14:20-14:22 **Paper #52: Early Proximal Junctional Failure After Deformity Surgery in Patients Older than 55 Years**

Darrel S. Brodke, MD; Prokopis Annis, MD; Brandon Lawrence, MD; Michael D. Daubs, MD

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Meeting Agenda—Thursday, July 11

THURSDAY, JULY 11, 2013

- 14:22-14:24 **Paper #53: Prospective, Multi-Center Assessment of Risk Factors for Early Rod Fracture Following Surgery for Adult Spinal Deformity (ASD)**
David M. Ibrahim, MD; Justin S. Smith, MD, PhD; Eric Klineberg, MD; Christopher I. Shaffrey, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Themistocles S. Protopsaltis, MD; Munish C. Gupta, MD; Richard Hostin, MD; Vedat Deviren, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group
- 14:24-14:26 **Paper #54: Early Proximal Junctional Failure in Patients with Preoperative Sagittal Imbalance**
Micah W. Smith, MD; Prokopis Annis, MD; Brandon Lawrence, MD; Michael D. Daubs, MD; Darrel S. Brodke, MD
- 14:26-14:28 **Paper #55: Sacropelvic Fixation in Adult Spinal Deformity (ASD): A Very High Rate of Mechanical Failure**
Emre Acaroglu, MD; Onur Yaman; Umit O. Guler, MD; Ferran Pellise, MD; Alba Vila-Casademunt; Montse Domingo-Sabat; Ahmet Alanay, MD; Francisco J. S. Pérez-Grueso, MD; European Spine Study Group
- 14:28-14:30 **Paper #56: A Comparison of Rod Breakage Rates in Adult Idiopathic Scoliosis Patients Treated with Posterior Only Surgery with BMP Versus Anterior/Posterior Surgery Without BMP**
Davor Saravanja, B Med, FRACS; John A. Ferguson, FRACS; Khaled Kebaish, MD; Matthew J. Geck, MD; Ali M. Maziad, MD, MSc; Behrooz A. Akbarnia, MD; Oheneba Boachie-Adjei, MD; Complex Spine Study Group
- 14:30-14:32 **Paper #57: Proximal Junctional Kyphosis Following Long Segment Spinal Fusion and Instrumentation: A Look at Both Uncemented and Cemented Constructs**
Anthony Ho; Warren D. Yu, MD; Zachary M. Napier, BA; Colin Haines, MD; Joseph R. O'Brien, MD, MPH
- 14:32-14:40 **Discussion**
- 14:40-14:42 **Paper #58: Calculating and Defining Minimally Important Clinical Difference (MCID) and Substantial Clinical Benefit (SCB) Values for Adult Spinal Deformity (ASD): A Robust Methodology for Consistent Data Reporting**
Ian McCarthy, PhD; Shay Bess, MD; Breton Line, BSME; Michael F. Obrien, MD; Frank J. Schwab, MD; Eric Klineberg, MD; Christopher I. Shaffrey, MD; Munish C. Gupta, MD; Virginie Lafage, PhD; Christopher P. Ames, MD; Richard Hostin, MD; International Spine Study Group
- 14:42-14:44 **Paper #59: Disease State Correlates for Type and Severity of Adult Spinal Deformity (ASD): Assessment Guidelines for Health Care Providers**
Shay Bess, MD; Kai-Ming Fu, MD, PhD; Virginie Lafage, PhD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Robert A. Hart, MD; Eric Klineberg, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Douglas C. Burton, MD; Munish C. Gupta, MD; Oheneba Boachie-Adjei, MD; Justin S. Smith, MD, PhD; International Spine Study Group
- 14:44-14:46 **Paper #60: HRQoL Scores and Radiographic Parameters Do Not Drive Patient Satisfaction After Adult Spinal Deformity Surgery**
D. Kojo Hamilton, MD; Jayme R. Hiratzka, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Gregory M. Mundis, MD; Virginie Lafage, PhD; Vedat Deviren, MD; Justin S. Smith, MD, PhD; Eric Klineberg, MD; Behrooz A. Akbarnia, MD; Douglas C. Burton, MD; Robert A. Hart, MD; International Spine Study Group
- 14:46-14:48 **Paper #61: Operative and Nonoperative Treatment Approaches for Lumbar Degenerative Disc Disease Have Similar Long-Term Clinical Outcomes Among Patients with Positive Discography**
Justin S. Smith, MD, PhD; Gursukhman S. Sidhu, MBBS; Mitchell Maltenfort, PhD; Christopher I. Shaffrey, MD; Alexander R. Vaccaro, MD, PhD

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THURSDAY, JULY 11, 2013

- 14:48-14:50 **Paper #62: A Prospective Propensity Matched Cohort Analysis of Minimally Invasive (MIS), Hybrid (HYB), and Open Spine Surgery (OPEN) for the Treatment of Adult Spinal Deformity (ASD)**
Gregory M. Mundis, MD; Virginie Lafage, PhD; Behrooz A. Akbarnia, MD; Robert K. Eastlack, MD; Michael Y. Wang, MD; Juan S. Uribe, MD; Neel Anand, MD; Praveen V. Mummaneni, MD; David O. Okonkwo, MD, PhD; Adam S. Kanter, MD; Frank La Marca, MD; Richard G. Fessler, MD, PhD; Christopher I. Shaffrey, MD; Vedat Deviren, MD; International Spine Study Group
- 14:50-14:52 **Paper #63: Severity and Treatment Response of Back and Leg Pain Differ by Curve Location in Adult Spinal Deformity (ASD)**
Han Jo Kim, MD; Gregory M. Mundis, MD; Robert K. Eastlack, MD; Douglas C. Burton, MD; Justin K. Scheer, BS; Oheneba Boachie-Adjei, MD; Matthew E. Cunningham, MD, PhD; Justin S. Smith, MD, PhD; Shay Bess, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; International Spine Study Group
- 14:52-15:02 **Discussion**
- 15:02-15:04 **Paper #64: Health Impact Comparison of Cervical Sagittal Deformity and Thoracolumbar Sagittal Deformity on Baseline Disability and Surgical Outcomes: Cervical PSO Versus Lumbar PSO**
Justin K. Scheer, BS; Themistocles S. Protopsaltis, MD; Han Jo Kim, MD; Richard Hostin, MD; Khaled Kebaish, MD; Justin S. Smith, MD, PhD; Gregory M. Mundis, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Robert A. Hart, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Vedat Deviren, MD; Christopher P. Ames, MD; International Spine Study Group
- 15:04-15:06 **Paper #65: Cervical Sagittal Deformity Develops After PJK in Adult Thoracolumbar Deformity Correction: Radiographic Analysis Utilizing a Novel Global Sagittal Parameter, the CTPA**
Themistocles S. Protopsaltis, MD; Nicolas Bronsard, MD, PhD; Jamie S. Terran, BS; Justin S. Smith, MD, PhD; Eric Klineberg, MD; Gregory M. Mundis, MD; Han Jo Kim, MD; Richard Hostin, MD; Robert A. Hart, MD; Christopher P. Ames, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group
- 15:06-15:08 **Paper #66: Effect of Adult Spinal Deformity on Cervical Degeneration**
Takahito Fujimori, MD, PhD; Hai Le; William Schairer; Sigurd H. Berven, MD; Bobby Tay, MD; Vedat Deviren, MD; Shane Burch, MD; Serena S. Hu, MD
- 15:08-15:10 **Paper #67: Evaluation of Spinal Cord Motion in Patients with Normal Sagittal Cervical Alignment Using Kinetic MRI**
Chengjie Xiong; Michael D. Daubs, MD; Akinobu Suzuki, MD, PhD; Bayan Aghdasi, BA; Trevor P. Scott, MD; Kevin Phan; Monchai Ruangchainikom, MD; Jeffrey C. Wang, MD
- 15:10-15:12 **Paper #68: Vertical Reduction and Fixation Technique of C1-2 Joint for the Treatment of Basilar Invagination**
Jae Taek Hong, MD, PhD; Ho Jin Lee; Il Sup Kim
- 15:12-15:14 **Paper #69: Utility of Flexion and Extension Views for Screening of Children with Down Syndrome**
Walter F. Kregel, MD; Sid Baucom, MD; Samuel Browd, MD, PhD
- 15:14-15:20 **Discussion**

15:20 – 15:30 **Walking Break**

15:30 – 16:30 ***Hands-On Workshops with Beverages, Snacks**

East 16-19

(See “Exhibits and Hands-On Workshops” section on page 193 for more information.)

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Meeting Agenda—Friday, July 12

FRIDAY, JULY 12, 2013

7:00 – 16:00	Registration and Exhibits Open <i>East Convention Level Lobby Exhibit Hall A</i>
7:00 – 7:45	Breakfast & Exhibit Viewing and *Hands-On Workshops <i>*Beverages available throughout the day in the Exhibit Hall Hands-On Workshop - East 16-19 See "Exhibits and Hands-On Workshops" (HOW) section on page 193 for more information.)</i>
7:45 – 8:45	Concurrent Abstract and Debate Sessions (A-C) Concurrent Abstract Session A: Adult Deformity
	<i>Room: East Ballroom AB Moderators: Serena S. Hu, MD and Stephen J. Lewis, MD, MSc, FRCSC</i>
7:45-7:49	Paper #70: Clinical Improvement Through Nonoperative Treatment of Adult Spinal Deformity: Who is Likely to Benefit? <i>Caroline E. Poorman, BA; Kseniya Slobodyanyuk; Justin S. Smith, MD, PhD; Themistocles S. Protosaltis, MD; Richard Hostin, MD; Shay Bess, MD; Gregory M. Mundis, MD; Frank J. Schwab, MD; <u>Virginie Lafage, PhD</u>; International Spine Study Group</i>
7:49-7:53	Paper #71: Clinical and Radiographic Outcomes Following 3-Column Osteotomies at a Minimum 5-Year Follow-up <i>Kevin R. O'Neill, MD, MS; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Seung-Jae Hyun, MD; Brian J. Neuman, MD; Ian G. Dorward, MD; Linda Koester, BS</i>
7:53-7:57	Paper #72: Impact of Major and Minor Complications on Health Related Quality of Life Following Adult Spinal Deformity Surgery: Multi-Center Prospective Database <i>Eric Klineberg, MD; Kai-Ming Fu, MD, PhD; Justin S. Smith, MD, PhD; Virginie Lafage, PhD; Frank J. Schwab, MD; Shay Bess, MD; Robert A. Hart, MD; Khaled Kebaish, MD; Douglas C. Burton, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Richard Hostin, MD; Gregory M. Mundis, MD; Munish C. Gupta, MD; International Spine Study Group</i>
7:57-8:04	Discussion
8:04-8:08	Paper #73: Coronal Imbalance May be Neglected in Patients Undergoing Majority Sagittal Deformity Correction <i>Munish C. Gupta, MD; Oheneba Boachie-Adjei, MD; Matthew E. Cunningham, MD, PhD; Themistocles S. Protosaltis, MD; Vedat Deviren, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Richard Hostin, MD; Virginie Lafage, PhD; Eric Klineberg, MD; Justin S. Smith, MD, PhD; Jamie S. Terran, BS; International Spine Study Group</i>
8:08-8:12	Paper #74: Early and Late Thoracic Kyphosis Following 104 Lumbar Pedicle Subtraction Osteotomies (LPSO) with Unfused Thoracic Spine <i>Eric Klineberg, MD; Virginie Lafage, PhD; Jamie S. Terran, BS; Christopher P. Ames, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Kai-Ming Fu, MD, PhD; Themistocles S. Protosaltis, MD; Frank J. Schwab, MD; Khaled Kebaish, MD; Munish C. Gupta, MD; International Spine Study Group</i>
8:12-8:16	Paper #75: Scoliosis is a Risk Factor for Gastroesophageal Reflux Disease in Adult Spinal Deformity <i>Naobumi Hosogane, MD; Kota Watanabe; Mitsuru Yagi, MD, PhD; Shinjiro Kaneko, MD, PhD; Hitoshi Kono; Masanobu Shioda; Masafumi Machida, MD; Masashi Saito; Yoshiaki Toyama; Morio Matsumoto, MD</i>
8:16-8:23	Discussion

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- 8:23-8:27 **Paper #76: Comparison of S2 AI and Iliac Bolt Pelvic Fixation in the Reconstruction of Adult Spine Deformities**
Niranjan Kavadi, Trevor D. Ramsey, BS; Donald A. Deinlein, MD; Steven Theiss, MD
- 8:27-8:31 **Paper #77: Comparison of Standard 2-Rod to Multiple-Rod Constructs for Fixation Across Three-Column Spinal Osteotomies**
Seung-Jae Hyun, MD; Lawrence G. Lenke, MD; Linda Koester, BS
- 8:31-8:35 **Paper #78: Transforaminal Anterior Release for the Treatment of Fixed Sagittal Imbalance and Segmental Kyphosis**
Fred A. Sweet, MD
- 8:35-8:45 **Discussion**

7:45-8:45 **Concurrent Abstract Session B: Trauma/Tumor**

Room: East Ballroom C

Moderators: Vedat Deviren, MD and Mark B. Dekutoski, MD

- 7:45-7:49 **Paper #79: A Novel Scientific Model for Rare and Often Neglected Neoplastic Conditions: AOSpine Knowledge Forum Tumor International Dataset for Primary Tumors of the Spine**
Charles G. Fisher, MD, MHS; Michael G. Fehlings, MD, PhD; Mark Bilsky, MD; Mark B. Dekutoski, MD; Luzzati Alessandro; Richard Williams; Sigurd H. Berven, MD; Nasir A. Quraishi, FRCS; Laurence D. Rhines, MD; Chetan Bettegowda, MD, PhD; Ziya L. Gokaslan, MD
- 7:49-7:53 **Paper #80: A Comparison of the Tokuhashi Revised and Tomita Scoring Systems in a Prospective Cohort of Patients with Metastatic Epidural Spinal Cord Compression (MESCC)**
Søren S. Morgen, MD; Dennis Hallager Nielsen, MD; Rikke Søgaard, MSc, MPH, PhD; Claus F. Larsen, MD, DMSci; Svend Aage Engelholm, DMSci; Benny Dahl, MD, PhD, DMSci
- 7:53-7:57 **Paper #81: Spinal Instability Neoplastic Score: An Analysis of Reliability and Validity in Radiation Oncologists: An AOSpine Knowledge Forum Tumor Project**
Charles G. Fisher, MD, MHS; Laurence D. Rhines, MD; Norio Kawahara, MD, PhD; Daryl R. Fourney, MD, FRCS, FACS; Jeremy J. Reynolds, MBChB; Michael G. Fehlings, MD, PhD; Rowan Schouten; Ziya L. Gokaslan, MD
- 7:57-8:04 **Discussion**
- 8:04-8:08 **Paper #82: Change of Survival in Patients with Metastatic Epidural Spinal Cord Compression According to Primary Cancer Diagnosis**
Søren S. Morgen, MD; Casper Lund-Andersen, MD, DMSci; Claus F. Larsen, MD, DMSci; Alfred L. Fugla; Svend Aage Engelholm, DMSci; Benny Dahl, MD, PhD, DMSci
- 8:08-8:12 **Paper #83: Modified Posterior Vertebral Column Resection for The Treatment of Osteoporotic Fractures with Neurological Deficit in Elderly Patients**
Meric Enercan; Cagatay Ozturk, MD; Sinan Kahraman; Bekir Y. Uçar, MD; Alaa Zakout; Azmi Hamzaoglu, MD
- 8:12-8:16 **Paper #84: Stabilization of the Craniocervical Junction After an Internal Dislocation Injury: An In-Vitro Study**
Kristen E. Radcliff, MD; Mir Hussain; Mark Moldavsky, MS; Noelle Klocke, MS; Alexander R. Vaccaro, MD, PhD; Todd J. Albert, MD; Saif Khalil, PhD; Brandon Bucklen
- 8:16-8:23 **Discussion**

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FRIDAY, JULY 12, 2013

- 8:23-8:27 **Paper #85: Efficacy and Safety of Riluzole in Acute Spinal Cord Injury (SCI). Rationale and Design of AOSpine Phase III Multi-Center Double Blind Randomized Controlled Trial. (RISCIS)**
Michael G. Fehlings, MD, PhD; Branko Kopjar; Robert G. Grossman, MD
- 8:27-8:31 **Paper #86: Comparison of Neurological Improvements in Acute Traumatic Central Cord Syndrome Following Surgical and Non-Surgical Interventions**
Naresh S. Kumar, FRCS(Ed), FRCS(Orth), DM; Jason Tay TE; Shi Hui Lee; Effie Chew; Gabriel Liu, MSc, FRCS(Ed&Orth); Joseph Thambiah, FRCS; Hee-Kit Wong
- 8:31-8:35 **Paper #87: Thoracic and Lumbar Compression Fractures in the Pediatric Patient**
Avrum Joffe, MD; Carrie E. Bartley, MA; Tracey Bastrom, MA; Peter O. Newton, MD; Burt Yaszay, MD
- 8:35-8:45 **Discussion**

Concurrent Session C: Debate Session 2

Room: East 1

Moderators: Todd J. Albert, MD and Steven M. Mardjetko, MD, FAAP

7:45 – 8:15 **Debate 1: SI Joint Arthritis is a Common Entity Requiring Surgical Intervention**

Pro: David W. Polly, Jr., MD

Con: Jens R. Chapman, MD

8:15 – 8:45 **Debate 2: Open vs. MIS TLIF: Which Gives the Better Long-Term Results?**

MIS: Raj Y. Rampersaud, MD, FRCSC

Open: Regis W. Haid, Jr., MD

8:45 – 9:15

Refreshment Break

Break Served in the Exhibit Hall

9:15 – 10:15

Concurrent Roundtable Sessions 2A-D and Two-Minute Point Presentations

2A: Cervical Deformity

Room: East 2&3

Moderator: K. Daniel Riew, MD

Case Presenters:

09:15 – 09:30 Christopher P. Ames, MD

09:30 – 09:45 Vincent Traynelis, MD

09:45 – 10:00 Christopher I. Shaffrey, MD

10:00 – 10:15 Jeffrey D. Coe, MD

2B: Thoracolumbar Trauma

Room: East 11

Moderator: Alexander R. Vaccaro, III, MD, PhD

Case Presenters:

09:15 – 09:30 Marcel F. Dvorak, MD, FRCSC

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09:30 – 09:45 *F. Cumhur Oner, MD, PhD*

09:45 – 10:00 *John C. France, MD*

10:00 – 10:15 *Sigurd H. Berven, MD*

2C: Cervical Degenerative Disease/Cervical Spondylotic Myelopathy (CSM)

Room: *East 1*

Moderator: *Justin S. Smith, MD, PhD*

Case Presenters:

09:15 – 09:30 *Morio Matsumoto, MD*

09:30 – 09:45 *Praveen V. Mummaneni, MD*

09:45 – 10:00 *John R. Dimar, II, MD*

10:00 – 10:15 *Yousry M.K. El-Hawary, MD*

2D: Infection

Room: *East 8&15*

Moderator: *Kenneth MC Cheung, MD*

Case Presenters:

09:15 – 09:30 *Tyler Koski, MD*

09:30 – 09:45 *Jacob M. Buchowski, MD, MS*

09:45 – 10:00 *Baron S. Lonner, MD*

10:00 – 10:15 *Kamal N. Ibrahim, MD, FRCS(C), MA*

2E: Two-Minute Point Presentations

Rooms: *East Ballroom C*

Moderators: *Michael D. Daubs, MD and Michael G. Vitale, MD, MPH*

9:15-9:17 **Paper #88: The Reported Rate of Adjacent Segment Disease in Cervical Disc Arthroplasty Versus Single Level Fusion: An Analysis of Prospective Studies**

Kushagra Verma, MD, MS; Sapan Gandhi, BS; Alexander R. Vaccaro, MD, PhD; Alan S. Hilibrand, MD; Todd J. Albert, MD; Kristen E. Radcliff, MD

9:17-9:19 **Paper #89: Long-Term Evaluation of Dysphasia (Bazaz) with PCM Cervical Disc Compared to ACDF in a Prospective Randomized Clinical Trial: Five-Year Results From US IDE Study**

Paul C. McAfee, MD, MBA; Kye Gilder, PhD; Kelli M. Howell, MS; Frank M. Phillips, MD; Fred H. Geisler, MD, PhD; Christopher D. Chaput, MD; John G. DeVine, MD; Christopher J. Reah, PhD

9:19-9:21 **Paper #90: Evaluation of Dysphagia/Dysphonia with PCM Cervical Disc Compared to ACDF in a Prospective Randomized Clinical Trial: Two-Year Results from the US IDE Study**

Paul C. McAfee, MD, MBA; Kye Gilder, PhD; Kelli M. Howell, MS; Frank M. Phillips, MD; Fred H. Geisler, MD, PhD; Christopher D. Chaput, MD; John G. DeVine, MD

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FRIDAY, JULY 12, 2013

- 9:21-9:23 **Paper #91: A Clinical Prediction Rule to Determine Outcomes in Patients with Degenerative Cervical Myelopathy Undergoing Surgical Treatment: Data from the Prospective, Multicentre AOSpine North America CSM Study**
Lindsay Tetreault; Branko Kopjar; S. Tim Yoon; Paul Arnold; Eric Massicotte, MD, MSc FRCS; Alexander R. Vaccaro, MD, PhD; Michael G. Fehlings, MD, PhD
- 9:23-9:25 **Paper #92: Outcomes of Single-Level Cervical Disc Arthroplasty Versus Anterior Discectomy and Fusion: A Single Center, Retrospective Review**
Ronald A. Lehman, MD; Robert W. Tracey, MD; John P. Cody; Daniel G. Kang, MD; Adam J. Bevevino, MD; Michael Rosner, MD
- 9:25-9:27 **Paper #93: Cervical Posterior Foraminotomy's Effect on Segmental Range of Motion in the Setting of Total Disc Arthroplasty**
Ronald A. Lehman, MD; Adam J. Bevevino, MD; Daniel G. Kang, MD; Rachel E. Gaume, BS; Divya V. Ambati, MS; David E. Gwinn, MD; Anton E. Dmitriev, PhD
- 9:27-9:35 **Discussion**
- 9:35-9:37 **Paper #94: Return to Surgery Does Not Worsen Health Related Quality of Life (HRQL) or Patient Satisfaction at Two Year: An Analysis of Incidence and Risk Factors for Secondary Surgery in Adult Spinal Deformity (ASD)**
Shay Bess, MD; Breton Line, BSME; Robert A. Hart, MD; Eric Klineberg, MD; Christopher P. Ames, MD; Behrooz A. Akbarnia, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Richard Hostin, MD; Khaled Kebaish, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group
- 9:37-9:39 **Paper 95: Comparison of QALYs Predicted from the ODI and QALYs Calculated from the SF-6D Following Surgical Treatment for Adult Spinal Deformity (ASD)**
Ian McCarthy, PhD; Michael F. O'Brien, MD; Christopher P. Ames, MD; Han Jo Kim, MD; Oheneba Boachie-Adjei, MD; Frank J. Schwab, MD; Eric Klineberg, MD; Christopher I. Shaffrey, MD; Munish C. Gupta, MD; Richard Hostin, MD; International Spine Study Group
- 9:39-9:41 **Paper #96: Do Operative Outcomes for Adults with Spinal Deformity Differ Based on the Relative Severity of Back and Leg Pain Prior to Surgery?**
Robert K. Eastlack, MD; Justin K. Scheer, BS; Han Jo Kim, MD; Oheneba Boachie-Adjei, MD; Vedat Deviren, MD; Justin S. Smith, MD, PhD; Robert A. Hart, MD; Shay Bess, MD; Gregory M. Mundis, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; International Spine Study Group
- 9:41-9:43 **Paper #97: Radiographic and Clinical Outcome Comparing Traditional Iliac Fixation to the S2 Alar-Iliac (S2AI) Technique in Adult Deformity Patients Fused to the Sacrum: A Multi-Center Study**
Khaled Kebaish, MD; Robert A. Hart, MD; Floreana Naef, MD; Jamie S. Terran, BS; Virginie Lafage, PhD; Jacob M. Buchowski, MD, MS; Shay Bess, MD; Christopher P. Ames, MD; Eric Klineberg, MD; Richard Hostin, MD; Oheneba Boachie-Adjei, MD; Frank J. Schwab, MD; Munish C. Gupta, MD; International Spine Study Group
- 9:43-9:45 **Paper #98: Stiffness After Fusion for Adult Spinal Deformity Does Not Significantly Impact Patients' Functional Status or Satisfaction**
Jayme R. Hiratzka, MD; D. Kojo Hamilton, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Gregory M. Mundis, MD; Virginie Lafage, PhD; Vedat Deviren, MD; Justin S. Smith, MD, PhD; Eric Klineberg, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Robert A. Hart, MD; International Spine Study Group
- 9:45-9:47 **Paper #99: Multiple Regression Analysis of Factors Affecting HRQL in Adult Spinal Deformity (ASD)**
Emre Acaroglu, MD; Umit O. Guler, MD; Yalçın Yavuz, MSc; Ferran Pellise, MD; Montse Domingo-Sabat; Sule Yakici; Yasemin Genc, PhD; Ahmet Alanay, MD; Francisco J. S. Pérez-Gruoso, MD; European Spine Study Group
- 9:47-9:55 **Discussion**

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FRIDAY, JULY 12, 2013

- 9:55-9:57 **Paper #100: A Retrospective, Multi-Center Analysis of the Efficacy of Antifibrinolytics on Intraoperative Blood Loss during Complex Adult Deformity Surgery**
Adam L. Shimer, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Lawrence G. Lenke, MD; Christopher P. Ames, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Michael P. Kelly, MD
- 9:57-9:59 **Paper #101: Efficacy of Tranexamic Acid and Aminocaproic Acid on Blood Loss in Spine Surgery: A Meta-Analysis**
Thomas Cherian; Stephen P. Maier, BA; Kristina Bianco, BA; Kseniya Slobodyanyuk; Frank J. Schwab, MD; Baron S. Lonner, MD; Virginie Lafage, PhD; Thomas J. Errico
- 9:59-10:01 **Paper #102: Comparison of Operative Complications in Posterior Only Surgery Utilizing BMP Versus Combined Anterior/Posterior Surgery with No BMP for Adult Idiopathic Scoliosis Surgery**
John A. Ferguson, FRACS; Davor Saravanja, B Med, FRACS; Khaled Kebaish, MD; Matthew J. Geck, MD; Ali M. Maziad, MD, MSc; Behrooz A. Akbarnia, MD; Oheneba Boachie-Adjei, MD; Complex Spine Study Group
- 10:01-10:03 **Paper #103: Comprehensive Program Aligning Structure, Processes and the Electronic Medical Record Improves Quality and Safety of Complex Spinal Deformity Surgery**
Suken A. Shah, MD; William G. Mackenzie, MD; Stephen T. Lawless, MD, MBA
- 10:03-10:05 **Paper #104: Pediatric Spine CT Radiation Dose Reduction: Protocol Refinement Based On Measurement Variation At Simulated Lower Radiation Acquisitions**
Jonathan O. Swanson, MD; Neil Vining, MD; Klane M. White, MD, MSc; Walter F. Krengel, MD; Adam M. Alessio, PhD; Seth D. Friedman; Kit Song, MD
- 10:05-10:07 **Paper #105: Evaluation of Pedicle Screw Placement by Pedicle Channel Classification in Scoliosis: Is Screw Placement into a Cortical Channel Really Difficult?**
Tsutomu Akazawa, MD; Toshiaki Kotani; Tsuyoshi Sakuma, MD, PhD; Shohei Minami
- 10:07-10:15 **Discussion**

10:15 – 10:25 **Walking Break**

10:25 – 11:50 **Concurrent Abstract Sessions and Complication Series (A-C)**

Concurrent Abstract Session A: Cervical Spine

Room: East Ballroom AB

Moderators: Christopher P. Ames, MD and K. Daniel Riew, MD

- 10:25-10:29 **Paper #106: Laminoplasty Versus Corpectomy in the Treatment of Cervical Spondylotic Myelopathy: 5-12 Year Follow-Up**
Christopher G. Furey, MD; Katherine Sadowski, BS; Nicholas U. Ahn, MD; Sanford E. Emery, MD, MBA
- 10:29-10:33 **Paper #107: Prognostic Factors for Neurologic Improvement Following Surgical Management of Cervical Spondylotic Myelopathy**
Katherine Sadowski, BS; Nicholas U. Ahn, MD; Sanford E. Emery, MD, MBA; Christopher G. Furey, MD
- 10:33-10:37 **Paper #108: Prevalence of OPLL and DISH in USA: CT-Based Study of 3403 Patients**
Takahito Fujimori, MD, PhD; Hai Le; Cynthia T. Chin; Murat Pekmezci, MD; William Schairer; Bobby Tay, MD; Motoki Iwasaki, MD; Serena S. Hu, MD
- 10:37-10:44 **Discussion**

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Meeting Agenda—Friday, July 12

FRIDAY, JULY 12, 2013

- 10:44-10:48 **Paper #109: Cervical Spinal Sagittal Alignment: An Analysis of Young, Asymptomatic Volunteers**
Peter Wilson, MBBS; Davor Saravanja, B Med, FRACS; Yanni Sergides; William R. Sears, MBBS, FRACS; Gavin White
- 10:48-10:52 **Paper #110: Evaluation of Spinal Cord Motion in Patients with Abnormal Sagittal Cervical Alignment Using Kinetic MRI**
Chengjie Xiong; Michael D. Daubs, MD; Akinobu Suzuki, MD, PhD; Bayan Aghdasi, BA; Trevor P. Scott, MD; Kevin Phan; Monchai Ruangchainikom, MD; Jeffrey C. Wang, MD
- 10:52-10:56 **Paper #111: Restoration of Cervical Lordosis is Associated with Improved Clinical Outcome in One or Two Level Anterior Cervical Discectomy and Fusion (ACDF) Patients**
Xiaobang Hu, PhD; Isador Lieberman, MD, MBA, FRCSC
- 10:56-11:03 **Discussion**
- 11:03-11:07 **Paper #112: Can Long Fusions Crossing the Cervicothoracic Junction have Good Outcomes at a Minimum Two Years Follow-Up?**
Han Jo Kim, MD; Lawrence G. Lenke, MD; Jeremy L. Fogelson, MD; Addisu Mesfin, MD; Stuart Hershman, MD; Brenda A. Sides, MA
- 11:07-11:11 **Paper #113: Does T1 Pelvic Angle (TPA) Effectively Assess Sagittal Imbalance and Can it Predict Sustainable Correction?**
Devon J. Ryan, BA; Themistocles S. Protopsaltis, MD; Christopher P. Ames, MD; Richard Hostin, MD; Eric Klineberg, MD; Gregory M. Mundis, MD; Ibrahim Obeid; Khaled Kebaish, MD; Justin S. Smith, MD, PhD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Virginia Lafage, PhD; International Spine Study Group
- 11:11-11:15 **Paper #114: Occipito-Cervical Fusion in Skeletal Dysplasia: A New Surgical Technique**
Prakash Sitoula, MD; Laurens Holmes, PhD, DrPH; Colleen Ditro, MSN; Kenneth J. Rogers, PhD; Suken A. Shah, MD; William G. Mackenzie, MD
- 11:15-11:19 **Paper #115: Effect of Cervical Spinal Deformity on Skull Position and Upper Cervical Motion with Horizontal Gaze**
Monchai Ruangchainikom, MD; Michael D. Daubs, MD; Akinobu Suzuki, MD, PhD; Tetsuo Hayashi, MD; Haijun Tian; Chengjie Xiong; Trevor P. Scott, MD; Kevin Phan; Bayan Aghdasi, BA; Jeffrey C. Wang, MD
- 11:19-11:26 **Discussion**
- 11:26-11:30 **Paper #116: Reconstruction of Complex Subaxial Cervical Spine Pathology Using Pedicle Screws Inserted with Stealth Navigation Guidance**
Alexander A. Theologis, MD; Shane Burch, MD
- 11:30-11:34 **Paper #117: Less Invasive Surgery for Treating Adult Spinal Deformities (ASD): Ceiling Effects for Cobb Angle Correction with Three Different Techniques**
Michael Y. Wang, MD; Praveen V. Mummaneni, MD; Kai-Ming Fu, MD, PhD; Neel Anand, MD; David O. Okonkwo, MD, PhD; Adam S. Kanter, MD; Frank La Marca, MD; Richard G. Fessler, MD, PhD; Juan S. Uribe, MD; Christopher I. Shaffrey, MD; Virginia Lafage, PhD; Raqeeb Haque, MD; Vedat Deviren, MD; Gregory M. Mundis, MD; International Spine Study Group
- 11:34-11:38 **Paper #118: Assessment of the Insertional Torque of Screws During Posterior Spinal Surgery**
Takuya Mishiro, MD, PhD; Koichi Sairyo, MD; Akira Shinohara; Takashi Chikawa, MD, PhD
- 11:38-11:42 **Paper #119: Osteocel® Plus in Anterior Cervical Discectomy and Fusion (ACDF): Evaluation of Patient Outcomes from a Prospective Multi-Center Study**
Robert K. Eastlack, MD; Craig Meyer, MD; Chris R. Brown, MD
- 11:42-11:50 **Discussion**

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Meeting Agenda—Friday, July 12

FRIDAY, JULY 12, 2013

- 10:25-11:50 **Concurrent Abstract Session B: Lumbar Degenerative/Spondylolisthesis**
- Room: East Ballroom C*
Moderators: John R. Dimar, II, MD and Hubert Labelle, MD
- 10:25-10:29 **Paper #120: 5-Year Outcome of Minimally Invasive Versus Open Transforaminal Lumbar Interbody Fusion**
Chusheng Seng, MBBS, MRCS(Edin); Mashfiqul A. Siddiqui, MD; Kenneth Wong; Seang Beng Tan, MD; Karen Zhang, BSc; William Yeo, MS; Wai-Mun Yue, MBBS, FRCS(Ed)in, FAMS (Ortho Surg)
- 10:29-10:33 **Paper #121: High Grade Spondylolisthesis Reduction using Temporary Alar Distraction Rods and Sacral Dome Osteotomy**
Dennis Crandall, MD
- 10:33-10:37 **Paper #122: Cost-Effectiveness of Lumbar Spondylolisthesis Surgery at Two-Year Follow-Up**
Charla R. Fischer, MD; Ryan Cassilly, MD; Yuriy Trimba, BA; Austin Peters; Jeffrey A. Goldstein, MD; Jeffrey M. Spivak, MD; John A. Bendo, MD
- 10:37-10:44 **Discussion**
- 10:44-10:48 **Paper #123: New Formulation of Demineralized Bone Matrix Putty Performs Substantially Equivalent to Iliac Bone Graft in Rabbit Posterolateral Lumbar Spine Arthrodesis**
Paul D. Kiely, MCh, FRCS (Tr&Orth); Antonio Brecevic; Fadi Taher, MD; Frank P. Cammisa, MD; Celeste Abjornson, PhD
- 10:48-10:52 **Paper #124: Influence of Patient Expectations and Depression Symptoms on Clinical Outcomes in the Surgical Management of Spinal Stenosis**
Baron Zarate, MD; Alejandro Urban Baeza, MD; Samuel Romero-Vargas, MD; Alejandro A. Reyes-Sanchez, MD
- 10:52-10:56 **Paper #125: Characteristics Associated with Active Defects in Juvenile Spondylolysis**
Jeffrey L. Gum, MD; Charles H. Crawford, MD; Phillip N. Collis, MD; Leah Y. Carreon, MD, MSc
- 10:56-11:03 **Discussion**
- 11:03-11:07 **Paper #126: Establishing the Efficacy of Lumbar Discectomy and Single Level Fusion for Spondylolisthesis -Experience with the AANS' NeuroPoint SD Registry**
Praveen V. Mummaneni, MD; Zohar Ghogawala, MD, FACS; John Ziewacz, MD, MPH; Christopher I. Shaffrey, MD; Robert F. Heary, MD; Joseph S. Cheng, MD, MS; Anthony L. Asher, MD; Justin S. Smith, MD, PhD; Neil R. Malhotra, MD; Robert G. Whitmore, MD; Subu Magge, MD; Michael Kaiser; John Knightly, MD; Khalid Abbed, MD; Daniel Resnick, MD
- 11:07-11:11 **Paper #127: Cost-Utility and Comparative Effectiveness Analyses of Surgery Versus Comprehensive Medical Management for Lumbar Spondylosis in Elderly**
Scott L. Zuckerman, MD; Saniya S. Godil, MD; Scott L. Parker, MD; Stephen Mendenhall; David Shau; Clinton J. Devin, MD; Matthew J. McGirt, MD
- 11:11-11:15 **Paper #128: The National Neurosurgery Quality and Outcomes Database (N2QOD) Pilot: Interim Analysis of Registry Feasibility, Data Integrity, and the Safety and Effectiveness of Surgical Spine Care**
Matthew J. McGirt, MD; Steven D. Glassman, MD; John Knightly, MD; Praveen V. Mummaneni, MD; Gregory Oetting, MD; Oren Gottfried, MD; Saad Khairi, MD; Timothy Ryken; Gregory Balturshot; Thomas B. Briggs, MD; Christopher I. Shaffrey, MD; Eric Elowitz; Clarence Watridge; Anthony L. Asher, MD
- 11:15-11:19 **Paper #129: A Novel 6-Item Outcome Instrument (VBI-6) for Assessing the Effectiveness of Lumbar Surgery in Registry Efforts**
Saniya S. Godil, MD; Scott L. Zuckerman, MD; Clinton J. Devin, MD; Matthew J. McGirt, MD

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Meeting Agenda—Friday, July 12

FRIDAY, JULY 12, 2013

- 11:19-11:26 **Discussion**
- 11:26-11:30 **Paper #130: Disc Space Preparation in Unilateral Transforaminal Lumbar Interbody Fusion: A Comparison of Minimally Invasive and Open Approaches**
Jeffrey A. Rihn, MD; Sapan Gandhi, BS; Patrick J. Sheehan, BBA; Alexander R. Vaccaro, MD, PhD; Alan S. Hilibrand, MD; Todd J. Albert, MD; D. Greg Anderson, MD
- 11:30-11:34 **Paper #131: Risk Factors for the Need of Surgical Treatment of a First Recurrent Lumbar Disc Herniation**
Ratko Yurac, MD; Juan J. Zamorano, MD; Fernando Lira, Resident; Diego Valiente, MD; Vicente Ballesteros, MD; Alejandro Urzua, MD; Francisco Ilabaca, MD; Jose Fleiderman, MD; Milan Munjin, MD; Miguel Lecaros, MD; Sergio Ramirez, MD; Carlos Tapia
- 11:34-11:38 **Paper #132: Changes in Foraminal Dimensions Following Anterior Lumbar Interbody Fusion (ALIF): A 3D-CT and Clinical Analysis**
Sergio A. Mendoza-Lattes, MD; Bethany Harpole, BS; Rachel C. Nash, BS; Andrew Pugely, MD
- 11:38-11:42 **Paper #133: Total Hospital Costs of Surgical Treatment for Adult Spinal Deformity (ASD): An Extended Follow-Up Study**
Ian McCarthy, PhD; Michael F. O'Brien, MD; Christopher P. Ames, MD; Han Jo Kim, MD; Justin S. Smith, MD, PhD; Oheneba Boachie-Adjei, MD; Frank J. Schwab, MD; Eric Klineberg, MD; Christopher I. Shaffrey, MD; Munish C. Gupta, MD; David W. Polly, MD; Richard Hostin, MD; International Spine Study Group
- 11:42-11:50 **Discussion**
- 10:25-11:50 **Concurrent Session C: Complication Series 2 — My Worst Complication and Strategies to Prevent/Manage**
- Room: East 1*
Moderators: Ahmet Alanay, MD and Keith H. Bridwell, MD
- 10:25 – 10:45 **Adult Deformity**
Steven D. Glassman, MD
- 10:45 – 11:05 **Thoracolumbar Trauma**
Jens R. Chapman, MD
- 11:05 – 11:25 **Thoracolumbar Degenerative Disease**
Stephen J. Lewis, MD, MSc, FRCSC
- 11:25 – 11:45 **Pediatric Deformity**
Stefan Parent, MD, PhD
- 11:50 – 12:00 **Walking Break**
- 12:00 – 13:00 **Lunch Break**
- Exhibit Viewing**
Exhibit Hall A
- Member Information Session**
*East Ballroom AB *Please Pick up Lunch in the Exhibit Hall A before proceeding to Ballroom AB*
- Hands-On Workshops with Lunch**
(See “Exhibits and Hands-On Workshops” section on page 193 for more information.)
East 16-19

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Meeting Agenda—Friday, July 12

FRIDAY, JULY 12, 2013

13:00 – 13:10 **Walking Break**

13:10 – 14:10 **Concurrent Roundtable Sessions 3A-D**

3A: Osteoporotic Spine

Room: East 1

Moderator: Henry F.H. Halm, MD

Case Presenters:

13:10 – 13:25 *Manabu Ito, MD, PhD*

13:25 – 13:40 *Tyler Koski, MD*

13:40 – 13:55 *Charles H. Crawford, III, MD*

13:55 – 14:10 *Michael D. Daubs, MD*

3B: Ethical Dilemmas

Room: East 8&15

Moderator: Peter S. Rose, MD

Case Presenters:

13:10 – 13:25 *Kamal N. Ibrahim, MD, FRCS(C), MA*

13:25 – 13:40 *Serena S. Hu, MD*

13:40 – 13:55 *Todd J. Albert, MD*

13:55 – 14:10 *Charles Gregory Fisher, MD, MHSc*

3C: Cervical Trauma

Room: East 11

Moderator: Praveen V. Mummaneni, MD

Case Presenters:

13:10 – 13:25 *Brian K. Kwon, MD, PhD, FRCSC*

13:25 – 13:40 *Vincent Traynelis, MD*

13:40 – 13:55 *Michael G. Fehlings, MD, PhD, FRCSC, FACS*

13:55 – 14:10 *Justin S. Smith, MD, PhD*

3D: My Most Complex and Challenging Case

Room: East 2&3

Moderator: Lawrence G. Lenke, MD

Case Presenters:

13:10 – 13:25 *Se-Il Suk, MD*

13:25 – 13:40 *Daniel J. Sucato, MD, MS*

13:40 – 13:55 *Christopher I. Shaffrey, MD*

13:55 – 14:10 *Keith H. Bridwell, MD*

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Meeting Agenda—Friday, July 12

FRIDAY, JULY 12, 2013

14:10 – 14:20

Refreshment Break

Refreshments available in the South Foyer, East Meeting Level

14:20 – 15:20

Instructional Course Lectures 2A-D

2A: EOS: Clinical Evaluation/Surgical Techniques

Room: East 8&15

Moderator: Peter O. Newton, MD

14:20 – 14:30 **Evaluation and Classification**

Baron S. Lonner, MD

14:30 – 14:40 **Timing of Surgery and Indications for Definitive Fusion**

Suken A. Shah, MD

14:40 – 14:50 **Growing Rod Techniques**

Richard E. McCarthy, MD

14:50 – 15:00 **The Role of VEPTR for EOS**

Muharrem Yazici, MD

15:00 – 15:20 **Discussion**

2B: Adult Deformity II: Surgical Planning & Techniques

Room: East 1

Moderator: Stephen J. Lewis, MD, MSc, FRCSC

14:20 – 14:30 **Techniques to Reduce Blood Loss and Intra-Operative Complications**

Jacob M. Buchowski, MD, MS

14:30 – 14:40 **Anterior, Transposas, Posterior-Only: How to Choose the Best Approach**

Serena S. Hu, MD

14:40 – 14:50 **Planning the PSO Technique to Give the Best Result**

Frank J. Schwab, MD

14:50 – 15:00 **Role for Vertebral Column Resection in Adult Spinal Deformity**

Se-Il Suk, MD

15:00 – 15:20 **Discussion**

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Meeting Agenda—Friday, July 12

FRIDAY, JULY 12, 2013

2C: MIS Approaches for Degenerative Disease

Room: East 2&3

Moderator: Justin S. Smith, MD, PhD

14:20 – 14:30 **Techniques to Maximize Decompression Through an MIS Approach**

Raj Y. Rampersaud, MD, FRCSC

14:30 – 14:40 **Techniques to Maximize Lumbar Lordosis in Degenerative Disease Through an MIS Approach**

Mark B. Dekutoski, MD

14:40 – 14:50 **Role for Transpoas Approach in Degenerative Disease**

Praveen V. Mummaneni, MD

14:50 – 15:00 **Are There Any Limits to Deformity Correction Through MIS Techniques?**

Richard G. Fessler, MD, PhD

15:00 – 15:20 **Discussion**

2D: Management of Spondylolisthesis

Room: East 11

Moderator: B. Stephens Richards, III, MD

14:20 – 14:30 **Surgical Approaches for Degenerative Spondylolisthesis in the Elderly**

Steven M. Mardjetko, MD, FAAP

14:30 – 14:40 **Management of Isthmic Spondylolisthesis in Childhood**

Stefan Parent, MD, PhD

14:40 – 14:50 **Management of Spondylolysis and Low-Grade Spondylolisthesis in the Elite Athlete**

Panagiotis M. Korovessis, MD, PhD

14:50 – 15:00 **How Classification Impacts Treatment of High-Grade Spondylolisthesis**

Hubert Labelle, MD

15:00 – 15:20 **Discussion**

15:20 – 15:30 **Walking Break**

15:30 – 16:30 ***Hands-On Workshops with Beverages, Snacks**

(See "Exhibits and Hands-On Workshops" section on page 193 for more information.)

East 16-19

19:00 – 23:00 **Course Reception**

***Tickets required, Vancouver Convention Center West Ballroom & West Pacific Terrace*

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Meeting Agenda—Saturday, July 13

SATURDAY, JULY 13, 2013

7:00 – 12:15	Registration Open <i>East Convention Lobby</i>
	Exhibits Closed <i>E-Poster and Intern Cafe Open - Exhibit Hall A</i>
7:00 – 7:45	Breakfast <i>South Foyer, East Meeting Level</i>
7:45 – 8:45	Instructional Course Lectures 3A-D
	3A: Management of CSM
	<i>Room: East 11</i>
	<i>Moderator: Benny T. Dahl, MD, PhD, DMSci</i>
7:45 – 7:55	Anterior vs. Posterior Approaches: How to Choose <i>Manabu Ito, MD, PhD</i>
7:55 – 8:05	Do Neuroprotective Agents Have a Role in the Surgical Treatment of CSM (Steroids, Riluzole)? <i>Michael G. Fehlings, MD, PhD, FRCSC, FACS</i>
8:05 – 8:15	Has the Role of Laminoplasty Changed in the Surgical Treatment of CSM? <i>K. Daniel Riew, MD</i>
8:15 – 8:25	The Role for Osteotomies in Patients with Cervical Myelopathy and Deformity <i>Christopher P. Ames, MD</i>
8:25 – 8:45	Discussion
	3B: Management of Metastatic Spine Disease
	<i>Room: East 1</i>
	<i>Moderator: Christopher I. Shaffrey, MD</i>
7:45 – 7:55	The Impact of Tumor Burden and Medical Condition on the Decision to Pursue Surgical Management <i>John C. France, MD</i>
7:55 – 8:05	Role of En Bloc Resection in Metastatic Disease <i>Ziya L. Gokaslan, MD</i>
8:05 – 8:15	Surgical Approach and Role for Instrumentation in Metastatic Spine Disease <i>Morio Matsumoto, MD</i>
8:15 – 8:25	Role for Vertebroplasty and Radiation for Radiosensitive Metastases <i>Charles H. Crawford, III, MD</i>
8:25 – 8:45	Discussion

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Meeting Agenda—Saturday, July 13

SATURDAY, JULY 13, 2013

3C: Emerging Technologies in Spine Surgery

Room: East 2&3

Moderator: Laurel C. Blakemore, MD

7:45 – 7:55 **Emerging Technologies in MIS**
Richard G. Fessler, MD, PhD

7:55 – 8:05 **Emerging Technologies in Spinal Cord Injury**
Brian K. Kwon, MD, PhD, FRCSC

8:05 – 8:15 **Emerging Technologies in Intra-Op Guidance**
David W. Polly, Jr., MD

8:15 – 8:25 **Emerging Technologies in Treatment of Pediatric Deformity**
Michael G. Vitale, MD, MPH

8:25 – 8:45 **Discussion**

3D: Pediatric Deformity: Surgical Planning & Techniques

Room: East 8&15

Moderator: Peter O. Newton, MD

7:45 – 7:55 **How 3D Classification is Changing Surgical Approach**
Peter O. Newton, MD

7:55 – 8:05 **Advances in Treatment of Scheuermann's Kyphosis**
Daniel J. Sucato, MD, MS

8:05 – 8:15 **Advances in Treatment of Neuromuscular Scoliosis**
Paul D. Sponseller, MD

8:15 – 8:25 **Best Techniques for Congenital Scoliosis**
Youssef M.K. El-Hawary, MD

8:25 – 8:45 **Discussion**

8:45 – 9:00 **Walking Break**

9:00 – 10:30 **Concurrent Abstract and Debate Sessions (A-C)**

Concurrent Abstract Session A: Innovative and Diagnostic Methods

Room: East Ballroom AB

Moderators: Amer Samdani, MD and Mark Weidenbaum, MD

9:00-9:04 **Paper #134: A Comparison of SHILLA™ GROWTH GUIDANCE SYSTEM and Growing Rods in the Treatment of Spinal Deformity in Children Less than 10 Years of Age**
Scott J. Luhmann, MD; Richard E. McCarthy, MD

9:04-9:08 **Paper #135: Introduction of Shilla Surgery into Japan: A Report on the First 18 Patients**
Tepei Suzuki; Koki Uno, MD, PhD

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Meeting Agenda—Saturday, July 13

SATURDAY, JULY 13, 2013

- 9:08-9:12 **Paper #136: Hybrid Constructs for the Growing Spine**
Elias Dakwar, MD; Amer F. Samdani, MD; Anuj Singla, MD; Michael Auriemma; Joshua M. Pahys, MD; Randal R. Betz, MD; Patrick J. Cahill, MD
- 9:12-9:19 **Discussion**
- 9:19-9:23 **Paper #137: Are Complications in Adult Spinal Deformity (ASD) Surgery Related to Approach or Patient Characteristics? A Prospective Propensity Matched Cohort Analysis of Minimally Invasive (MIS), Hybrid (HYB), and Open (OPEN) Approaches**
Juan S. Uribe, MD; Gregory M. Mundis, MD; David O. Okonkwo, MD, PhD; Adam S. Kanter, MD; Robert K. Eastlack, MD; Michael Y. Wang, MD; Praveen V. Mummaneni, MD; Neel Anand, MD; Richard G. Fessler, MD, PhD; Frank La Marca, MD; Paul Park, MD; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Vedat Deviren, MD; International Spine Study Group
- 9:23-9:27 **Paper #138: Predictors of Early Postoperative Discharge Following Minimally Invasive Lateral Interbody Fusion (MI-LIF)**
William B. Rodgers, MD; Edward J. Gerber, PA-C; Jeffrey A. Lehmen, MD; Jody A. Rodgers, MD, FACS
- 9:27-9:31 **Paper #139: Pedicle Screw Insertion with a Cortical Bone Trajectory (CBT): Is it a Less Invasive Alternative to a Traditional Trajectory?**
Takashi Kaito, MD, PhD; Hiroyasu Fujiwara, MD; Takahiro Makino; Kazuo Yonenobu, MD, DMSc
- 9:31-9:38 **Discussion**
- 9:38-9:42 **Paper #140: What is the Impact of Adding 3D Information to Pre-Operative Fusion Level Determination?**
Stefan Parent, MD, PhD; Jean-Marc Mac-Thiong, MD, PhD; Kariman Abelin-Genevois, MD, MSc; Ibrahim Obeid; Jacques Griffet, MD, PhD; Keyvan Mazda; Tamás Illés; Isabelle Turgeon, BSc; Marjolaine Roy-Beaudry, MSc
- 9:42-9:46 **Paper #141: Single Institution Results of Anterior Vertebral Body Tethering for Immature Idiopathic Scoliosis**
Amer F. Samdani, MD; Robert J. Ames, BA; Joshua M. Pahys, MD; Jeff S. Kimball; Harsh Grewal, MD, FACS, FAAP; Glenn J. Pelletier, MD; Randal R. Betz, MD
- 9:46-9:50 **Paper #142: The Use of Suspension Radiographs to Predict LIV Tilt**
Hanneke van West, MD; Jean-Marc Mac-Thiong, MD, PhD; Hubert Labelle, MD; Diane Moulin, B. Ing; Isabelle Turgeon, BSc; Marjolaine Roy-Beaudry, MSc; Nathalie Bourassa; Yvan Petit, PhD; Stefan Parent, MD, PhD
- 9:50-9:54 **Paper #143: Geometric Torsion in AIS: a New Method to Differentiate Between Lenke 1 Sub-Types**
Jesse Shen; Samuel Kadoury; Hubert Labelle, MD; Marjolaine Roy-Beaudry, MSc; Carl-Éric Aubin, PhD, PEng; Stefan Parent, MD, PhD
- 9:54-10:01 **Discussion**
- 10:01-10:05 **Paper #144: An Expandable Crescent Shaped TLIF Cage to Improve Segmental Lordosis: Safety, Efficacy, and Early Clinical Outcomes**
Dennis Crandall, MD; J. Abbott Byrd, MD; Sigurd H. Berven, MD; Neel Anand, MD; Murali P. Kadaba, PhD, MBA; Jan Revella, RN; Lynette Taylor
- 10:05-10:09 **Paper #145: Anterior Column Realignment (ACR) has Similar Results to Pedicle Subtraction Osteotomy (PSO) in Treating Adults with Sagittal Spinal Deformity: A Multi-Center Study**
Gregory M. Mundis, MD; Behrooz A. Akbarnia, MD; Nima Kabirian, MD; Jeff Pawelek; Robert K. Eastlack, MD; Christopher I. Shaffrey, MD; Eric Klineberg, MD; Shay Bess, MD; Christopher P. Ames, MD; Vedat Deviren, MD; Virginie Lafage, PhD; International Spine Study Group

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Meeting Agenda—Saturday, July 13

SATURDAY, JULY 13, 2013

- 10:09-10:13 **Paper #146: Apical Short-Segment Correction in Adolescent Idiopathic Scoliosis: A Multi-Center Study of a New Innovative Posterior Technique**
Martin Repko, PhD; Ufuk Aydinli; Lubos Rehak, MD; Michael Grevitt, FRCS(Orth); Martin Zabka, MD; Burak Akesen, MD; Colin Nnadi, FRCS(Orth); William Klemme; Allen L. Carl, MD; Behrooz A. Akbarnia, MD
- 10:13-10:17 **Paper #147: Does Minimally Invasive Posterior Instrumentation (PPI) Prevent Proximal Junctional Kyphosis (PJK) in Adult Spinal Deformity (ASD) Surgery? A Prospectively Acquired Propensity Matched Cohort Analysis**
Praveen V. Mummaneni, MD; Michael Y. Wang, MD; Virginie Lafage, PhD; John Ziewacz, MD, MPH; Jamie S. Terran, BS; David O. Okonkwo, MD, PhD; Juan S. Uribe, MD; Neel Anand, MD; Richard G. Fessler, MD, PhD; Adam S. Kanter, MD; Frank La Marca, MD; Christopher I. Shaffrey, MD; Vedat Deviren, MD; Gregory M. Mundis, MD; International Spine Study Group
- 10:17-10:25 **Discussion**

9:00-10:30

Concurrent Abstract Session B: Two-Minute Point Presentations

Room: East 1

Moderators: Douglas C. Burton, MD
 Jacob M. Buchowski, MD, MS

- 9:00-9:02 **Paper #148: Muscular Volume and Fat Infiltration Parameters of the Spino-Pelvic Complex Correlate with HRQOL and Skeletal Malalignment in Adult Spinal Deformity**
Bertrand Moal, MS; Nicolas Bronsard, MD, PhD; Jamie S. Terran, BS; Jose G. Raya; Themistocles S. Protopsaltis, MD; Jean-Marc Vital; Wafa Skalli, PhD; Frank J. Schwab, MD; Virginie Lafage, PhD
- 9:02-9:04 **Paper #149: Clinical Results and Functional Outcome of Revision Surgery for Symptomatic Proximal Junctional Kyphosis in Adult Spinal Deformity**
Haruki Funao, MD; Floreana Naef, MD; Khaled Kebaish, MD
- 9:04-9:06 **Paper #150: Clinical Results and Functional Outcome of Revision Surgery for Distal Junctional Kyphosis in Adult Spinal Deformity Patients**
Haruki Funao, MD; Floreana Naef, MD; Khaled Kebaish, MD
- 9:06-9:08 **Paper #151: Does Pelvic Fixation Decrease the Incidence of Pseudoarthrosis and Proximal Junctional Kyphosis (PJK) in Long Fusion Constructs? Long-Term Follow-Up of 139 Adult Patients**
Joseph K. Lee, MD; Mark F. Kurd, MD; Kasra Ahmadinia; Steven J. Fineberg, MD; Christopher DeWald, MD
- 9:08-9:10 **Paper #152: Extension of Spine Fusion to the Sacrum Following Long Fusions for Deformity Correction**
Kevin R. O'Neill, MD, MS; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Michael P. Kelly, MD; Tapanut Chuntarapas; Ian G. Dorward, MD; Brian J. Neuman, MD; Azeem Ahmad, BA, BS; Christine Baldus, RN, MHS
- 9:10-9:12 **Paper #153: Improving Local and Regional Lordosis in Degenerative Scoliosis: Preliminary Findings on the Effect of an Expandable TLIF Cage**
Dennis Crandall, MD; Lynette Taylor; J. Abbott Byrd, MD; Sigurd H. Berven, MD; Neel Anand, MD; Murali P. Kadaba, PhD, MBA; Jan Revella, RN
- 9:12-9:23 **Discussion**
- 9:23-9:25 **Paper #154: Validation of the Fusion Risk Score: Predictor for the 90 Day Perioperative Complication Rate**
Kedar Deogaonkar, MD, FRCS; Amir A. Mehbod, MD; Ensor E. Transfeldt, MD

† = Whitecloud Award Nominee — Best Clinical Paper * = Whitecloud Award Nominee — Best Basic Science Paper

Meeting Agenda—Saturday, July 13

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- 9:25-9:27 **Paper #155: Clinical Decision Making in Early Wound Drainage After Pediatric Spine Surgery**
Ozgur Dede, MD; Austin Bowles, MS; James W. Roach, MD; W. Timothy Ward, MD; Patrick Bosch, MD
- 9:27-9:29 **Paper #156: Neurologic Risks Associated with Treating Myelopathy due to Severe Spinal Deformity with Vertebral Column Resection**
Terrence F. Holekamp, MD, PhD; Lawrence G. Lenke, MD; Jakub Godzik; Sam Q. Sun, BS; Ian G. Dorward, MD; Kevin R. O'Neill, MD, MS; Linda Koester, BS; Michael P. Kelly, MD
- 9:29-9:31 **Paper #157: Perioperative Morbidity and Mortality in High Risk Pediatric Patients with Severe Restrictive Lung Disease Undergoing Posterior-Only Spine Deformity Surgery**
Brian J. Neuman, MD; Lawrence G. Lenke, MD; Brenda A. Sides, MA; Keith H. Bridwell, MD; Ian G. Dorward, MD; Kevin R. O'Neill, MD, MS; Sang D. Kim, MD, MS
- 9:31-9:33 **Paper #158: Venous Thromboembolic Events in Spine Surgery Patients: Which Patients are High Risk?**
Vadim Goz, BA; Jeffrey H. Weinreb, BS; Kai Dallas; John A. Bendo, MD; Virginie Lafage, PhD; Thomas J. Errico
- 9:33-9:35 **Paper #159: Wound Complications of VEPTR Incisions**
Sumeet Garg, MD; Jaren LaGreca; Tricia St. Hilaire, MPH; Dexiang Gao, PhD; Michael Glotzbecker, MD; Ying Li, MD; John T. Smith, MD; John M. Flynn, MD
- 9:35-9:45 **Discussion**
- 9:45-9:47 **Paper #160: Role of Weekly Administered Teriparatide in Bony Union Enhancement After Posterior Lumbar Interbody Fusion for Osteoporosis-Associated Lumbar Degenerative Deformity: A Prospective, Randomized Multi-Center Study**
Hirotaaka Haro, MD; Jun Takahashi, MD; Yukihiko Matsuyama, MD
- 9:47-9:49 **Paper #161: Re-Operation Rates in the Surgical Treatment of Metastatic Spinal Cord Compression**
Nasir A. Quraishi, FRCS; Sakhthivel Rajan Rajaram Manoharan; Ash Khurana; Kimberley L. Edwards, PhD; Hossein Mehdian, MD, MS(Orth) FRCS(Ed); Broniek M. Boszczyk, DM
- 9:49-9:51 **Paper #162: Suitability of Stand-Alone ALIF as Replacement for Supplemental Posterior Fixation in Long Fusion Constructs**
Jeremi M. Leasure, MSME; Morsi Khashan, MD; William Camisa, MSME; Hooman M. Melamed, MD; Sigurd H. Berven, MD
- 9:51-9:53 **Paper #163: The Effect of Sagittal Alignment on Standing Balance: Correlation with Sway Path Length and Sway Velocity**
Sergio A. Mendoza-Lattes, MD; Monica Paliwal; Christopher Graves, MD, MS; Bethany Harpole, BS; Rachel C. Nash, BS
- 9:53-9:55 **Paper #164: Global Tilt: A New Sagittal Plane Parameter Combining Spinal Balance and Pelvic Compensatory Mechanisms**
Ibrahim Obeid; Virginie Lafage, PhD; Ahmet Alanay; Jean M. Vital; Olivier Gille; Anouar Bourghli, MD
- 9:55-9:57 **Paper #165: Revision Rate Following Thoracolumbar Fusion for Adult Deformity: Upper Versus Lower Thoracic UIV**
Prokopis Annis, MD; Brandon Lawrence, MD; Michael D. Daubs, MD; Darrel S. Brodke, MD
- 9:57-10:07 **Discussion**
- 10:07-10:09 **Paper #166: Short-Term Mortality and Morbidity after Surgical Treatment of Fixed Spinal Deformities. Two-Years Experience in 102 Adult Patients**
Benny Dahl, MD, PhD, DMSci; Tanvir Bari; Sven Karstensen; Sidsel S. Fruergaard; Martin Gehrchen, MD, PhD

† = Whitecloud Award Nominee – Best Clinical Paper * = Whitecloud Award Nominee – Best Basic Science Paper

Meeting Agenda—Saturday, July 13

SATURDAY, JULY 13, 2013

- 10:09-10:11 **Paper #167: Adult Spinal Deformity (ASD) Patients have Distinct Baseline Characteristics based on Idiopathic Versus Degenerative Scoliosis Types**
Han Jo Kim, MD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Vedat Deviren, MD; Justin S. Smith, MD, PhD; Matthew E. Cunningham, MD, PhD; Shay Bess, MD; Richard Hostin, MD; Khaled Kebaish, MD; Christopher P. Ames, MD; International Spine Study Group
- 10:11-10:13 **Paper #168: Long-Term Radiographic Outcomes of a Central Hook-Rod Construct for Osteotomy Closure: Minimum 5-Year Follow-Up**
Seung-Jae Hyun, MD; Lawrence G. Lenke, MD; Linda Koester, BS
- 10:13-10:15 **Paper #169: Is There a Patient Profile That Characterizes a Patient as a Candidate for Minimally Invasive Surgery (MIS) to Treat Adult Spinal Deformity (ASD)?**
Robert K. Eastlack, MD; Gregory M. Mundis, MD; Michael Y. Wang, MD; Praveen V. Mummaneni, MD; Juan S. Uribe, MD; David O. Okonkwo, MD, PhD; Behrooz A. Akbarnia, MD; Neel Anand, MD; Adam S. Kanter, MD; Paul Park, MD; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Richard G. Fessler, MD, PhD; Vedat Deviren, MD; International Spine Study Group
- 10:15-10:17 **Paper #170: Reoperation Rate After Surgery for Lumbar Herniated Intervertebral Disc Disease: Nationwide Cohort Study**
Chi Heon Kim, MD, PhD; Chun Kee Chung, MD, PhD
- 10:17-10:19 **Paper #171: Bending the Cost Curve in Spinal Surgery**
Melissa Esparza; Sigurd H. Berven, MD; Serena S. Hu, MD; Todd J. Lansford, MD
- 10:19-10:30 **Discussion**

9:00-10:30

Concurrent Session C: Debate Session 3

Room: East Ballroom C

Moderators: Manabu Ito, MD, PhD and Shay Bess, MD

9:00 – 9:30 **Debate 1: Thoracolumbar Fractures Without Neurological Deficits are Best Treated with MIS Techniques**

Pro: Mark B. Dekutoski, MD

Con: John C. France, MD

9:30 – 10:00 **Debate 2: Multilevel Spinal Stenosis with Spondylolysis is Best Treated with an MIS Approach**

Pro: Richard G. Fessler, MD, PhD

Con: Serena S. Hu, MD

10:00 – 10:30 **Debate 3: Is BMP Needed for Satisfactory Results in Adult Deformity Surgery?**

Pro: Keith H. Bridwell, MD

Con: Sigurd H. Berven, MD

10:30 – 10:45

Refreshment Break

Refreshments available in Exhibit Hall A

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10:45 – 12:15 Concurrent Abstract Sessions and Complications Series (A-B)

Concurrent Abstract Session A: Kyphosis/Congenital/Neuromuscular Deformity

Room: East Ballroom AB

Moderators: Shay Bess, MD and Youssry M.K. El-Hawary, MD

- 10:45-10:49 **Paper #172: Hemivertebra Resection via Posterior Approach in Children Under Age of Five Years with More than Five Years Follow-Up**
Sinan Kahraman; Meric Enercan; Gurkan Gumussuyu, MD; Bekir Y. Uçar, MD; Cagatay Ozturk, MD; Azmi Hamzaoglu, MD
- 10:49-10:53 **Paper #173: Safety and Efficacy of Osteotomy for Congenital Spinal Deformity Associated with Split Spinal Cord Malformation**
Ding-Jun Hao, MM; Hua Hui; Bao-Rong He, MM
- 10:53-10:57 **Paper #174: Management of Thoracic Insufficiency Syndrome in Patients with Myelomeningocele Using Vertical Expandable Prosthetic Titanium Rib**
Vishwas Patil, MD; William Koeck; Kent Reinker, MD; Davin Cordell, MD; Hope Trevino, AA; Megan K. Roth, PhD; James W. Simmons, DO, PhD; Robert M. Campbell, MD; Ajeya P. Joshi, MD
- 10:57-11:04 **Discussion**
- 11:04-11:08 **Paper #175: What is the Anticipated U.S. Cost of Pedicle Screws Versus Luque Wire Instrumentation for Neuromuscular Scoliosis Surgery?**
A. Noelle Larson, MD; Charles Gerald T. Ledonio, MD; David W. Polly, MD; Suken A. Shah, MD; Scott J. Luhmann, MD
- 11:08-11:12 **Paper #176: Single Stage Internal Distraction for the Correction of Pelvic Obliquity**
Jahangir Asghar, MD; Amer F. Samdani, MD; Harry L. Shufflebarger, MD; Burt Yaszay, MD; Paul D. Sponseller, MD
- 11:12-11:16 **Paper #177: Hybrid Fixation with Sublaminar Polyester Bands in the Treatment of Neuromuscular Scoliosis: A Comparative Analysis**
Michael C. Albert, MD; Brett LaFleur, MD
- 11:16-11:23 **Discussion**
- 11:23-11:27 **Paper #178: Biomechanical Analysis of the Proximal Adjacent Segment After Scoliosis Correction: Do Hooks Ease the Transition?**
Melodie F. Metzger, PhD; Samuel T. Robinson, BS; Doniel Drazin, MD; Mark T. Svet; Rick B. Delamarter, MD; Frank L. Acosta, MD
- 11:27-11:31 **Paper #179: Posterior Three Column Spinal Osteotomies for Severe Pediatric Deformities: Comparison Between Revision and Primaries**
Stephen J. Lewis, MD; James G. Jarvis, MD; Marc R. Lipkus, BS; David E. Lebel, MD, PhD; Ilyas Aleem, MD
- 11:31-11:35 **Paper #180: The Efficacy and Complications of Posterior Surgical Correction with Transpedicular Instrumentation of Congenital Kyphosis: More than 2 Years Follow-Up.**
Zhang Jianguo, MD
- 11:35-11:39 **Paper #181: Long-Term Outcome of Laminectomy for Cervical Ossification of the Posterior Longitudinal Ligament**
Chun Kee Chung, MD, PhD; Soo Eon Lee, MD; Tae-Ahn Jahng, MD, PhD; Hyun-Jib Kim
- 11:39-11:46 **Discussion**

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- 11:46-11:50 **Paper #182: Proximal Junctional Kyphosis (PJK) is a Common Feature in Scheuermann's Kyphosis Treated with Pedicle Screw Instrumentation**
Preethi M. Kulkarni, MD; Terry D. Amaral, MD; Abhijit Pawar, MD; Adam L. Wollowick, MD; Yungtai Lo, PhD; Vishal Sarwahi, MD
- 11:50-11:54 **Paper #183: Prediction of Sagittal Balance in Patients with Osteoporosis Using Spinopelvic Parameters**
Jung Sub Lee, MD, PhD; Jong Ki Shin; Tae Sik Goh
- 11:54-11:58 **Paper #184: The Change of Aortic Length After Closing-Opening Wedge Osteotomy for Ankylosing Spondylitis Patients with Thoracolumbar Kyphosis: A Computed Tomography Study**
Jun Jiang; Mingliang Ji, PhD; Bangping Qian; Qiu Yong, MD; Wang Bin; Yu Yang; Zhu Ze-zhang, Xu Sun, MD, PhD
- 11:58-12:02 **Paper #185: The Impact of Posterior Corrective Surgery on Pulmonary Function and Thoracic Volume in Kyphosis Patients**
Zhongqiang Chen, MD; Yan Zeng, MD; Zhaoqing Guo, MD; Desi Ma, MD
- 12:02-12:10 **Discussion**

10:45-12:15 **Concurrent Session B: Complication Series 3—My Worst Complication and Strategies to Prevent/Manage**

Room: East Ballroom C

Moderators: Kamal N. Ibrahim, MD, FRCS(C), MA and Christopher I. Shaffrey, MD

10:45 – 11:07 **Cervical Degenerative Disease**
Todd J. Albert, MD

11:07 – 11:29 **Adult Degenerative (MIS)**
Richard G. Fessler, MD, PhD

11:29 – 11:53 **Lumbar Degenerative Disease**
Benny T. Dahl, MD, PhD, DMSci

11:53 – 12:15 **Pediatric Deformity**
Peter O. Newton, MD

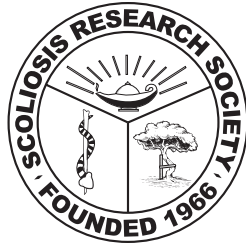
12:15 **Adjourn**

**denotes non-CME session*

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Paper Abstracts





The Scoliosis Research Society gratefully acknowledges Orthofix
for support of the IMAST E-Newsletter and Internet Kiosks.



Podium & Point Presentation Abstracts

1. A Prospective, Randomized Clinical Investigation of the PCM Cervical Disc: Five-Year Results from US IDE Study

Frank M. Phillips, MD; Kye Gilder, PhD; Kelli M. Howell, MS; Fred H. Geisler, MD, PhD; Christopher D. Chaput, MD; John G. DeVine, MD; Christopher J. Reah, PhD; Paul C. McAfee, MD, MBA

USA

Summary: First presentation of long-term (5-year) results from US FDA IDE clinical trial of PCM® Cervical Disc versus anterior cervical discectomy and fusion (ACDF) with allograft and plate.

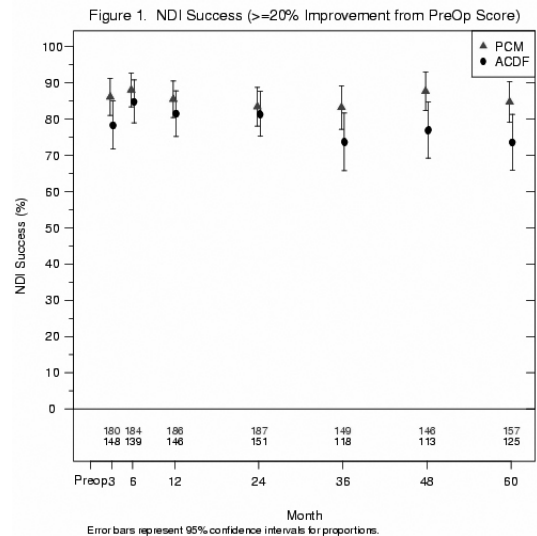
Introduction: PCM Cervical Disc is a newly FDA-approved non-constrained device.

Methods: Prospective, randomized, multi-center, IRB-approved clinical trial evaluating longitudinal outcomes over 5 years comparatively between arthroplasty and fusion groups. Patients (pts) 18-65 years of age with degenerative disc disease at one level between C3 and T1 with neurologic symptoms 404 pts treated (214 PCM, 190 ACDF). Patient sample at 5 yrs included 160 PCM pts and 124 ACDF pts. Outcomes measures included neck disability index (NDI), neurological success, overall success (composite primary endpoint), range of motion (ROM), and rate of secondary surgeries at operative level (revisions, reoperations, removals, supplemental fixation). NDI success is defined as a minimum 20% improvement over baseline. Neurological success defined as maintenance or improvement in neurological status over baseline.

Results: At 5 yrs, mean NDI score was 20.4 in PCM group compared to 28.5 in ACDF group (p=0.001). Mean reduction in NDI score from baseline was 34.4 in PCM compared to 26.8 in ACDF (p=0.003). NDI success achieved in 84.7% (133/157) of PCM pts compared to 73.6% (92/125) in ACDF pts (p=0.025). Neurological success achieved in 92.1% (140/152) of PCM and 88.2% (105/119) of ACDF (p=0.305). Mean ROM averaged 5.3° (range 0-16.1) for PCM and 0.5° (range 0-4.1) for controls. In both groups, adjacent level ROM was generally consistent with 2-, 3-, and 4-year results. Overall success achieved in 66.9% (107/160) of PCM and 57.3% (71/124) of ACDF (p=0.108). Of treated pts, secondary surgeries at operative level (only reoperations and removals observed) performed on 7.9% (17/214) of the PCM pts and 7.4% (14/190) of the controls (p=0.854).

Conclusion: PCM Cervical Disc maintained motion and continued to achieve clinical outcomes at least equivalent to ACDF. At 5 yrs, pts who received PCM device had statistically higher mean reduction from baseline in NDI and statistically higher rate of NDI success. NDI measures were either stable or improved for PCM at 3, 4, and 5 yrs, whereas control group were either stable or

slightly degraded. Neurological success and rate of secondary surgeries were similar. Overall success favored PCM, but rates were not statistically different.



2. Laminoplasty Versus Laminectomy and Fusion to Treat Cervical Spondylotic Myelopathy: Outcomes of the Prospective Multi-Center AOSpine International CSM Study

Michael G. Fehlings, MD, PhD; Branko Kopjar; Helton L. Defino, MD; Giuseppe Barbagallo; Ronald H. Bartels, MD, PhD; Paul Arnold; Mehmet Zileli, MD; Gamaliel Tan, MBBS; Yasutsugu Yukawa, MD; Massimo Scerrati, Ancona; Tomoaki Toyone, MD, PhD; Qiang Zhou, PhD

Canada

Summary: Laminoplasty vs Laminectomy and Fusion to Treat Cervical Spondylotic Myelopathy: Outcomes of the Prospective multi-center AOSpine International CSM Study

Introduction: The optimal posterior surgical approach to treat cervical spondylotic myelopathy (CSM) remains debated with varying opinions favoring laminectomy and fusion vs laminoplasty. To address this controversy, we present an analysis of a prospective observational multi-center study examining outcomes of surgical treatment for CSM.

Methods: Subjects included were a part of a larger ongoing prospective observational study that has enrolled 492 subjects with CSM involving 16 clinical sites in Europe, Asia, North and South America. Of those, 108 received laminectomy and fusion; 66 received laminoplasty. The choice of surgical approach was at the discretion of the surgeon. Outcome measures were the Modified Japanese Orthopedic Assessment Scale (mJOA), the Nurick scale, the Neck Disability Index (NDI) and the SF36 Physical (PCS) and Mental (MCS) Component Scores.

Results: Average age was 60.2 years (SD 10.8), 29.8% were female. Subjects treated with laminectomy and fusion had more levels operated (5.0 versus 4.4,

Podium & Point Presentation Abstracts

$P < .01$), shorter length of stay (7.7 versus 15.7 days, $P < .01$) and, less severe neurologic impairment measured by mJOA (12.6 versus 11.2, $P < .01$). There were no differences in age, and baseline NDI, SF36v2 PCS and SF36v2 MCS. At 12 month follow-up, there were no differences in neurologic and functional outcomes for laminoplasty compared to laminectomy and fusion; mJOA (3.0 and 2.3, respectively, $P=0.15$). Moreover, there were no differences in NDI (13.3 and 12.0, respectively, $P=0.71$), SF-36v2 PCS (8.5 and 7.7, respectively, $P=0.66$) and SF-36v2 MCS (7.9 and 6.9, respectively, $P=0.56$).

Conclusion: Patients undergoing laminectomy and fusion and laminoplasty surgery for CSM show similar improvements in generic and disease specific outcome measures allowing for baseline differences in clinical presentation between the two groups of patients. Longer term follow-up will be required to determine whether any differences in outcome between the two forms of treatment emerge.

3. The Clinical, Functional, and Occupational Outcomes of Smokers Versus Non-Smokers Undergoing Spinal Arthrodesis: Diagnosis Related Results

Dennis Crandall, MD; Jan Revella, RN; Kurt Crandall; Michael S. Chang, MD USA

Summary: Clinical, functional, and occupational data on 956 consecutive adults who underwent primary or revision spinal fusion were reviewed comparing 133 smokers vs 823 nonsmokers. Diagnoses were evenly divided between deformity, degenerative, and spondylolisthesis. 47% had undergone prior lumbar surgery. Both smokers and nonsmokers improved VAS and ODI scores and returned to work in similar numbers. Primary vs revision surgery was a more reliable predictor of outcomes after spinal arthrodesis than smoking.

Introduction: Smoking has been linked with nonunions after spinal fusion and inferior clinical results after laminectomy. BMP has been shown to overcome the negative effect of smoking on fusion. Little is known about the clinical, functional, and occupational outcomes after spine fusion in smokers versus nonsmokers, by diagnosis.

Methods: Retrospective review of 956 consecutive adults who underwent primary or revision spinal fusion, 133 smokers(S) vs 823 nonsmokers(NS); 47% had undergone prior lumbar surgery. Diagnoses: Deformity-304, spondylolisthesis-332, degenerative-320. Age: 60.5(18-90); All had posterior fusion- 5.1 levels(2-17); ALIF in 137patients- 4.2 levels(1-13), TLIF in 712patients- 1.7 levels(1-4). BMP was used in 756 patients. Work status was divided into light/medium/heavy by lifting requirements. Clinical, occupational, and radiographic results recorded preop, 1yr, 2yrs, and latest.

Results: At 5 years follow-up (2-9 years): Nonunions: S- 8(6.0%), NS- 28(3.4%); Infections: S-6(4.5%), NS- 21(2.6%). Significant clinical improvement ($p < 0.05$) was noted for both S and NS for all diagnoses, primary and revision surgery, but no difference S vs NS. VAS: S preop- 7.0, 2yr- 4.0; NS preop- 6.2, 2yr- 3.5. ODI: S preop- 54.2, 2yr- 35.8; NS preop- 48.5, 2yr- 30.4. Returned to work

was similar: primary surgery: S-26/31(84%), NS-128/175(73%); revision surgery: S-16/29(55%), NS-72/118(61%). Patients undergoing primary surgery had lower preop and 2 year VAS and ODI scores than patients undergoing revision surgery, regardless of smoking status.

Conclusion: Whether a patient undergoes primary or revision spine surgery is more important in predicting clinical, functional, and occupational outcomes than smoking. Fusion rates are still better in nonsmokers, though not significantly.

4. Surgical Treatment of Pathological Loss of Lumbar Lordosis (Flatback) in the Setting of Normal Sagittal Vertical Axis (SVA) Achieves Similar Clinical Improvement as Surgical Treatment for Elevated SVA

Manish Singh, MD; Justin S. Smith, MD, PhD; Eric Klineberg, MD; Christopher I. Shaffrey, MD; Virginia Lafage, PhD; Frank J. Schwab, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Vedat Deviren, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group USA

Summary: Severe disability is associated with elevated sagittal vertical axis (SVA>5cm), however disability and treatment response for patients with flat back deformity (pelvic incidence-lumbar lordosis mismatch; PI-LL >10°) and normal SVA is underappreciated. Comparison of surgically treated adult spinal deformity patients demonstrated isolated flat back deformity correction resulted in similar radiographic and health-related quality of life improvements as patients treated for elevated SVA. Evaluation of sagittal malalignment should extend beyond measuring SVA. PI-LL mismatch can be considered a primary surgical indication.

Introduction: Increased sagittal vertical axis (SVA) correlates strongly with pain and disability in adult spinal deformity (ASD). A subset of patients with sagittal spinopelvic malalignment (SSM) have flat back deformity (pelvic incidence-lumbar lordosis mismatch; PI-LL>10°) but remain sagittally compensated with normal SVA. Few data exist for SSM patients with flat back deformity and normal SVA. Purpose: compare baseline disability and treatment outcomes for patients with compensated versus decompensated SSM.

Methods: Multi-center, prospective, analysis of consecutive ASD patients surgically treated for SSM. Inclusion criteria: ASD, age>18, min 1-yr follow-up. SSM patients divided into two groups: 1) decompensated SSM (DECOMP) = SVA>5cm, 2) compensated SSM (COMP)= SVA <5cm and PI-LL >10°. Baseline and 1-yr follow-up radiographic and HRQL outcomes evaluated.

Results: 125 patients met inclusion criteria (DECOMP=98, COMP=27). DECOMP was older (63 vs 55 yrs, $p=0.004$), had less scoliosis (36° vs 51°, $p=0.002$), poorer HRQL (ODI, SF-36 PCS, SRS-22 total), greater SVA (12 vs 1.8cm), and greater PI-LL (27° vs 21°) than COMP, respectively ($p < 0.05$). Both groups had improved postop SVA (DECOMP=4.8cm, COMP= -1.1cm; $p < .005$) and improved postop PI-LL (DECOMP= 5°, COMP= 5°; $p < 0.001$). Both groups improved in all HRQL measures ($p < 0.005$). Magnitude of HRQL improvement and

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proportion achieving MCID was similar for both groups.

Conclusion: Significant disability occurs in decompensated SSM patients with elevated SVA, however, the amount of disability in compensated SSM patients with flat back deformity due to PI-LL mismatch but normal SVA is underappreciated. Surgical correction of SSM for both DECOMP and COMP demonstrated similar radiographic and HRQL improvements in both groups. Evaluation of SSM should extend beyond measuring SVA. PI-LL mismatch must be evaluated for SSM patients and can be considered a primary surgical indication.

5. Convex Instrumented Hemiepiphyodesis with Concave Distraction: A New Treatment Modality for Long Sweeping Congenital Curves

Gokhan H. Demirkiran, MD; Ozgur Dede, MD; Mehmet Ayyaz, MD; Ahmet Alanay, MD; Muharrem Yazici, MD
Turkey

Summary: The convex growth arrest (CGA) procedure has been well accepted for treatment of congenital scoliosis. Convex instrumented hemiepiphyodesis with concave distraction resulted in good curve correction while maintaining the growth of thorax. This procedure may obviate the need for osteotomies and long fusions in young children with long sweeping thoracic deformities involving multiple anomalous vertebra

Introduction: The CGA procedure has been well accepted for treatment of congenital scoliosis as it is a simpler procedure with successful results. However, unpredictability of curve behavior, slow and usually inadequate correction, and necessity of anterior surgery for completeness of the epiphyodesis are its shortcomings. The purpose of this study was to report the results and complications of an instrumented convex growth arrest procedure modified with concave distraction

Methods: We retrospectively reviewed 11 patients with long sweeping congenital curves who underwent the procedure. Convex instrumented hemiepiphyodesis with pedicle screws was applied to the anomalous segments, and a concave distraction rod was added spanning the whole deformity. Mean age at index operation was 58 months (29-101 months). The patients underwent concave distractions every 6 months. The magnitude of coronal and sagittal deformity and T1-T12 height were measured on the pre-operative, immediate post-operative and most recent follow-up radiographs. Average follow-up was 31 months

Results: In the coronal plane, the convex hemiepiphyodesis segment was corrected from an average of 60.5 degrees to 40.4 postoperatively and was further improved to 27.6 at the latest follow-up. The distracted segment was corrected from 33.4 degrees to 15.2 postoperatively and to 14.7 at the latest follow-up. Sagittal plane alignment was minimally affected from the procedure. The average T1-T12 height was 158.1mm in the early postoperative period and 171mm at last follow-up. During follow-up we identified partial pull-out of screws on the distraction side in 5 of the eleven patients and rod breakages in 3 patients. These were revised at the time of planned lengthenings. There were no unplanned

surgeries, deep wound infections nor neurologic complications.

Conclusion: Convex instrumented hemiepiphyodesis with concave distraction resulted in good curve correction while maintaining the growth of thorax. The correction of the anomalous segment improved over time, proving the effectiveness of the hemiepiphyodesis. We believe that concave distraction enhances the growth of the anomalous segment, thereby augmenting the hemiepiphyodesis effect.

6. Comparison of Radiographic Results After Minimally Invasive (MIS), Hybrid (HYB) and Open (OPEN) Surgery for Adult Spinal Deformity (ASD): A Multi-Center Study of 184 Patients

Raqeeb Haque, MD; Gregory M. Mundis, MD; Yousef M. Ahmed, BS; Tarek Y. El Ahmadieh, MD; Michael Y. Wang, MD; Praveen V. Mummaneni, MD; Juan S. Uribe, MD; David O. Okonkwo, MD, PhD; Neel Anand, MD; Adam S. Kanter, MD; Frank La Marca, MD; Virginie Lafage, PhD; Jamie S. Terran, BS; Vedat Deviren, MD; Richard G. Fessler, MD, PhD; International Spine Study Group
USA

Summary: MIS techniques are gaining momentum in their application in ASD surgery. Much scrutiny exists with regard to MIS techniques and their ability to correct ASD. Radiographically, there was significant improvement of the lumbar coronal curve in MIS patients, and improvement of lumbar lordosis and SVA to within normal range (data not statistically significant). Pelvic tilt did not change. Clinically, the three patient populations showed improvement in clinical outcomes as measured by VAS/ODI.

Introduction: Treatment strategies for adult spinal deformity (ASD) include OPEN surgical techniques, and more recently, MIS applications with retroperitoneal lateral interbody fusion (LLIF) and MIS TLIF. We compared these techniques specifically targeting how radiographic parameters were affected.

Methods: Retrospective review of 2 prospective databases (MIS n=75; OPEN n=109) that were stratified into 3 groups: 1) cMIS (n=42) patients with LLIF or MIS TLIF and MIS pedicle screws; 2) HYB (n=33)- LIF with open posterior surgery and; 3) OPEN (n=109). Inclusion criteria: coronal Cobb > 20°, age > 45 yrs, and minimum 1 yr Follow-Up. Paired, Unpaired t-tests and ANOVA was used to compare groups.

Results: (See table) MIS (63.9) and HYB(63.4y) were older than OPEN(60.4y, p=0.0001). Patients were 84.2% female. MIS had smaller preop (32.1°) and postop lumbar curves (13.1°) than OPEN (43.2° to 20.4°) and HYB (44.3° to 17.7°) (p<0.05). HYB had more lumbar curve correction (26.6°) than MIS (18.8°, p=0.045). Preop lumbar lordosis (LL) was less in MIS (33.8) and HYB (31.9) than OPEN (42.7, p=0.025, p=0.010). Postop LL was less in MIS (39.4) than either HYB (48.5) or OPEN (53.2, p=0.0001). Preoperative PI-LL was smaller for OPEN (12.3) than MIS(21.6) and HYB(22.03, p=0.018, 0.026). Postop PI-LL for OPEN(2.00) and HYB(2.13) were smaller than MIS (p=0.0001, 0.001). The change in PI-LL was larger for HYB (20.6) than OPEN(10.2) and

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MIS (5.5, $p=0.023$, 0.003). SVA was higher in HYB and OPEN (65, 47 mm) than MIS (29mm; $p<0.05$). The amount of SVA correction was greater for HYB and OPEN (36,34 mm) than MIS (1 mm). Pre and postop ODI and VAS were similar among the groups.

Conclusion: OPEN, HYB, and MIS techniques resulted in significant correction of coronal plane deformity. OPEN and HYB showed superior correction toward physiologic sagittal parameters compared to MIS techniques. MIS was unable to restore PT or PI-LL revealing limitations associated with MIS surgery. However, all groups achieved significant improvement in ODI and VAS.

7. Mechanical Versus Chemical Prophylaxis for Deep Venous Thrombosis in Patients Undergoing Lumbar Spinal Fusion: Comparative Effectiveness and Cost-Benefit

Saniya S. Godil, MD; Michael C. Dewan, MD; Scott L. Parker, MD; Clinton J. Devin, MD; Matthew J. McGirt, MD
USA

Summary: Venous thromboembolism is a common preventable cause of morbidity after surgery. Therefore, patients undergoing any surgical procedure receive routine prophylaxis for DVT. Recently, the added utility of chemical DVT prophylaxis in addition to mechanical prophylaxis has been questioned. In our experience, mechanical and chemical DVT prophylaxis had equivalent effectiveness in preventing peri-operative DVT after elective lumbar spinal fusion. Use of mechanical versus chemical DVT prophylaxis can lead to cost savings of up to \$20,937 per 150 patients treated per year.

Introduction: Venous thromboembolism is a common preventable cause of morbidity after surgery with an incidence ranging from 0.3-31% in elective spinal surgery patients. Therefore, patients undergoing any surgical procedure receive routine prophylaxis for DVT. Recently, the added utility of chemical DVT prophylaxis in addition to mechanical DVT prophylaxis has been questioned. We set out to determine comparative effectiveness and cost-benefit of mechanical versus chemical DVT prophylaxis in patients undergoing elective lumbar spinal fusion.

Methods: All patients undergoing lumbar spinal fusion (1-3 levels) for degenerative spine disease at a single medical institution over a 2-year period were enrolled into our prospective registry. During the first year, all patients received mechanical and chemical prophylaxis (subcutaneous heparin twice a day) for DVT [chemical prophylaxis group]. During the second year, patients only received mechanical prophylaxis for DVT [mechanical prophylaxis group]. At the end of this 2-year period, we evaluated whether this categorical switch influenced the incidence of DVT and the cost-benefit associated with it.

Results: A total of 355 patients (208 in chemical group and 147 in mechanical group) were included in the study. There were no significant differences in the baseline characteristics and treatment variables of the two groups ($p>0.05$). The categorical switch from chemical to mechanical DVT prophylaxis did not change the incidence of DVT after lumbar fusion surgery in chemical versus mechanical prophylaxis group [1 (0.48%) versus 1 (0.68%); $p=0.80$] in mechanical

prophylaxis group). Incidence of bleeding complications like epidural hematoma was 0.96% in chemical group versus 0.68% in mechanical group. Converting from chemical to mechanical prophylaxis resulted in \$20,937 savings without a rise in peri-operative thromboembolism.

Conclusion: In our experience, mechanical and chemical DVT prophylaxis had equivalent effectiveness in preventing peri-operative DVT after elective lumbar spinal fusion. Use of mechanical versus chemical DVT prophylaxis can lead to cost savings of up to \$20,937 per 150 patients treated per year.

8. Evaluation of the Alarm Criteria of Transcranial Electrical Stimulation Muscle Evoked Potential in Scoliosis Surgery: Multi-Institution Survey by the Monitoring Committee of the Japanese Society for Spine Surgery and Related Research

Kei Yamada, MD, PhD; Sho Kobayashi, PhD; Nobuaki Tadokoro, MD; Kanichiro Wada; Akio Muramoto, MD; Hiroshi Iwasaki, MD; Tsukasa Kanchiku; Shoji Seki, MD, PhD; Muneharu Ando; Yujiro Hirao; Atsuko Saruwatari, MD; Ryo Ohta; Yukihiro Matsuyama, MD

Japan

Summary: A total of 221 patients (male / female = 50 / 171) received spinal corrective surgery for scoliosis in eleven medical institutions, and were prospectively enrolled in this study. The alarm criteria were set at a 70% amplitude loss in TES-MEP. Among these, 26 patients showed wave changes, three of whom sustained postoperative motor loss. The 70% decrease in amplitude of TES-MEP was acceptable to prevent iatrogenic neurological deficit.

Introduction: The alarm criteria of transcranial electrical stimulation motor evoked potentials (TES-MEP) has not yet been established. Accordingly the Monitoring Committee of the Japanese Society for Spine Surgery and Related Research (JSSR) has proposed a 70% amplitude loss in TES-MEP can be accepted as the alarm criteria of TES-MEP in spinal surgery based on the results of a nationwide retrospective study. The aim of the present study is to evaluate the alarm criteria of TES-MEP during scoliosis surgery.

Methods: Since April 2010 until March 2012, a total of 221 patients (male / female = 50 / 171) received spinal corrective surgery for scoliosis in eleven medical institutions, and were prospectively enrolled in this study. The clinical diagnosis was idiopathic scoliosis in 93 patients, symptomatic scoliosis in 34, congenital scoliosis in 6, and adult idiopathic scoliosis / kyphoscoliosis in the other 88 patients. The alarm criteria were set at a 70% amplitude loss in TES-MEP. We investigated (1) the correlation if any between wave change, corrective maneuver, and any postoperative neurological deficit, (2) the sensitivity and specificity of the alarm criteria.

Results: Among these, 26 patients showed wave changes, three of whom sustained postoperative motor loss. The intraoperative corrective measures that produced wave change of TES-MEP included derotation in 14, compression in 3, translation in 2, distraction in 1, insertion of pedicle screw in 6, and abscission of thoracic nerve root in one. Two patients with adult kyphoscoliosis showed a

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wave change induced by derotation sustained postoperative motor loss despite preventive decompression. One patient presented complete wave loss after abscission of the nerve root showed persistent motor loss even after 3 months. The sensitivity of the alarm criteria was 100%, and the specificity was 89.4%. Preventative measures including decompression and release of correction after warning improved amplitude of TES-MEP in 9 cases, who did not present postoperative motor loss.

Conclusion: The 70% decrease in amplitude of TES-MEP was acceptable to prevent iatrogenic neurological deficit. Proper preventative measures after warning of 70% amplitude loss could rescue neurological function from iatrogenic damage.

9. A Prospective Randomized Study Comparing Neurophysiologic Monitoring With Total Intravenous Anesthesia and Inhalational Anesthesia in the Treatment of Adolescent Idiopathic Scoliosis

Walter P. Samora, MD; Allan Beebe; Jan Klamar, MD; David P. Martin, MD USA

Summary: The purpose of this study is to compare efficacy of neurophysiologic monitoring during general anesthesia with either TIVA or a volatile agent. Twenty-five adolescent patients were prospectively randomized to receive general anesthesia with either TIVA or volatile agent during posterior spinal fusion for idiopathic scoliosis. Findings support the use of volatile-based anesthetic when utilized effectively by experienced teams performing neurophysiologic monitoring.

Introduction: At present, most recommendations support the administration of total intravenous anesthesia (TIVA) for scoliosis patients undergoing corrective spinal surgery. The use of these agents facilitates neurophysiologic monitoring of spinal cord function. However, significant disadvantages with propofol relate to its sensitive half-life and the potential for prolonged wake-up times. Despite our experience demonstrating successful neurophysiologic monitoring with titrated use of the volatile agent desflurane, there are limited data supporting this practice. The purpose of this study is to compare efficacy of neurophysiologic monitoring during general anesthesia with either TIVA or a volatile agent.

Methods: Following informed consent, patients were randomized to receive general anesthesia with either TIVA or volatile agent during posterior spinal fusion for idiopathic scoliosis. Neurophysiologic monitoring was conducted per standard practice.

Results: The study included 25 adolescents (range 12-18 years). One patient was excluded due to intraoperative loss of neurophysiologic monitoring. No differences were noted between cohorts with respect to intraoperative fluid therapy, surgical duration, and intraoperative course. Use of volatile agent necessitated administration of 30-35% greater stimuli (mV) to achieve the MEP (baseline value of 441 ± 70 versus 325 ± 75 mV, $p < 0.01$). Additionally, the amplitude of the SSEP was decreased with the volatile agent. No clinically significant effect on latency was noted. One patient receiving a volatile agent required a reduction in the inhaled concentration to improve neurophysiologic monitoring. At the

completion of the surgical procedure, mean wake times were shorter with the volatile agent than with TIVA (3 minutes versus 10 minutes).

Conclusion: Although neurophysiologic monitoring was facilitated by the use of TIVA, a volatile-based anesthetic can be utilized effectively by experienced teams performing neurophysiologic monitoring. The primary advantage of the volatile-based technique includes a more rapid awakening. This may be particularly relevant should a wake-up test become necessary.

10. Effect of Intermittent Administration of Teriparatide(PTH1-34) on BMP Induced Bone Formation in a Rat Spinal Fusion Model

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Japan

Summary: Intermittent PTH1-34 administration significantly increased fusion rates and improved the quality of the newly formed bone in a BMP-induced rat spinal fusion model. These results suggest its potential clinical applications in BMP-induced spinal fusion surgery.

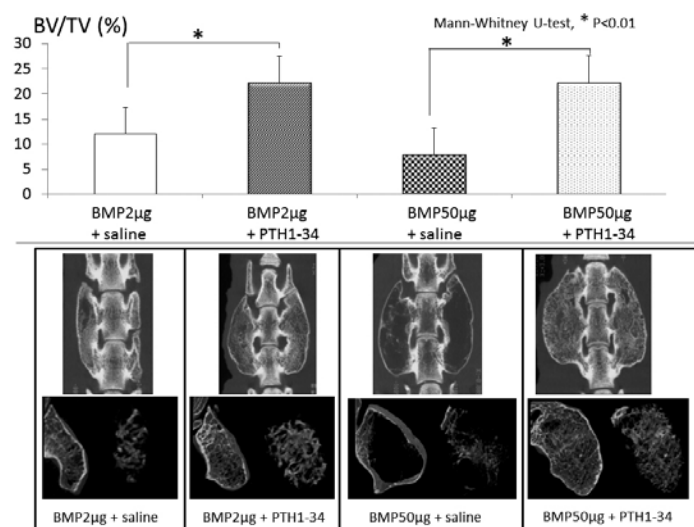
Introduction: Although clinical bone morphogenetic protein (BMP) therapy is effective, required doses are very high. Teriparatide(PTH1-34) is approved to treat osteoporosis and is a potent anabolic agent that stimulates osteoblastic proliferation and differentiation. In this study, intermittent PTH1-34 administration combined with BMP transplantation was performed to elucidate the effect of PTH1-34 on fusion rate and bone quality of the newly formed bone in a rat spinal fusion model.

Methods: A total of 48 Sprague Dawley male rats aged 8 weeks were operated with posterolateral fusion at L4-5 by three different BMP-2 treatments; (1) 0µg (control), (2) 2µg (low dose), (3) 50µg (high dose). Each of the BMP treatments was studied in combination of intermittent PTH1-34(180µg/kg/w) or saline injection since 2 weeks before the operation to 6 weeks after the operation. Bony fusion at L4-5 was quantified using plain radiographs and manual palpation test. BV/TV of the newly formed bone was evaluated to compare the bone quality by microCT. Serum bone markers were also quantified.

Results: Fusion rate at L4/5 in BMP 2µg group significantly increased from 57 % to 100% by PTH administration ($p < 0.05$). Fusion rate in the other groups did not change significantly with or without PTH administration (BMP 0µg; 0% v.s. 0%, BMP 50µg; 89% v.s. 100%). BV/TV of the newly formed bone was significantly increased in both the BMP 2µg and 50µg treatment groups by PTH administration ($p < 0.01$). (fig.1 upper) Micro CT coronal 2D image and reconstructed 3D image of the newly formed bone clearly demonstrated abundant trabecular bone formation in the PTH treatment group. (fig.1 lower) Bone formation marker(osteocalcin) was significantly increased in PTH-treated group, however bone resorption marker (TRAP-5b and I CTP) was not different with or without PTH administration.

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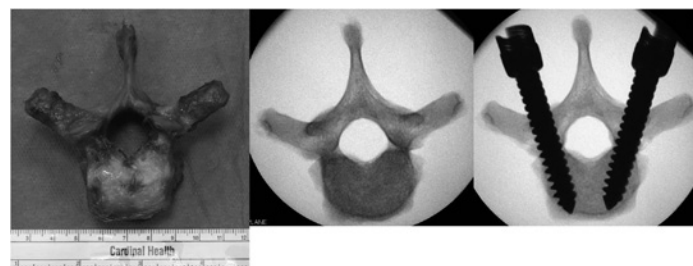
Conclusion: Intermittent PTH1-34 administration significantly increased fusion rates in the BMP low dose treatment group (i.e. reduction in the required BMP dose) and improved the quality of the newly formed bone in both the BMP low dose and high dose groups in a BMP-induced rat spinal fusion model. These results suggest its potential clinical applications in BMP-induced spinal fusion surgery.



Photographs and fluoroscopic images of representative specimens were taken for visual assessment. Two-tailed Student t-test was performed.

Results: The average coronal spinal canal diameter prior to screw insertion was 17.7 mm (T1 20.3, T2 18.4, T3 17.0, T4 16.5, T5 15.9, T6 16.3, T7 16.6, T8 16.3, T9 16.7, T10 16.7, T11 19.7, T12 22.3). The average canal diameter with the largest screw inserted before bony breach was 17.6 mm ($p=0.92$) (T1 21.0, T2 18.0, T3 16.7, T4 16.3, T5 15.4, T6 15.9, T7 16.6, T8 16.7, T9 16.8, T10 16.6, T11 19.2, T12 22.3). The average diameter of the largest screw inserted before breach was 6.9 mm (T1 7.7, T2 6.5, T3 6.5, T4 5.8, T5 6.6, T6 6.5, T7 6.5, T8 5.7, T9 7.3, T10 7.7, T11 7.5, T12 7.9). Pedicle circumference increased from 41.8 mm before screw placement to 43.4 mm at maximal expansion before bony breach with the next sized screw. 28 pedicles did not break with 9.5 mm-diameter screws. There were 133 lateral breaches (99.3%) but only 1 medial breach (0.7%).

Conclusion: Increasing pedicle screw size caused pedicle expansion laterally but did not alter spinal canal dimensions. When there was an osseous breach, all but 1 were lateral.



T2 vertebra before and after pedicle screw insertion with lateral breach with 8.5 mm diameter screw.

11. The Effect of Increasing Pedicle Screw Diameter on Thoracic Spinal Canal Dimensions: An Anatomic Study

Samuel K. Cho, MD; Young Lu; Branko Skovrlj, MD; John Caridi, MD; Lawrence G. Lenke, MD

USA

Summary: Large diameter pedicle screws increase biomechanical fixation strength, but pedicle expansion or osseous breach medially can potentially decrease spinal canal dimensions and cause spinal cord and/or nerve root compression. We found increasing pedicle screw diameter did not decrease spinal canal diameter in the thoracic spine. When there was an osseous breach, all but one (133 versus 1) were lateral and did not involve the spinal canal.

Introduction: Insertion of a pedicle screw that is larger in diameter than that of the native pedicle has been shown to expand the pedicle and also increase biomechanical fixation strength. With this technique, there is a potential concern for medial expansion of the pedicle causing decrease in spinal canal diameter, especially in the concavity of scoliosis, and resulting in spinal cord compression. Also, large pedicle screws that are placed correctly may still cause undetected medial bony breach during surgery.

Methods: 162 pedicles from 81 thoracic vertebrae (T1-T12) of 7 fresh-frozen adult cadavers were probed under direct visualization. After undertapping the pedicle by 1 mm, pedicle screws were inserted in increasing diameter (range, 4.0 mm - 9.5 mm) bilaterally until there was an osseous breach in the pedicle. 938 screws were used in total. Coronal spinal canal diameter and pedicle circumference were measured (in mm) before and after each pedicle screw placement.

12. Biomechanical Demands on Posterior Fusion Instrumentation during Lordosis Restoration Procedures

Calvin C. Kuo, MD; Audrey Martin; Connor J. Telles, MD; Jeremi M. Leasure, MSME; Christopher P. Ames, MD; Dimitriy Kondrashov, MD

USA

Summary: In a cadaveric study comparing three lordosis restoration techniques, in situ bending resulted in higher intraoperative mechanical demand on posterior lumbar instrumentation as well as larger postoperative loads at the upper instrumented vertebra when compared with cantilever bending and compression/distraction techniques.

Introduction: Restoration of lumbar lordosis in patients with preoperative sagittal imbalance is important to prevent postoperative sagittal decompensation. Corrective maneuvers impart large forces that may lead to failure of instrumentation and inability to achieve correction. The aim of this study is to investigate the forces placed on posterior fusion instrumentation by three commonly used intraoperative techniques to restore lumbar lordosis: (1) cantilever bending (CL), (2) compression/distraction (CD), and (3) in situ bending (IS) of posterior fusion rods.

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Methods: Seven cadaveric torsos were instrumented with pedicle screws at levels L1-L5. Specimens underwent each of the lordosis restoration procedures. Real-time measurements of load were captured during each maneuver. Pedicle screw pullout force was evaluated after completion of the procedure. The degree of correction was noted through fluoroscopic imaging. Loads were normalized with the corresponding degrees of correction. Peak loads experienced on the screws during surgery and resting loads after corrective maneuvers were measured.

Results: Intra-operative loads on instrumentation were largest with IS with an average of 486 ± 154 N per degree of correction ($N/^\circ$), followed by CD (431 ± 125 $N/^\circ$) and CL (347 ± 238 $N/^\circ$). A mean overall lordotic correction of $10.9^\circ (\pm 4.7^\circ)$ was achieved. No statistically significant difference in lordotic correction was observed between restoration procedures. IS produced the largest post-operative loads at L1 (109 ± 115 $N/^\circ$) while CL and CD produced comparable post-operative loads at L1 (31 ± 33 and 22 ± 18 $N/^\circ$).

Conclusion: IS resulted in the highest mechanical demand on posterior lumbar instrumentation as well as the largest post-operative loads at the upper instrumented level. These results indicate a greater chance of intraoperative instrumentation failure and post-operative proximal pedicle screw pullout with IS in comparison to CL and/or CD techniques. The results of this study are aimed to optimize correction and fusion strategies in lordosis restoration cases.

13. The Influences of Rod Contouring on Rod Strength and Stiffness of Different Spinal Constructs

Satoru Demura; Hideki Murakami; Satoshi Kato, MD; Katsuhito Yoshioka; Hiroyuki Hayashi; Hiroyuki Tsuchiya

Japan

Summary: We investigated the influences of rod contouring on yield strength and stiffness of rods varying in material type and diameter. Rod contouring procedure reduced yield strength and stiffness of the rods.

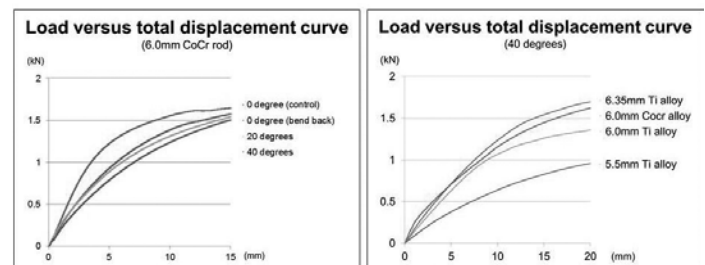
Introduction: For the correction of spinal deformity or spinal fusion at multiple levels, intraoperative rod contouring is required to realign the spine. A French bender is the most common contouring tool during the surgery. There are several reports on the mechanical properties of various rods with no preparation, however, few reports describing the changes in the rod property after contouring procedures.

Methods: A three point bending test was conducted. Each 18cm-length rod was loaded at a rate of 10mm/min with a load applicator. Three different rod diameters (5.5mm, 6.0mm, 6.35mm) and two types of materials (titanium alloy -Ti, cobalt-chromium alloy - CoCr) were assessed. We evaluated the different rod curvatures: 1) no preparation rod of 0 degree (control), 2) 0 degree rod which was bent at 1 point, and then bent back from the opposite side, 3) tangential angles of 20 degrees bent rod, 4) 40 degrees bent rod. Bending stiffness (N/mm) and yield strength (N) of the rod were determined by load versus total displacement curve.

Results: The yield strength in all type of rod materials and diameter decreased after rod contouring using a French bender. The extent of decrease depended on

the degree of bend (figure). The bending stiffness of each rod also decreased. However, the extent of decrease in bending stiffness was smaller than that in yield strength. The CoCr rod showed higher bending stiffness than the Ti rod of the same diameter. After rod contouring of 40 degrees, load versus total displacement curve in the 6.0mm CoCr rod was close to that in the 6.35mm Ti rod (figure).

Conclusion: Rod contouring using a French bender reduced the yield strength more than stiffness in all types of rods. Decrease of yield strength correlated to the degree of bend. These results might offer better understanding of mechanical properties after rod contouring, and might influence the selection of rod materials and diameter.



14. The Utility of an Allograft Tendon for Scoliosis Correction via the Costotransverse Foramen in a Porcine Model

Richard E. McCarthy, MD; Dong Sun, PhD; Michael H. McCarthy, BA

USA

Summary: A novel treatment for early adolescent scoliosis has been tested on induced scoliosis pig models. An allograft tendon was placed via the costotransverse foramen to act as a tether for the treatment of the established scoliosis. Spinal deformity correction in three planes was obtained in the treatment group, while there was no correction in the non-treatment group.

Introduction: Current work on convex tethering techniques has centered on anterior convex staples or polypropylene tethers. These are inserted anteriorly through the chest cavity. In this study, we hypothesized that the allograft tendon via the costotransverse foramen on the convex side of the curve would correct an established spinal deformity.

Methods: In this IACUC-approved study, a scoliosis model was first established in 11 immature full size pigs. Once the animals had demonstrated a spinal deformity > 50 degrees, they underwent a 2nd stage surgery with either a treatment or no treatment (scoliosis control). For the treatment group, a posterior convex side allograft tendon tether was inserted into the costotransverse foramen in 7 levels and secured with a bone anchor in an effort to correct the deformity. Monthly radiographs were used to assess curve changes.

Results: Treatment and control animals were observed for 3 months after the 2nd surgery. The mean coronal scoliotic Cobb angle was 39.2° for the treatment group and 50.25° for the non-treatment group, mean kyphosis was $35.6.25^\circ$ for treatment group and 24.25° for the non-treatment group at final follow-up.

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Post-mortem CT studies demonstrated mean maximum vertebral axial rotation was 22.26 in the treatment and 34.73 in the non-treatment group.

Conclusion: The placement of a unilateral allograft tendon into the costotransverse foramen across the convexity of a scoliotic curve acted as a spinal tether able to significantly correct the deformity in three planes compared to the non-treatment group. These data suggest that an allograft tendon tethering approach may represent a novel fusion-less procedure to treat idiopathic scoliosis in an immature population.

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).

15. Comparison of an Oxysterol Molecule and rhBMP2 Fusion Rates in a Rabbit Posterolateral Lumbar Spine Model

Trevor P. Scott, MD; Kevin Phan; Akinobu Suzuki, MD, PhD; Scott R. Montgomery, MD; Michael D. Daubs, MD; Farhad Parhami, PhD, MBA; Jeffrey C. Wang, MD USA

Summary: This study was a randomized controlled trial comparing rhBMP2 and oxysterol 133 in a rabbit posterolateral lumbar fusion model. Low dose oxysterol 133 appears to promote earlier fusion than rhBMP2 and our high dose oxysterol group seemed to have both earlier fusion and a greater ultimate fusion rate than rhBMP2.

Introduction: The non-union rate following lumbar spinal fusion is potentially as high as 35%. Over the past 10 years bone morphogenic proteins (rhBMP2) has been used as biological adjunct to promote bony fusion. However, recently there have been increasing concerns about BMP relating to increased inflammatory response, and potential problems with bone fusion quality. Oxysterol 133 (oxy) has been shown to promote excellent fusion rates in rodent lumbar spine models. The purpose of this study is to compare the fusion rate of rhBMP2 and oxy in a posterolateral lumbar rabbit spinal fusion model.

Methods: The study is a randomized control trial in an animal model. 24 male adult white New Zealand rabbits (3-3.5kg) underwent bilateral posterolateral lumbar spinal fusion at L4-L5. Rabbits were divided into 4 groups; control (A), 30 ug rhBMP2 (B), 20 ug oxy (C), 60 ug oxy (D). A mineral collagen matrix infused with saline for control or one of the above compounds was implanted at the fusion site. At 4 weeks fusion was evaluated by fluoroscopy. At 8 weeks the rabbits were sacrificed and fusion was evaluated radiographically and by manual palpation.

Results: At 4 weeks fusion rates as evaluated by fluoroscopy were as follows; group A 25%, group B 75%, group C 91.7%, group D 91.7%. At 8 weeks fusion by radiographic analysis were: group A 33%, group B 91.7%, group C 91.7%, and group D 100%. When the fusion masses were evaluated by manual palpation group A was 40% fused, group B was 67.7% fused, group C was 67.7% fused, and group D was 100% fused.

Conclusion: Oxy 133 was successful in promoting fusion in a rabbit posterolateral lumbar spinal fusion model. Compared to rhBMP2, low dose oxysterol seems to

lead to earlier fusion and high dose oxysterol results in earlier fusion and a higher rate of fusion (100%).



Image of fusion in a rabbit given 20 micrograms of oxysterol at 8 weeks. The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

16. International Variations in the Clinical Presentation and Management of Cervical Spondylotic Myelopathy: One-Year Outcomes of the AOSpine Multi-Center Prospective CSM-I Study

Michael G. Fehlings, MD, PhD; Branko Kopjar; Helton L. Defino, MD; Giuseppe Barbagallo; Ronald H. Bartels, MD, PhD; Paul Arnold; Mehmet Zileli, MD; Gamaliel Tan, MBBS; Yasutsugu Yukawa, MD; Massimo Scerrati, Ancona; Tomoaki Toyone, MD, PhD; Qiang Zhou, PhD Canada

Summary: International Variations in the Clinical Presentation and Management of Cervical Spondylotic Myelopathy: One Year Outcomes of the AOSpine multi-center Prospective CSM-I Study.

Introduction: Little information is available with respect to differences in global approaches to treatment of cervical spondylotic myelopathy (CSM).

Methods: 486 patients with CSM were enrolled in a prospective multi-center controlled, cohort study involving 16 sites in Europe, Asia, South America and North America. One-year follow-up data of 389 were analyzed using multivariate techniques adjusting for baseline differences (demographics, surgical approach, number of levels and baseline outcome values) in patient populations.

Results: 394 patients have completed the 1-year follow-up. 35% females with an average age of 56.36 yrs (SD 11.92). Patients underwent anterior(58%), posterior(40%) or circumferential(2%) surgery. Significant differences in age

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at presentation and baseline neurological status among the regions, with Asian and Latin American patients being significantly younger. Significant ($P < 0.001$) improvement from baseline values to 12-months in all outcome parameters. mJOA improved from 12.5 ± 2.8 baseline to 14.9 ± 2.6 12-months. NDI improved from 38.0 ± 20.2 baseline to 24.7 ± 18.7 12-months. Nurick improved from 3.3 ± 1.2 baseline to 1.9 ± 1.5 12-months. SF36 PCS improved from 35.2 ± 8.5 baseline to 43.5 ± 10.2 12-months. SF36 MCS improved from 38.8 ± 9.9 baseline to 46.5 ± 10.7 12-months. The amount of improvement varied across the regions with patients from Asia-Pacific and Latin America having generally better self-reported outcomes on the SF36—despite similar degrees of improvement on mJOA and Nurick—than those from North America and Europe.

Conclusion: This study shows that surgical treatment for CSM is associated with significant improvements in generic and patient-specific outcome measures at one-year. However, there are significant variations in clinical presentation and in patient perceptions of improvement that require further investigation.

17. C2 Nerve Root Transection during C1 Lateral Mass Screw Fixation: Does it Affect Functionality and Quality of Life?

Michael C. Dewan, MD; Saniya S. Godil, MD; Clinton J. Devin, MD; Matthew J. McGirt, MD

USA

Summary: Our prospective cohort study demonstrates that C2 nerve root transection is associated with increased post auricular numbness but this has no effect on patient reported outcomes and quality of life. C2 nerve root preservation can be associated with posterior auricular neuralgia which has a negative impact on patient disability and quality of life. Our experience suggests no negative consequences with C2 nerve root transection during C1-2 stabilization and arthrodesis.

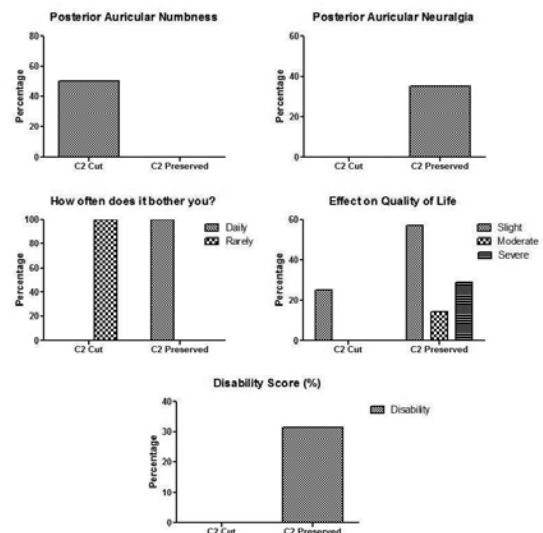
Introduction: Sectioning of the C2 nerve root allows for direct visualization of the C1-2 joint and facilitates arthrodesis of the C1-2 motion segment. However, concern of posterior-auricular numbness often precludes C2 sectioning in routine practice. In a prospective cohort study, we set out to determine the clinical and functional consequences of routine sectioning of C2 nerve root during placement of C1 lateral mass screws.

Methods: All patients undergoing posterior atlantoaxial stabilization via C1 lateral mass screw fixation over a 2-yr period were included. Surgeons' preference/training practices determined whether bilateral transection of the C2 nerve root was performed. Data was prospectively collected on patient demographics, surgical variables, and clinical outcome. A standard questionnaire was used to determine the presence and severity of posterior auricular numbness or pain, and its effect on QOL. Domains of NDI were used to assess disability related to C2 symptoms

Results: A total of 28 patients were included (C2 nerve root transection=8; C2 nerve sparing=20). Groups were similar at baseline. A trend of decreased blood loss and length of surgery was observed in the C2 transection cohort. Posterior auricular numbness was reported by 4 (50.0%) patients after C2 transection

versus 0 (0.0%) with C2 preservation. Posterior auricular neuralgia was reported by 0 (0.0%) patients after C2 transection versus 7 (35.0%) with C2 preservation. For patients with posterior auricular numbness, none reported being "bothered" by it. For patients with posterior auricular neuralgia, all reported being "bothered" by it daily and 4 (57.1%) reported moderate to severe effect on QOL. None of the patients with numbness required medications, whereas 5 (71.4%) patients with posterior auricular neuralgia reported use of medication. Mean disability score was significantly higher with posterior auricular neuralgia ($p=0.016$).

Conclusion: C2 nerve root transection is associated with increased post auricular numbness but no effect on patient reported outcomes and QOL. C2 nerve root preservation can be associated with posterior auricular neuralgia which has a negative impact on disability and QOL. Our experience suggests no negative consequences with C2 nerve root transection.



18. When is it Safe to Return to Driving Following Cervical and Lumbar Spinal Surgery?

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USA

Summary: We performed a prospective trial on spinal surgery patients to determine when their post surgery driver reaction times returned to preoperative levels. Both cervical and lumbar surgery patients had either returned to preoperative levels, or were faster than preoperative times, by the first follow-up visit at 2-3 weeks.

Introduction: Surgeon's recommendations for safe return to driving following cervical and lumbar surgery vary and are often based on empirical data. Driver reaction time (DRT) is an objective measure of ability to drive safely. There is limited data about the effect of cervical and lumbar surgery on DRT. The purpose of our study was to use DRT to determine when patients undergoing cervical and lumbar surgery may safely return to driving.

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Methods: We tested 37 patient's DRT using computer software (Vericom Genius Speed Wheel 3). Cervical patients were subdivided into anterior versus posterior approach and myelopathic versus non-myelopathic groups. Lumbar spinal patients were subdivided by decompression versus fusion +/- decompression and single level versus multi-level surgery. 17 men and 6 women (50.5 yrs +/- 17.7) received lumbar surgery. In the cervical group were 8 women and 6 men (56.7 yrs +/- 10.9). Patients were tested pre-operatively and then at 2-3, 6 and 12 weeks following surgery. Patients were compared to 14 healthy male controls (32 yrs, +/- 5.19). Use of opioids was noted if present.

Results: The 14 cervical patients had no significant difference between pre and postoperative DRT (P= 0.49). Further there was no significant difference between pre and postoperative DRT in any cervical subgroup. The lumbar surgery preop DRT was not significantly different than the 2-3 wk visit DRT (P=0.196). Single level patients had significant improvement from a preop DRT of 0.951 s (SD 0.255) to 0.794 s (SD 0.152) at 2-3 weeks; (P=0.012). None of the other sub groups had a difference in DRT. All groups were slower than the control group DRT 0.762 s (SD 0.91) except the anterior approach group throughout and the single level and decompression groups post operatively. There was no relationship between DRT and VAS score or opioid use for any group.

Conclusion: Patients who have undergone cervical or lumbar surgery show no measurable change in DRT between the preop visit and the first post-op visit (2-3 weeks). Based on the findings of this study, using DRT data it appears safe to allow patients, not taking opioids, to return to driving as early as two weeks following spinal surgery.

Patients	Reaction Time				Patients	Reaction Time			
	Pre-op	Post-op	6 wks	12 wks		Pre-op	Post-op	6 wks	12 wks
Overall	0.976 ±0.242	1.007 ±0.212 (P<0.590)*	0.938 ±0.234	0.936 ±0.205 (P<0.852)*	Overall	1.011 ±0.222	0.955 ±0.224 (P<0.195)*	0.841 ±0.071	0.945 ±0.153 (P<0.113)*
Myelopathic	0.998 ±0.095	1.021 ±0.245 (P<0.554)*	---	---	Single Level	0.991 ±0.277	0.855 ±0.265 (P<0.011)*	---	---
Non-myelopathic	0.917 ±0.127	0.957 ±0.227 (P<0.692)*	---	---	Multi level	1.001 ±1.154	2.077 ±1.821 (P<0.950)*	---	---
Anterior	0.828 ±0.115	0.857 ±0.143 (P<0.515)*	---	---	Fusion	1.077 ±0.156	1.115 ±0.232 (P<0.713)*	---	---
Posterior	1.088 ±0.255	1.120 ±0.264 (P<0.722)*	---	---	Decompression	0.952 ±0.270	0.884 ±0.252 (P<0.117)*	---	---

19. Prospective Analysis of Risk Factors for Proximal Junctional Failure in Adult Deformity Patients

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USA

Summary: Proximal Junctional Failure (PJF) is a severe form of Proximal Junctional Kyphosis (PJK), as it includes mechanical failure. A prospective multi-center cohort of 352 adult spinal deformity patients showed no difference in post-op sagittal alignment for PJF patients vs those without. There was no difference in incidence of PJF for patients fused to UT vs TL proximal end points. Increased age, pre-op sagittal imbalance and operative corrections as well as fusion to the pelvis are risk factors for PJF.

Introduction: Proximal Junctional Failure (PJF), a severe form of Proximal Junctional Kyphosis (PJK) with evidence of mechanical failure, is an important concern in adult deformity patients. Post-operative sagittal imbalance, as well as proximal and distal end points for the fusion are possible risk factors for this complication. Prospective evaluation of these factors have not been reported.

Methods: 352 adult deformity surgical patients from 10 centers were followed prospectively with minimum 1 year follow-up. PJF was defined as increased proximal kyphosis of > 10 degrees plus fracture of UIV or UIV+1 or instrumentation failure. Proximal Junctional Kyphosis (PJK) was defined as increased kyphosis of > 10 degrees without evidence of mechanical failure. Patients were grouped as PJF, PJK, or neither (NoPJF). Proximal fusion levels were defined as Upper Thoracic (UT, T2-T5) or Thoracolumbar (TL, T9-T12). Age, Sacral Slope (SS), Pelvic Tilt (PT), Pelvic Incidence (PI), Sagittal Vertical Axis (SVA), Lumbar Lordosis (LL), and PI-LL were compared.

Results: There were 41 (11.7%) PJF, 54 (15.3%) PJK, and 257 (73.0%) NoPJF patients over 1 year follow-up. There were significant differences in age (65.1 vs 55.7; p=.001) and pre-op PT (26.8 vs 22.0; p=.043) between PJF and NoPJF patients. There was a trend toward increased pre-op SVA and PI-LL, as well as operative change in SVA, LL, and PI-LL among PJF patients. Postop SVA and PI-LL were similar between PJF and no PJF patients. No patient experienced PJF without fusion to the pelvis. Among patients fused to the pelvis, there was no difference between UT versus TL proximal endpoints for rate of PJF (13.4% vs 16.8%; p>.05), although the rate of PJK was greater for UT patients (26.8% vs 13.5%; p=.017).

Conclusion: Post-op sagittal alignment and proximal fusion end point did not differ between PJF and NoPJF patients. Older patients with worse pre-op sagittal imbalance, larger sagittal corrections and pelvic fixation were identified as those at greatest risk of PJF. This is the first prospective study of risk factors for PJF in adult deformity patients.

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20. Short Segment Anterior Fusion with Interbody Spacers and Anterior Instrumentation for Moderate, Flexible, Functionally Restrictive, Painful Scheuermann's Kyphosis

*Jwalant S. Mehta, FRCS(Orth); Kan Min, MD; Robert W. Gaines, MD
United Kingdom*

Summary: Anterior short segment inter-body fusion for Scheuermann's disease allows safe and effective correction of the deformity and results in stable and consistent fusion. This is particularly useful for the painful patients with moderate, flexible kyphotic deformity.

Our series shows that this approach achieves clinically acceptable goals by fusing half the levels operated by the traditional posterior approach.

Introduction: Traditional surgical management of symptomatic Scheuermann's kyphosis has focussed on treating the deformity by long posterior fusions—and straightening the deformity.

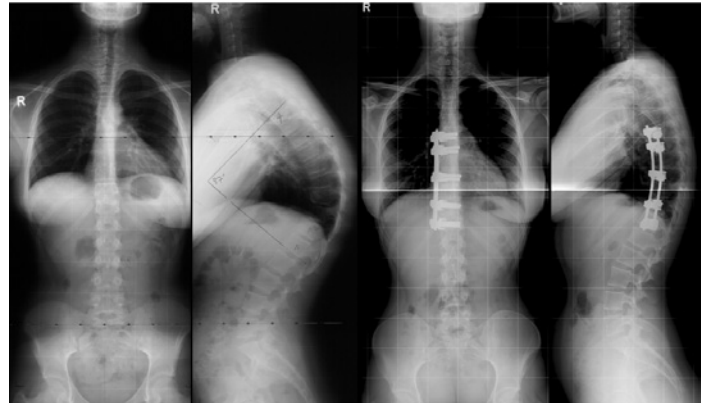
Rather than the traditional long posterior fusion, we report on our experience with a short segment anterior fusion of the affected discs in these patients—with correction of the deformity.

This technique was applied to patients with moderate, flexible deformity who presented with pain as their primary complaint.

Methods: We report the outcomes on 20 patients treated in two centres by the short segment anterior inter-body fusion of the apical motion segments with a minimal of 2 year follow-up after failed conservative treatment for lifestyle limiting pain and hyper-kyphotic deformity. The mean age of the cohort was 20.9 years (range 14 - 34); and 18 were male.

Results: All the patients were off narcotic analgesics by 4 months after the operation. The mean pre-operative thoracic kyphosis was 76.9 (95% CI 72.1 - 81.6) which corrected to 43.6 (95% CI 39.9 - 47.3) on the hyperextension film. This was surgically corrected to 45.9 (95% CI 43.2 - 48.7) with the fusion of 5.2 ± 0.95 levels. The correction was well maintained, with a final measure of 48.5 (95% CI 45 - 51.9) at a mean follow-up of 50.9 months (range 24 - 96), after the surgery. There were no neurological, visceral or implant related complications.

Conclusion: This is a safe and effective approach in the treatment of symptomatic Scheuermann's disease where pain is the predominant symptom and the deformity is moderate. This method allows for fusion of over half the levels as the posterior based approaches, with similar corrections. There have been no PJK or DJK in this series.



Pre-operative radiographs (left) and 5 years post-operative radiographs (right).

21. Clinical Results and Functional Outcomes after Direct Intralaminar Screw Repair of Spondylolysis

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Summary: Direct intralaminar screw fixation of spondylolysis in patients who fail nonoperative management offers a low profile fixation with successful clinical outcomes and low complication rates.

Introduction: Spondylolysis is usually treated nonoperatively, but there are multiple surgical techniques when nonoperative measures fail. We analyzed the clinical and functional outcomes of patients with pars defect treated via direct intralaminar screw fixation and autograft, a minimally invasive and motion-preserving surgery.

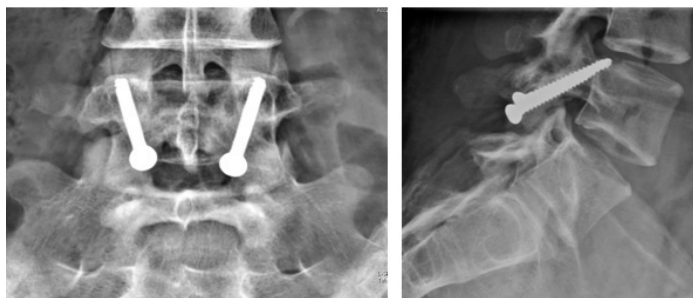
Methods: We reviewed patients with spondylolysis from 2000 to 2010 who underwent intralaminar screw fixation with bone grafting Fig1, had a minimum of 2 years' follow-up, and had completed pre- and postop visual analog scale (VAS) pain scores. Of 31 patients (15 males, 16 females; mean age, 16 years; range, 10-37) meeting the criteria, 25 (81%) were competitive athletes. Preop evaluation included radiography, computed tomography, single photon emission CT, and MRI as needed. The mean width of the spondylolysis on CT was 2 mm (range 0-8). All patients underwent extensive nonoperative therapy (mean duration, 22 months; range 7-60). The mean preop VAS score was 7 points (range 1-10). Preop MRI scans were graded using Pfirrmann classification for correlation with postop outcomes. Student t-test was used for analysis (sig. $P < 0.05$).

Results: At a mean follow-up of 59 months (range, 24-135), the mean postop VAS score was 2 points (range, 0-10) with no significant difference in the postop pain score ($P=0.39$) by preop defect size (≤ 2 mm versus ≥ 3 mm) measured on preop CT. Of the 31 patients, 28 (90%) reported postop improvement in activity level and pain (mean 5-point improvement in pain score $P < 0.01$). In 25 athletes,

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19 (76%) returned to competitive sports with a mean postop VAS score of 1 point (range, 0-4) at a mean of 6 months (range, 3-10) after surgery. One patient required L6 to S2 posterior spinal fusion for persistent pain starting 18 months after L6 spondylolysis repair. Two patients sustained asymptomatic unilateral intralaminar screw fractures at L5 and one patient required debridement for postop superficial infection. There was no correlation between the preop MRI disc morphology and clinical outcomes.

Conclusion: Direct intralaminar screws repair of pars defect offers a low profile fixation and a reliable method of treating symptomatic spondylolysis with good functional outcome and a low complication rate in active patients.



AP and Lateral X-rays of the Lumbar spine showing intralaminar screw fixation.

22. Early Experience with Use of Phenix Magnetic Distraction Device in Treatment of EOS

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USA

Summary: Phenix magnetic rod is a new device for potential treatment of early onset scoliosis. It differs significantly from existing implants by design and treatment principles.

Introduction: Phenix magnetic rod and principles of its use can be summarized into several key points:

- The lengthening is done by an external magnet by caregivers
- Only the main curve is instrumented leaving remaining spine fully mobile
- Toggle joint junction between spine anchors and the device decreases stresses on the anchor points
- Daily lengthenings done similar to Ilizarov method of lengthening

This presentation reports on the use of this device in a small group of patients who have run out of nonsurgical options for treatment of their EOS. Operative experience and early follow-up results are reported.

Methods: 5 patients with various underlying diagnoses associated with EOS had Phenix rod inserted into their spine for EOS refractory to non-surgical treatment. 3 boys and 2 girls, all skeletally immature, Risser 0. They were evaluated for preoperative Cobb, sagittal plane alignment and flexibility. The surgical parameters reviewed include OR time, EBL, and any perioperative complications. The follow-up ranged from 3 months to 1 year 3 months. Patients were evaluated for curve

progression/improvement, amount of lengthening accomplished, activity level and complications.

Results: The preoperative scoliosis ranged from 45° to 107°. All had an uneventful surgical procedure, wounds healed per primum, and improved Cobb on immediate postop x-ray on average 27°. At the last follow-up, the Cobb improvement from preoperative measurement averages 30°. The average lengthening was 16 mm. There were no infections, hardware protrusions or skin breakdowns. 2 children had minor hardware problem of set screw loosening requiring re-operation. All patients have so far retained their original device and are all fully active within the scope of their underlying disability.

Conclusion: It appears that the device is safe, reliable at early follow-up, is living up to its expectations and has potential to become a useful treatment option for this difficult group of EOS patients.

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).

23. Reducing Radiation Exposure in Early-Onset Scoliosis Patients: Novel use of Ultrasonography to Measure Lengthening in Magnetically-Controlled Growing Rods. Prospective Validation Study and Assessment of Clinical Algorithm

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United Kingdom

Summary: This is a prospective study using ultrasound to document rod distraction in magnetically controlled growing rods. A clinical algorithm using ultrasound, instead of radiographs, was developed and then validated under blinded conditions. The algorithm has been successfully implemented and the early clinical experience assessed with 6 consecutive distraction sessions. The protocol appears effective and will be described in detail. This novel technique has the potential to change clinical practice by significantly reducing cumulative radiation exposure in the developing child.

Introduction: The efficacy of magnetically controlled growing rods (MCGRs) for the treatment of early-onset scoliosis (EOS) has recently been reported. Monthly out-patient distractions have been documented using plain radiographs. This is associated with significant cumulative radiation exposure to the developing child. This prospective study aimed to develop, validate and demonstrate a protocol using ultrasound to document distractions.

Methods: Six EOS patients who underwent surgical treatment with MCGRs were prospectively recruited. All patients were imaged via ultrasound, ease of rod identification was established and the reliability and reproducibility of optimal reference point selection assessed blindly by three individuals. Plain radiographs were used to verify the distraction.

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Results: Assessment of the rod's neck distance on ultrasound demonstrated a high degree of inter-rater reliability ($\alpha=0.99$; $p<0.001$). Intra-rater reliability remained high on repeat measurements at different time intervals ($\alpha=1.00$; $p<0.001$). Satisfactory inter-rater reliability was noted when measuring the rod's neck ($\alpha=0.73$; $p=0.010$) and high reliability was noted in assessing the housing of the rod ($\alpha=0.85$; $p=0.01$) on plain radiographs. Under blinded conditions 2mm rod distraction measured on radiographs corresponded to 1.7mm distraction on ultrasound (SD: 0.24mm; $p<0.001$). Subsequently the clinical algorithm using ultrasound, instead of radiographs, has been successfully implemented and the early clinical experience assessed with 6 consecutive distraction sessions. The protocol appears to be effective and will be described in detail. Implementation of the clinical algorithm has resulted in a high level of patient and parent satisfaction.

Conclusion: This is the first report to note the novel use of ultrasonography to document lengthening of MCGRs in EOS patients. Optimal reference point selection was an important pre-requisite for accurate measurements, our protocol is described in the presentation. This validated imaging technique has the potential to decrease the frequent use of plain radiographs in scoliosis patients and the health risks associated with such cumulative exposure to ionizing radiation.

24. The Classification for Early-Onset Scoliosis (C-EOS) Identifies Patients at Higher Risk for Complications at Five Years of Follow-Up

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USA

Summary: The Classification of Early Onset Scoliosis (C-EOS) is a consensus-based classification system developed to predict disease course and prognosticate outcomes. This study examines the frequency and severity of complications among C-EOS classes of subjects with a minimum of 5 years of follow-up. The data show that a disproportionate share of complications occurred in predictable subsets of patients with early onset scoliosis, suggesting the value of the C-EOS in prognosticating outcomes.

Introduction: The Classification of Early Onset Scoliosis is a consensus-based classification system developed by a group of pediatric spine surgeons to predict disease course and prognosticate outcomes. An initial validation study demonstrated that the C-EOS predicts time to anchor failure in VEPTR surgery. To further validate the prognostic potential of the C-EOS, this study aims to examine the frequency and severity of complications among C-EOS classes.

Methods: 95 EOS patients were identified with minimum 5 years of follow-up from 2 multi-center EOS databases sourced from 45 centers. All patients were classified using the C-EOS, which includes a term for etiology (C:Congenital 37.9%, N:Neuromuscular 18.9%, S:Syndromic 16.8%, I:Idiopathic 24.2%), Cobb (1: ≤ 20 , 2:21-50, 3:51-90, and 4: >90) and kyphosis ("-" ≤ 20 , "N"; 21-50, "+" >50). Complications were categorized by the Classification System in

Growing Spine Surgery, which differentiates device from disease related complications and stratifies them into mild, moderate, and severe groups.

Results: Among device related complications, the greatest frequency of complications regardless of severity was within the Congenital/51-90/Normal-Kyphosis and Hyper-kyphosis (C3N & C3+) classes. 33% of all moderate device related complications were within the Congenital/51-90/Normal-kyphosis (C3N) class. 50% of all severe device related complications were represented by the Congenital/51-90/Hyper-kyphosis (C3+) class.

Three Idiopathic classes (I2N, I3-, I3+) comprised 100% of all disease related complications.

Conclusion: The frequency, and even type of complications vary widely among classification subtypes of patients with early onset scoliosis as stratified by the C-EOS. In documenting that a disproportionate share of complications occur in predictable subsets of patients with early onset scoliosis, this report suggests that the C-EOS might be useful in guiding different therapeutic approaches in patients depending on classification.

The Classification for Early Onset Scoliosis (C-EOS)

Etiology	Cobb Angle (Major Curve)	Maximum Total Kyphosis	Progression Modifier (optional)
Congenital/Structural	1: $\leq 20^\circ$	(-) $\leq 20^\circ$	P0: $<10^\circ/\text{yr}$
Neuromuscular	2: 21-50°	N: 21-50°	P1: 10-20°/yr
Syndromic	3: 51-90°	(+) $>50^\circ$	P2: $>20^\circ/\text{yr}$
Idiopathic	4: $>90^\circ$		

25. Early Onset Scoliosis with Intraspinal Anomalies: Management with Growing Rod

Ankur Goswami, MS(Orth); Pankaj Kandwal, MS(Orth); Ashok Kumar Jaryal; Upendra Bidre, MS; Ankit Gupta, MBBS, MS; Arvind Jayaswal, MS(Orth)
India

Summary: Safety and efficacy of growing rod was evaluated in 13 early onset scoliosis patients with intraspinal anomalies requiring prior neurosurgery in 11. Growing rod maintains correction achieved at index surgery while allowing spinal growth to continue. Absent posterior element and intracanal scarring after neurosurgical procedure may pose a risk during surgical procedure. Although presence of intraspinal anomalies do not seem to increase the risk of neurological deficits, neuromonitoring during surgery is advisable.

Introduction: To retrospectively evaluate clinical and radiological outcomes of growing rod (GR) in the management of Early Onset Scoliosis (EOS) with intraspinal anomalies from a single centre by a single surgeon.

Methods: During 2007 to 2010, 46 patients underwent fusionless surgery. Of these, 13 patients with 19 intraspinal anomalies underwent GR procedure. 11 patients had prior neurosurgery while 2 (filum terminale lipoma and syringomyelia) did not. A total of 88 procedures were conducted during the

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treatment period; 13 index surgeries, 74 distractions of GR and 1 unplanned surgery.

Results: 11 patients had congenital scoliosis and 2 had idiopathic scoliosis. The age at surgery was 6.8 ± 2.5 yrs (3.5-12 yrs). The average lengthening procedures per patient was 5.7 (4-9) with distraction interval of 6.7 (6-7.25) months. Pre-operative Cobb angle was 78.50 ± 18.1 (540-1140) which became 57.40 ± 14.70 (420-940) after index procedure and 53.10 ± 16.70 (360-840) at final follow-up. T1-S1 length increased from 22.7 ± 4.1 (16.4-25.6) cm to 27.5 ± 4.1 (19-38.2) cm at last follow-up with an average T1-S1 length increase of 1.53 cm/yr. The SAL improved from 0.7 ± 0.2 (0.6-0.9) to 0.9 ± 0.5 (0.8-1). A total of 17 complications related to implant (9), wound (2), anesthesia (2) and neurological (2) occurred in 7 patients. One patient had loss of Motor Evoked Potential during index surgery which was attributed to cord compression by rod to rod connector overlying the deficient posterior elements. It was reversed after repositioning of the Domino. The child had 3 uneventful subsequent distractions.

Conclusion: Dual GR can be applied with serial distractions for EOS with intraspinal anomalies that have been operated viz split cord abnormality, tethered cord syndromes etc. Absent posterior elements and intracanal scarring after neurosurgical procedures may be a risk factor for distractions and inadvertent pressure over the unprotected spinal cord or dura. Use of neuromonitoring is advisable for both index procedure and the subsequent distractions; although presence of previous intraspinal anomaly does not seem to increase the incidence of neurological deficit.

26. Modified Growing Rod Technique for the Treatment of Early-Onset Idiopathic Scoliosis

Cagatay Ozturk, MD; Bekir Y. Uçar, MD; Meric Enercan; Sinan Kahraman; Alauddin Kochaj; Azmi Hamzaoglu, MD
Turkey

Introduction: This study introduces a new surgical strategy allowing spinal growth and lung development and controlling the apical rotation without fusion for the surgical treatment of early-onset idiopathic scoliosis.

Methods: Between the years of 2007 and 2011, 16 children (7 males, 9 females; with a mean age of 5.5 years, ranging from 2-8 years) with progressive scoliosis (average 68 degrees) were included in the study. In the initial surgery; polyaxial pedicle screws were placed to the strategic vertebra after skin and subcutaneous tissue dissection without subperiosteal muscle dissection on midline. Then, rods were placed in situ after achieving correction with the help of manual traction (J-tongue from head and manual traction from lower extremities). The most proximal and most distal screws were fixed and the rest of the screws were left with nonlocked tap-screws. The lengthening re-operations were performed every 6 months. The patients were braced (TLSO) after surgeries. The coronal plane correction ratio, truncal height increase and complications were documented.

Results: Initial curve correction went from 68 degrees (38-92) to an average of 20 degrees (4-36) and maintained at 22 degrees (4-36) at minimum two-year

follow-up. Two of 16 patients underwent final permanent surgery after fifth lengthening surgery. In two of 16 patients, hybrid procedure was performed (apical vertebra resection + growing rod). The average number of lengthening operations was 5.5. The average coronal plane correction was 65% and average truncal height increase was 13%. The truncal height increase significantly reduced after fifth lengthening surgery. In the sagittal plane; decrease of thoracic kyphosis was not seen (preoperative and last follow-up mean thoracic kyphosis were 23.4 and 22.6 degrees). No patient had significant changes in the spinal cord monitoring. There was no infection. In one patient, instrumentation was elongated distally due to adding on deformity.

Conclusion: Our new treatment strategy provides that the screws in apical and intermediate vertebra controlled the curve, prevents progression, maintains rotational stability and allows continuation of trunk growth.

27. One Stage Posterior Osteotomy with Short Segmental Fusion and Dual Growing Rod Technique for Severe Rigid Early-Onset Congenital Scoliosis: A Hybrid Technique

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China

Summary: There have been many reports on both osteotomy with short segmental fusion and growing rod technique for early onset congenital scoliosis. But as some early onset congenital scoliosis are long, severe and rigid, the deformity can't be well corrected or controlled only with osteotomy or growing rod technique.

Introduction: This is a retrospective study on one stage posterior osteotomy with short segmental fusion and dual growing rod technique for severe rigid congenital scoliosis

Methods: From 2006 to 2011, 7 patients (2males, 5 females) underwent one stage posterior osteotomy with short segmental fusion and dual growing rod technique for severe rigid congenital scoliosis. The mean follow-up was 45.7 (24-71)months. There were 2 revision surgeries. The mean age at the initial surgery is 5.8 (2~10) years. Of 40 total procedures within the treatment period, 33 were lengthenings with an average of 4.7lengthenings per patient. The Analysis included age at initial surgery and the latest follow-up, number and frequency of lengthening, and complications. Radiographic evaluation included measured changes in scoliosis Cobb angle, thoracic kyphosis, lumber lordosis, trunk shift, length of T1-S1 and instrumentation.

Results: The mean scoliosis improved from 81.4° (range, $58^\circ-99^\circ$) to 41.1° (range, $30^\circ-55^\circ$) after initial surgery and was 40.7° (range, $30^\circ-58^\circ$) at the last follow-up or post-final fusion. T1-S1 length increased from 23.70 (range, 20.40-26.70) to 27.00 cm (range, 23.50-30.00) after initial surgery and to 31.70 cm (range, 27.50-34.80) at last follow-up with an average T1-S1 length increase of 1.37cm per year (range, 0.70-2.30). The length increase of instrumentation was 0.82cm per year (range, 0.22-1.65). The SAL increased from 0.86 to 0.96.

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Conclusion: One stage posterior osteotomy with short segmental fusion and dual growing rod technique is safe and effective for severe and rigid congenital scoliosis with large apex vertebra translation or short, angular kyphosis. The osteotomy with short fusion could help to improve the correction of the growing rod and eliminate the large asymmetric growth potential around the apex, with little influence to the length of the spine. This is also helpful to decrease the stress of implants and thus decrease the implants-related complications. Furthermore, it could maintain correction achieved at initial surgery while allowing spinal growth to continue.



28. Five to Sixteen-Year Results of 201 Growing Rod Patients: Is There a Difference Between Etiologies?

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Summary: 201 growing rod (GR) patients with 5-year minimum follow-up had the majority of their scoliosis correction achieved at the index GR surgery. Annual T1-S1 growth was similar across all etiologies (P=0.628). Congenital patients had the smallest T1-S1 increase at index GR surgery. Syndromic patients had the highest annual T1-S1 growth after index GR surgery.

Introduction: Etiology was identified as a core component for a new classification system of Early Onset Scoliosis (C-EOS). The purpose of this study was to compare long-term results of GR treatment between etiologies in a large cohort of patients.

Methods: Out of 574 GR patients from a multi-center database, 201 patients had minimum 5-year follow-up (F/U) and data available for analysis. Based on C-EOS, patients were grouped into four etiologies: Congenital/Structural (C), Neuromuscular (N), Syndromic (S) and Idiopathic (I). Annual T1-S1 growth is the T1-S1 increase from post-index GR surgery to the latest F/U divided by the length of time from post-index GR surgery to the latest F/U. Latest F/U was the most

recent visit prior to final fusion.

Results: There were 47 (24%) "C" patients, 49 (24%) "N" patients, 62 (31%) "S" patients and 43 (21%) "I" patients. "C" patients had the least curve correction at index GR surgery and the greatest loss of curve correction from post-index surgery to latest F/U. Only "I" patients preserved their curve correction from post-index GR to latest F/U. Annual T1-S1 growth was not statistically different across all etiologies (P=0.628). "N" patients had the largest T1-S1 increase at index but the lowest annual T1-S1 growth. "C" patients had the smallest T1-S1 increase at index surgery. "S" patients had the highest annual T1-S1 growth after index GR surgery. (Table 1)

Conclusion: Across all etiologies, the majority of curve correction was achieved at the index GR surgery. "I" patients maintained their curve correction during the treatment period but non-"I" patients lost up to 30% of their curve correction from post-index GR surgery to latest F/U. Annual T1-S1 growth was comparable across all etiologies.

	CONGENITAL	NEUROMUSCULAR	SYNDROMIC	IDIOPATHIC
Age at Pre-Index Surgery (years)	4.7	6.1	4.9	5.8
Mean Length of F/U (years)	7.0	7.2	7.0	7.2
Mean # of Lengthenings	5.1	4.6	6.2	5.0
Mean # of Revisions	3.1	2.6	2.1	1.4
Curve Correction: Pre- to Post-Index Surgery	33%	46%	47%	47%
Curve Correction: Post-Index Surgery to Latest F/U	-29%	-17%	-26%	5.4%
T1-S1 Increase: Pre- to Post-Index Surgery	29 mm	45 mm	38 mm	38 mm
Annual T1-S1 Growth	10.1 mm	7.9 mm	10.4 mm	9.1 mm

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).

29. Comparison between 44 Early Fusion and 31 Growing Rod Graduates for Early-Onset Scoliosis

Koki Uno, MD, PhD; Tepei Suzuki; Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Morio Matsumoto, MD; Kota Watanabe; Haruhisa Yanagida, MD; Katsushi Takeshita, MD; Toru Hirano; Manabu Ito, MD, PhD Japan

Summary: To evaluate the surgery for early onset scoliosis (EOS), 44 patients who had fusion at 10 years old or earlier (Fusion Group; FG) and 31 growing rod graduates (Growing Rod Graduates; GRG) were examined and compared. Spine elongation (T1-S1 gain after surgery) and lung space gain throughout the treatment was significantly less in FG. However, the clinical significance of these results need to be examined.

Introduction: To evaluate the effect of early fusion for early onset scoliosis (EOS), 44 patients who had fusion at 10 years old or earlier (Fusion Group; FG) and 31 growing rod graduates (GRG) were examined and compared.

Methods: There were 44 patients (16 male, 28 female) in FG, and 31 patients (9 male, 21 female) in GRG, average age the initial surgery was 8.3 and 8.7 years and average follow-up was 7.8 and 7.4 years respectively. Diagnosis included idiopathic in 11 (FG), 8 (GRG), Congenital in 0 (FG), 3 (GRG),

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Neurofibromatosis in 10(FG), 5(GRG), Syndromic in 7(FG), 10(GRG), Neuromuscular in 4(FG), 4(GRG), and others in 10(FG), 1(GRG) respectively. Data was collected from 7 different hospital as a multi-center study. Height, sitting height, radiological findings(magnitude of scoliosis, kyphosis, T1-S1 length, lung capacity, trunk balance), at pre, post surgery, final follow-up was measured and examined.

Results: Curve Magnitude was 73(FG) and 88 degrees(GRG) pre initial op, 29(FG) and 49degrees (GRG) post initial op, 35(FG) and 43(GRG) degrees at final follow or post definitive fusion. Kyphosis(T5-12) was 44(FG) and 48(GRG)degrees pre initial op, 32(FG) and 42(GRG)degrees post initial op, and 40(FG) and 44(GRG) degrees at final follow or post definitive fusion. Good Coronal balance and sagittal balance was obtained in both groups. T1-S1 gain between pre and post initial operative period was 29(FG), 43mm(GRG), T1-S1 gain between post initial op and final follow was 25(FG), 43(GRG)mm respectively. Lung space gain was 14(FG), 22(GRG)mm between pre and post initial op period. Lung space between post initial op and final follow was 25(FG), 35(GRG)mm).

Conclusion: Spine elongation(T1-S1 gain after surgery) and lung space gain throughout the treatment was significantly less in FG. The clinical significance of these results need to be examined.

30. The Effect of Rib-Based Distraction Surgery on Spine Growth

Ron El-Hawary, MD, MSc, FRCSC; Michael G. Vitale, MD, MPH; Amer F. Samdani, MD; John A. Heflin, MD; Melissa Smith; Joshua W. Klatt, MD; John T. Smith, MD Canada

Summary: The purpose of this study was to evaluate the effect of rib-based distraction on spine growth. At 5-yr follow-up, scoliosis correction was maintained, and kyphosis, thoracic height, lumbar height, and T1-S1 height increased. Changes in T1-S1 height/lengthening decreased after the first five lengthenings, but maintained almost 50% of expected age-related growth through subsequent lengthenings. When expressed as a percentage of initial T1-S1 height, there is still a 15% increase in T1-S1 height between the 6th and 10th lengthening.

Introduction: For children with spine-based distraction systems, it has been published that T1-S1 length achieved after the initial lengthening procedure decreases with each subsequent lengthening. Our purpose was to evaluate the effect of rib-based distraction on spine growth in children with EOS. The hypothesis was that rib-based distraction will improve spine growth; however these gains may decrease over time and may be related to the normal slowing of T1-S1 growth between the ages of 5 and 10 years.

Methods: This was a retrospective, multi-center, review of 37 patients with minimum 5 yr follow-up after rib-based distraction surgery. Radiographs were analyzed at initial implantation and at each lengthening procedure. Primary outcome was change in T1-S1 height per lengthening procedure which was normalized to the expected age-based T1-S1 growth. T1-S1 length gains were also normalized to initial T1-S1 length.

Results: Thirty seven patients with a mean age of 2.6 years at initial surgery were studied. Their diagnoses included congenital (n=19), syndromic (n=7), idiopathic (n=5), and low-tone neuromuscular (n=6). Major Cobb angle was 59.0° and maximum kyphosis was 39.6°. These patients had a mean of 9 lengthening procedures. Three groups were compared: First 5 lengthenings (L1-L5), 6th through 10th lengthenings (L6-L10), and 11th through 15th lengthenings (L11-L15). Cobb angle stayed relatively constant (51.9°, 49.1°, 53.8°) while maximum kyphosis increased (49.2°, 57.7°, 65.5°)*. Percent expected T1-S1/lengthening decreased (159%, 46%, 47%) while T1-S1 length / initial T1-S1 length increased (L1=7%, L2-5 = 10%, L6-10 = 15%).

Conclusion: When normalized to expected age-related spine growth, rib-based distraction appears to follow a similar law of diminishing returns to spine-based systems; however, when expressed as a percentage of initial T1-S1, there is still a 15% increase in T1-S1 between the 6th and 10th lengthening.

Although there is the appearance of a law of diminishing returns, these changes were not statistically significant. Even by the 10th lengthening, rib-based distraction continues to increase T1-S1 length.

31. The Use of Rib-Based Distraction in Dysplastic Early-Onset Scoliosis Associated with Neurofibromatosis

John T. Smith, MD; John A. Heflin, MD; Michael G. Vitale, MD, MPH; Ron El-Hawary, MD, MSc, FRCSC; Randal R. Betz, MD USA

Summary: Poor bone quality and dysplastic pedicles make the use of spine based growing rods challenging in patients with NF1. The use of rib-based distraction is an effective method to stabilize curve progression thru growth in severe dysplastic scoliosis associated with NF1. Despite associated dysplasia of the ribs, the incidence of rib migration in 33% of the patients was acceptable as was the overall rate of complications.

Introduction: . Patients with NF1 commonly have scoliosis curves that are frequently dysplastic, progressive, have associated rib anomalies, and respond poorly to bracing. Poor bone quality and dysplastic pedicles make the use of spine based growing rods challenging. The purpose of this study is to evaluate the effectiveness of rib based distraction and associated complications to manage scoliosis in the growing child.

Methods: This is a review of 12 children with NF1 and scoliosis treated with rib based distraction. The mean age at implantation of the VEPTR device was 6.3 years. The mean preoperative Cobb angle was 61 degrees. The average length of follow-up was 4.2 years (range 2- 9.6 yrs)

Results: The average postoperative Cobb angle was 51 degrees after an average of 5.2 lengthening procedures (0-13). No patient progressed beyond their pre-op curve. There were 15 complications in 8 patients (device migration 4, wound dehiscence 2, rod breakage 1, medical issues 5). 8 of 15 complications were Grade I, 7 Grade IIA, and there were no Grade III. Two patients reached skeletal maturity and have had a final fusion.

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Conclusion: The use of rib-based distraction is an effective method to stabilize curve progression thru growth in severe dysplastic scoliosis associated with NF1. Because of the associated dysplasia of the ribs, the incidence of rib migration in 33% of the patients was deemed acceptable, as was the overall rate of complications. We recommend rib-based distraction techniques as an effective method to manage progressive early onset curves in NF1, allowing them to have a definitive fusion at skeletal maturity.

32. Proximal Rib Anchors Have 77% Less Risk of Rod Breakage Than Proximal Spine Anchors In Distraction-Based Growing Rods

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USA*

Summary: This comparative survival analysis of rod breakage between distraction-based growing rods with proximal spine anchors versus proximal rib anchors shows that proximal rib-anchored rods have 1/4th the risk of rod breakage compared to proximal spine-anchored growing rods, without an increase in the risk of anchor complications.

Introduction: Rod breakage is a known complication of distraction-based growing rod instrumentation. We compare the risks of rod breakage and anchor complications between distraction-based growing rods with proximal spine versus rib anchors.

Methods: A retrospective multi-center study of 176 patients with inclusion criteria of: minimum 2 year follow-up; under 9yo at index surgery; distraction based growing rods (not VEPTR), and known anchor locations was performed. Mean follow-up was 56 months (24-152). We performed survival analysis via the Cox proportional hazards model, accounting for varying lengths of follow-up. Analyses of anchor complications, preoperative Cobb Angle, # growing rods, age, and # of levels instrumented were performed using significance of $p < 0.05$.

Results: 34 patients had rib-anchored growing rods and 142 patients had spine-anchored growing rods. Our analysis found that proximal rib-anchored growing rods have 23% the risk of lifetime rod breakage compared with spine-anchored growing rods ($p=0.041$) without a significant increase in risk of anchor complications ($p=0.117$). The number of implanted rods ($p=0.839$), age ($p=0.649$), and number of instrumented levels ($p=0.447$) were not statistically significant regarding rod breakage risk, though higher preoperative Cobb angles were associated with an increased risk of rod breakage ($p=0.014$).

Conclusion: Proximal rib-anchored growing rods are protective against rod breakage without increasing the risk of anchor complications. We postulate that the rib-anchored growing rod systems may be associated with less rod breakage as the system is less rigid as a result of some "slop" at the hook-rib interface, as well as the normal motion of the costovertebral joint.

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).

33. Peri-Operative Neurological Injury Associated with VEPTR Surgery

*Ron El-Hawary, MD, MSc, FRCSC; Luke Gauthier, MD; Amy L. McIntosh, MD; Yousef Mandourah, BSc; John M. Flynn, MD
Canada*

Summary: Our purpose was to define the rates of neurologic injury associated with rib-based distraction surgeries, as well as to determine if pre-operative diagnosis affects these rates. Our retrospective review of the CWSDSG database identified nine neurologic injuries in a sample of 524 patients, for a rate of 1.7%. Injuries were predominantly to the brachial plexus and generally resolved. Rates of neurologic injury were higher for patients with congenital/structural and for those with idiopathic diagnoses.

Introduction: General complication rates for posterior distraction-based surgery are known to be high; however, there are few reports in the literature on neurologic injury after rib-based distraction. Our purpose was to define the rates of neurologic injury associated with these surgeries as well as to determine if pre-operative diagnosis affects these rates.

Methods: This was a retrospective review of the CWSDSG database from 2004-2013. Chi-square testing was used to compare the distributions of proportions between diagnoses. Significance was defined as $p < 0.05^*$.

Results: There were 524 patients identified who were treated with rib-based distraction. Using the Classification for Early Onset Scoliosis, diagnoses was 223 congenital, 163 neuromuscular, 63 syndromic, 67 idiopathic, and 8 unknown. There were 9 neurologic injuries identified for a rate of 1.7%. Seven of these patients were classified as congenital and 2 as idiopathic, each with a neurologic injury rate of 3%*. At the time of injury, mean age was 4.1 years, mean scoliosis was 66.2° and mean kyphosis was 44.2° .

All injuries occurred at the time of initial implantation, with the exception of one patient in which injury occurred during revision surgery. There were no injuries identified during routine lengthening surgery. None of these injuries were complete spinal cord injuries and the majority involved injury to the brachial plexus ($n=5$). Re-operation (devices shortened or partially removed) was required for 4 patients. At a mean follow-up of 4.2 years, 7 of 9 patients had full resolution of their symptoms and 2 of 9 patients had residual upper extremity weakness.

Conclusion: The rate of neurologic injury for patients treated with rib-based distraction surgery was 1.7%. These injuries were predominantly to the brachial plexus and generally resolved. Rates of neurologic injury were higher for patients with congenital/structural and for those with idiopathic diagnoses.

Information on the rates of neurologic injury related to rib-based surgery is important as identification of high risk patients may assist surgeons to modify their technique to improve patient outcomes.

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34. Minimum 20-Year Health Related Quality of Life and Subsequent Surgical Rates for Braced, Observed and Surgical Patients Treated for Adolescent Idiopathic Scoliosis in the US

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USA

Summary: Reported health related quality of life scores at a mean 29-year follow-up were similar among braced, observed, and surgical AIS patients. Reoperation was common in patients undergoing childhood surgery (10%). No patients in the braced population have required spinal fusion for scoliosis as adults.

Introduction: There is limited data regarding the long-term outcomes of scoliosis treatment in the US population. A novel cohort of patients who underwent pediatric treatment with surgery, bracing, or observation for adolescent idiopathic scoliosis (AIS) was identified with minimum 20-year follow-up. We aimed to determine the health related quality of life (HRQL) and rate of related surgical procedures in adulthood.

Methods: Search of a single-center diagnostic registry generated a list of 2,661 patients treated for scoliosis. Of those, 337 patients met inclusion criteria (AIS, curve magnitude $> 35^\circ$, and childhood treatment with bracing, surgery, or observation between 1975-1992). Rates of additional surgery as well as EQ5D, ODI, SRS 30, SAQ scores were determined. Responses were obtained in 78 patients at a mean 29-year follow-up (range, 20-37 years). Childhood treatment entailed bracing (15 patients), surgery (49 patients), or observation (14 patients). There were no detected differences in gender or age at presentation in the 78 patients compared to the remaining cohort ($p=0.49, 0.56$).

Results: In adulthood, no bracing patients underwent scoliosis-related spine surgery, whereas 3/14 nonoperative patients (13%) and 5/49 childhood surgical patients (10%) underwent scoliosis-related surgery as adults. Five females (four surgical, one observed, all with major thoracic curves) underwent breast reconstructive surgery.

There were no detected differences in braced, surgical, and observed cohorts (Table). Patients who had undergone any spine surgery as an adult had poorer ODI (20 versus 13, $p=0.048$), SAQ expectation (13 versus 9, $p=0.01$), SRS pain (3.6 versus 3.8, $p=0.05$), and SRS satisfaction scores (3 versus 3.9, $p=0.04$) compared to patients who did not have adult spine surgery.

Conclusion: HRQL scores were similar between the surgical and nonoperative patients, despite larger childhood curve magnitudes in the operative group. There was a low rate of adult scoliosis surgery in the braced population, compared to those undergoing childhood surgery or those who were observed, typically for large magnitude curves at skeletal maturity. Efforts are underway to collect complete clinical follow-up with current radiographs and pulmonary function testing.

35. Parameters Leading to a Successful Outcome Following Surgical Treatment for Lenke 2 Curves

Heiko Koller, MD; Anna M. McClung, BSN, RN; Daniel J. Sucato, MD, MS
Germany

Summary: This study demonstrated that patients with Lenke 2 curves more commonly do not have inclusion of the proximal curve in the fusion levels when treating these curves. Despite differences in needing inclusion of the PT curve, the overall radiographic results with respect to fusion levels was similar between the two groups.

Introduction: The Lenke classification has established criteria which designate the proximal thoracic (PT) curve as structural (Lenke 2) in adolescent idiopathic scoliosis (AIS). Inclusion of the PT curve is generally thought to be necessary to balance shoulders, restore coronal balance and to yield a good overall result; however, there are conflicting data in the literature. The purpose of this study was to determine parameters that provide a successful balancing of the patient, in general, and of the shoulders and trunk in particular.

Methods: A retrospective review of a consecutive series of patients with Lenke 2 AIS at two institutions was performed. Patients were grouped into those who had inclusion of the PT curve (+PT fusion) vs not (-PT fusion). Outcome parameters were analyzed and compared to predictors for a successful outcome.

Results: There were 170 patients: 64 in the +PT group and 106 in the -PT group without differences in age (14.4 versus 15.1 yrs), gender, the preoperative PT magnitude (40.7 versus 39.0°), or flexibility (21.6% versus 21.2%), the main thoracic (MT) magnitude (65.9 versus 64.3°), lumbar curve (33.8 vs 36.8°) or coronal balance (15.4 vs 13.0 mm). The preoperative MT flexibility was less in the +PT group (49.5 vs 41.4%) ($p=0.0043$) and the T1 tilt was higher (6.0 vs 3.9°) ($p=0.04$). At 2 years, inclusion of the PT curve resulted in a smaller PT curve (23.5 vs 27.7°) ($p=0.021$), and greater PT curve correction (42.1 vs 29.8%) ($p=0.0019$) but no difference in MT Cobb (31.3 vs 33.2°), lumbar Cobb (17.7 vs 20.6°) in T1 tilt, shoulder height, or clavicle angle.

Conclusion: The PT curve inclusion for Lenke 2 curves requires critical evaluation of the clinical appearance of the patient and good clinical acumen to determine when it is necessary. The radiographic parameters alone cannot be used to determine when the PT inclusion is necessary since the patients in this study demonstrated no differences in shoulder height, T1 tilt and clavicle angle at 2 years whether the PT curve was included or not.

36. Does Selective Thoracic Fusion Provide Satisfactory Outcomes in Adolescents with Chiari Malformation-Associated Scoliosis?

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China

Summary: Twenty-seven adolescents with Chiari malformation-associated scoliosis (CMS), treated with posterior selective thoracic fusion, were retrospectively

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reviewed. Our results show that selective thoracic fusion can provide a satisfactory outcome in CMS patients if they meet the criteria of selective fusion for adolescent idiopathic scoliosis (AIS).

Introduction: Long instrumentation is considered to be necessary in neuromuscular scoliosis for preventing the coronal and sagittal decompensation after surgery. To our knowledge, there are few studies focusing on the long-term results of short instrumentation for scoliosis secondary to Chiari malformation. The purpose of this study is to evaluate the clinical outcome of posterior thoracic fusion in adolescents with thoracic scoliosis secondary to Chiari malformation.

Methods: A total of 273 patients with CMS treated in our center from July 2002 to May 2010. Among them, 27 adolescents met the following inclusion criteria: posterior selective thoracic fusion referring to the criteria for selective fusion in AIS, a minimum 2-year follow-up. There were 11 males and 16 females, with an average age of 15.2 years (range, 12-18 years). The following radiographic parameters before surgery, immediately after surgery and at the last follow-up were compared: coronal Cobb angle, apical vertebral translation (AVT), apical vertebral rotation (AVR), trunk shift (C7PL-CSVL distance), thoracic kyphosis (TK), lumbar lordosis (LL), thoracolumbar kyphosis, and sagittal vertical axis (SVA). The clinical outcome was evaluated using the SRS-22 questionnaire.

Results: All the patients received a follow-up from 2 to 7 years (mean 3.4 years). Lower instrumented vertebrae (LIV) located at L1 in 12 patients, at L2 in 15 patients. Average thoracic and lumbar Cobb angle was 51.5° and 30.4° respectively, while decreased to 22.7° and 12.4° immediately after surgery. At the last follow-up, the average correction rate of thoracic curve was 55.7% with an average rate of correction loss at 2.3%. The spontaneous correction rate of lumbar curve was 59.2% on average with no correction loss. No distal junctional kyphosis (DJK) and proximal junctional kyphosis (PJK) occurred. At the last follow-up, self-image was significantly improved (mean 10.3 vs 20.9), whereas pain (15.7 vs 12.3), function (16.4 vs 14.5) and mental health (15.5 vs 21.7) were similar when compared with the SRS-22 subscore before surgery.

Conclusion: Selective thoracic fusion can provide a satisfactory outcome in CMS patients if they meet the criteria of selective fusion for AIS.

37. Is Breast Asymmetry Present in Girls with Adolescent Idiopathic Scoliosis? Revisiting a Common Belief

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Canada

Summary: The aim of this study was to describe breast asymmetry using magnetic resonance imaging (MRI) in patients with AIS. In setting a breast asymmetry threshold at 5%, 33 % of our cohort is considered to present breast asymmetry with the left breast being larger. This finding could compound the apparent asymmetry secondary to trunk rotation as seen in scoliosis.

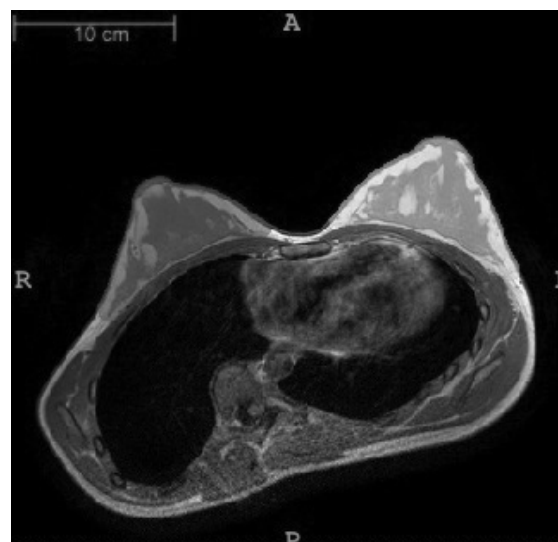
Introduction: Common belief regarding breast asymmetry in Adolescent Idiopathic

Scoliosis (AIS) is secondary to the trunk rotation and deformity. Breast asymmetry is common in the adult population. The aim of this study was to describe breast asymmetry as defined by breast volume difference of more than 5% using magnetic resonance imaging (MRI) in patients with AIS.

Methods: Thirty young girls (Mean age: 15.7 ± 1.4 yrs) skeletally matured (Risser 4 and 5) with AIS (29 right thoracic scoliosis and one left thoracic scoliosis) presenting a significant thoracic Cobb angle (Mean: 46 degrees, ranging from 26 to 81) were recruited in the Scoliosis Clinic without regard to their subjective opinion on their breast asymmetry. 18 patients were treated with a brace and at least 15 patients have planned spine surgery. The MRI acquisitions were performed in a prone position on a clinical 1.5T system (Achieva XR, Philips Healthcare, Best, The Netherlands) using a dedicated 16-channel breast coil. Breast segmentation was achieved in a semi-automatic manner by the same investigator using ITK-SNAP 2.4.0.

Results: The average breast volume obtained from this cohort is 498.8 cc (Min 174.3, Max 1178.1) The left breast is consistently larger in 22/30 patients. The mean breast volume asymmetry is 4.3% with a 95% CI (3.1%-5.5%) (p<0.0001). There is a weak correlation between the thoracic Cobb angle and the breast volume asymmetry (r=0.351, p=0.057). In setting a breast asymmetry threshold at 5%, 33 % of our cohort is considered to present breast asymmetry.

Conclusion: Breast asymmetry measured using MRI is objective, precise and considered reproducible. The majority of the patients in this series had a larger left breast, which could compound the apparent asymmetry secondary to trunk rotation as seen in a right thoracic scoliosis. In many cases, breast asymmetry is present independently of the thoracic deformity.



This image shows an axial cut showing the volume segmentation as well as the axial rotation present in scoliosis.

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38. Is Pelvic Incidence in Severe Adolescent Idiopathic Scoliosis Patients Different from General Population? Results of the Analysis of a Monocentric Cohort of 415-Adolescent Idiopathic Scoliosis Subjects

Christophe Vidal, MD; Brice Ilharreborde, MD; Keyvan Mazda

France

Summary: The human standing position requires dynamic reciprocal spino-pelvic adjustments in order to maintain an economic posture. Sagittal balance has been widely described in populations of healthy adults and children with large descriptive cohort studies and showed common characteristics of reciprocal correlations between pelvic parameters and lumbar sagittal curvature. Such large-scale descriptive cohort studies are scarce in adolescent idiopathic scoliosis (AIS). The present study allowed to compare sagittal parameters in AIS and non-scoliotic population and to highlight significative differences.

Introduction: Sagittal alignment in non scoliotic subject has been widely described and strong reciprocal correlations have been characterized between pelvic parameters and lumbar lordosis. The present study aimed to describe pelvic incidence (PI), L1L5 lumbar lordosis (LL) and T5T12 thoracic kyphosis (TK) measurements in severe AIS and compare them to those observed in healthy control patients issued from normal populations of children, adolescents and adults in order to be able to identify significant differences that could be related to AIS' pathogeny and/or progression.

Methods: A radiological analysis of prospectively collected data based on a monocentric cohort of 415-severe AIS subjects was performed. Full-spine antero-posterior and lateral views were analyzed with a validated numerical software. PI, LL and TK, main Cobb angle and frontal apical vertebra were recorded. Reference sagittal plane analysis cohort studies were chosen to compare severe AIS patients characteristics to non-scoliotic children, adolescent and adults. Welch t-test was used to compare means ($=0.01$).

Results: Sex ratio was 320 girls and 95 boys (3.4F/1M). Mean sagittal Cobb angle was 44.7° ($+/-21.2^{\circ}$). Repartition of Lenke type curvatures in the cohort was: type 1 50.6%, type 2 20.7%, type 3 5.8%, type 4 0.5%, type 5 13.5%, type 6 8.9%. Mean PI and LL were not different in AIS compared to normal adults. AIS subjects had lower TK, LL and higher PI than normal adolescents and children ($p<0.001$).

Conclusion: This cohort study allowed to compare severe AIS with normal children, adolescent and adults' sagittal plane. The sagittal plane was explored focusing on PI, LL and TK. Lower TK illustrated sagittal plane usual scoliotic deformity of main-thoracic curves.

Higher PI and lower LL were identified in AIS population. Such differences could be either an effect or a risk factor of scoliotic deformity. Lumbar sagittal curvature could be seen as an adjusting segment between a fixed PI and a stiff TK in AIS.

39. How Effective is Providence Nighttime Bracing for Adolescent Idiopathic Scoliosis?

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USA

Summary: This is a retrospective case series examining the effectiveness of the Providence night-time brace for the treatment of adolescent idiopathic scoliosis showing a 50% success rate and a 24% surgical rate.

Introduction: This is a retrospective case series examining the effectiveness of the Providence night-time brace. The results of this series were compared to the three studies previously published using the Providence brace as well as to the previously published natural history of AIS and data available for other brace types.

Methods: A retrospective chart review was conducted of all Providence brace treated patients from 2003-2008. A total of 89 patients were reviewed, with 34 patients meeting modified SRS inclusion criteria, which were ≥ 12 months and curves ≥ 20 that had shown progression during observation. SRS guidelines were followed to assess successfulness of brace treatment quantified by the percentage of patients with ≤ 5 degrees of progression, final curve ≤ 45 , and no surgical interventions or curve progression necessitating conversion to full-time bracing.

Results: Overall there was a 50% (17/34) success rate of Providence bracing with 24% (8/34) surgical rate and the remaining 26% of patients failing due to progression > 5 degrees and/or conversion to a full-time brace. There were no successes in the limited number of male patients with 4/5 (80%) failing to surgery. Thoracolumbar and lumbar curves had a higher success rate (67%) compared to Thoracic (47%) and Double curves (37.5%), as did curves with an apex below T8 (60%) compared to those T8 and above (36%). Risser stage 0 patients had a lower success rate (41%) compared to Riser stage 1 and 2 patients (67%).

Conclusion: The current study with a 50% success rate coupled with a recent study with a 31% success rate calls into question the effectiveness of Providence bracing compared with initial reports of success rates of approximately 70%. However, Providence bracing was shown to be most effective in female patients with low apex curves and higher Risser stages and remains an attractive alternative to full-time bracing in this subset of patients.

40. Prevalence of Spondylolisthesis and Concomitant Adolescent Idiopathic Scoliosis: A Matched Cohort Analysis

Ronald A. Lehman, MD; Lawrence G. Lenke, MD; Daniel G. Kang, MD; Kathy Blanke, RN; Ensor E. Transfeldt, MD; Hubert Labelle, MD; Stefan Parent, MD, PhD

USA

Summary: This is the first study in 25 years depicting the true prevalence of spondylolisthesis and AIS. We found that 4.4% of AIS patients requiring surgical correction had concomitant spondylolisthesis. However, there was a much more significant percentage of patients presenting with spondylolisthesis

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having associated scoliosis (asymptomatic = 19.7, symptomatic = 29.2%). Patients presenting with either AIS or spondylolisthesis require evaluation for both conditions.

Introduction: The association of spondylolisthesis and AIS has never been thoroughly evaluated. We set out to determine the prevalence of patients with both spondylolisthesis and AIS and to evaluate clinical outcomes following surgical treatment for only one of the concomitant conditions.

Methods: A prospective, multi-center database of patients evaluated/treated for a primary diagnosis of AIS or spondylolisthesis was reviewed. Pts were analyzed in 3 groups: Group I - AIS pts requiring fusion (n=1132); Group II - symptomatic spondylolisthesis requiring fusion (n=66); Group III - asymptomatic spondylolisthesis (n=149). A matched cohort analysis (Group 1: age, gender, Lenke curve type, curve magnitude, amount of curve correction; Group 2: age, gender, Meyerding slip grade) was performed to evaluate the clinical outcomes of patients without a concomitant spinal disorder.

Results: A total of 1,347 pts were identified, but only 1,266 had adequate radiographs. In Group I, adequate radiographs were available for 1076 pts, and 47 (4.38%) had concomitant spondylolisthesis. In Group II, adequate radiographs were available for 48 pts, and 14 (29.2%) had concomitant true scoliosis, as well as 9 (13.6%) with sciatic scoliosis. In Group 3, adequate radiographs were available for 142 pts, and 28 (19.7%) had concomitant true scoliosis, as well as 13 (9.2%) with sciatic scoliosis. No difference in demographics existed between Group 1 and 2 and their respective matched cohorts (AIS treated surgically without spondy and spondy treated surgically without AIS, respectively). There was no significant difference in all components and total SRS outcome score between Group 1 and the matched cohort, with similar findings between Group 2 and the matched cohort.

Conclusion: Our study found symptomatic and asymptomatic spondylolisthesis are associated with concomitant scoliosis in approximately 20-30% of patients. In contrast, the prevalence of AIS requiring fusion with concomitant spondylolisthesis was relatively uncommon (4.4%). In the presence of coexistent spondylolisthesis and AIS, to achieve similar clinical outcomes, each may be treated independently and according to their individual surgical indications.

41. Are Pedicle Screw Perforation Rates Influenced by Registered or Nonregistered Vertebrae in Multi-Level Registration using CT-Based Navigation System in the Setting of Scoliosis?

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Summary: In multilevel registration of 3 vertebrae, no significant difference was found in the perforation and violation rates among the registered vertebrae and the nonregistered adjacent vertebrae, which are 1 or 2 vertebrae above the registered vertebrae. The accuracy of the screws implant were kept. Also, in an

average time required for one Pedicle Screw implant, this method needs only shorter time than conventional methods. It was thought that this method might become less invasive surgery.

Introduction: We developed a multi-level registration for pedicle screw insertion for posterior scoliosis surgery in which 3 consecutive vertebrae were registered with CT-based navigation system. For registration, the reference frame was set to the one caudal vertebra of 3 consecutive vertebrae, and pedicle screws were inserted into those 3 consecutive vertebrae and into the adjacent vertebrae. The purpose of this study was to investigate the perforation rates of the registered vertebrae and of the nonregistered adjacent vertebrae, which are 1 or 2 vertebrae above the registered vertebrae.

Methods: Forty scoliosis patients who underwent pedicle screw insertion by multi-level registration from May 2010 to August 2012 were studied. The position of pedicle screws using postoperative axial CT was classified by Rao's classification, with grades 2 and 3 representing "perforation" and grade 3 represents "violation." The perforation and violation rates of the registered vertebrae and of the nonregistered adjacent vertebrae were studied.

Results: The evaluation of screw malposition were as follows (grade 0, grade 1, grade 2, grade 3): the registered vertebrae (total,303): 171 (56.4%), 102 (33.7%), 19 (6.3%), 12 (4.0%); the nonregistered adjacent vertebrae, which are 1 or 2 vertebrae above the registered vertebrae (total, 192): 110 (57.3%), 68 (35.4%), 4 (2.1%), 10 (5.2%). Perforation rates of the 2 groups were 10.2% and 7.3%, and Violation rates were 4.0% and 5.2% respectively. Fisher's exact test was performed among the 2 groups, and no significant difference was found.

Conclusion: In multilevel registration of 3 vertebrae, no significant difference was found in the perforation and violation rates among the registered vertebrae and the nonregistered adjacent vertebrae, which are 1 or 2 vertebrae above the registered vertebrae. The accuracy of the screws implant were kept. Also, in an average time required for one Pedicle Screw implant, this method needs only shorter time than conventional methods. It was thought that this method might become less invasive surgery.

42. Selective Thoracic Versus Non-Selective Fusion in Lenke 3 Curves

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Summary: In the hopes of retaining maximal lumbar flexibility, surgeons attempt selective thoracic fusion whenever possible, including Lenke 3 curves. The purpose of this study is to identify the radiographic and clinical outcomes in Lenke 3 curves fused selectively (S) versus non-selectively (NS). A prospectively collected multi-center database was queried to identify 74 patients with Lenke 3 curves that had a posterior spinal fusion with 2 year follow-up. Patients treated with a selective

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fusion were significantly more likely to demonstrate coronal imbalance with less correction of lumbar Cobb and prominence.

Introduction: The surgical treatment options for Lenke 3 curves include fusion of both thoracic and lumbar curves (NS) or selective fusion (S) of thoracic curve only. Selective fusion of the thoracic curve spares lumbar motion segments but may result in marked residual deformity. In this study, we analyzed the clinical and radiological outcome in these patients at 2 year follow-up.

Methods: A prospectively collected multi-center database was retrospectively reviewed to identify patients with Lenke 3 curves treated with a PSF and 2 year follow-up. These patients were divided into two groups: Non selective fusion (NS) or Selective thoracic fusion (S). Radiographic and clinical data were compared between the groups utilizing ANOVA.

Results: 74 patients met our inclusion criteria, with 49 patients (66.2%) in the NS group and 25 (33.8%) in Group S. Overall, the patients in both groups had similar preoperative clinical and radiographic parameters except for lumbar Cobb (NS=56.2° S=47.6° p=0.01), lumbar lordosis (NS=56.8°, S=67.2°, p=0.01) and lumbar rotational prominence (NS=11.2, S=8.2, p=0.03). Postoperatively, NS fusion group demonstrated significantly less coronal imbalance (≥ 2 cm, NS=8%, S=52%, p<0.01). NS had improved lumbar curve correction (NS=68.2%, S=51.9% p<0.01), NS had greater improvement in thoracic and lumbar apical translation correction (p=0.01), and NS had better % correction of lumbar prominence as measured by inclinometer (NS=66.5%, S=7.2%, p=0.01). SRS-22 scores at 2 years were comparable between the groups.

Conclusion: In this cohort, selective PSF of Lenke 3 curves was attempted in approximately one-third of the patients. However, despite preoperatively smaller lumbar curves with less apical translation and lumbar prominence, the majority of patients with selected fusions were out of balance postoperatively and had inferior radiographic outcomes as compared to their nonselective comparison cohort.

43. Safety of Instrumentation in Vertebral Osteomyelitis

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Summary: In this retrospective review of vertebral osteomyelitis, instrumentation did not hinder the rate that the osteomyelitis was cleared. The instrumented cases have comparable mortality rates and improvements in Oswestry scores as non-instrumented ones. However, as expected, the length of stay and hospital cost is higher with instrumented cases.

Introduction: Hardware in orthopedics is associated with increased infection rates. The purpose of the study is to re-evaluate if instrumentation prevents the clearance of vertebral osteomyelitis.

Methods: A retrospective review of 920 spinal osteomyelitis from 2001-2011 from one institution was performed. Inclusion criteria included appropriate initial imaging, lab results, evaluation by the orthopedic department, and no treatment done prior to admission at an outside institution. Chi-squared statistic and single

sampled t tests were used to examine the data. Clearance of the infection was defined as normalizing of serum markers and resolution of osteomyelitis on MRI after 6 months of treatment.

Results: One-hundred and six patients meet the inclusion criteria: 62 men (58%), 44 women (42%), mean age 54 yrs., mean follow-up 38 months. A total of 32 instrumented cases (INST) [cervical: 14, thoracic: 8, lumbar: 10, mean age: 56, Male: Female= 2.2: 1] and 74 non-instrumented cases (NINST) [cervical: 9, thoracic: 20, lumbar: 46, mean age: 53, Male: Female= 1.2: 1]. A higher rate of the osteomyelitis cleared in the instrumented group (82%, n=26) compared to the non-instrumented group (62%, n=46) [OR: 2.4, CI=0.8 to 6.7; p=0.08]. Long-term improvements in the Oswestry scores from the time of presentation were similar between the groups: INST= from 62.9 to 49.2, NINST= from 67.4 to 45.2. Length of stay for the instrumented group (15.5 days) was significantly longer than the non-instrumented group (12 days) [p=0.04], with a higher cost of hospital admission [\$216,966 versus \$162,173]. The mortality rate (directly related to the osteomyelitis) in the INST group (11%, n=4) was similar to that of the NINST group (7%, n=5).

Conclusion: Instrumentation does not hinder the rate that the osteomyelitis is cleared, and subsequently instrumented cases have comparable mortality rates and improvements in Oswestry scores as non-instrumented ones. The length of stay and hospital cost is higher with instrumented cases.

44. Infection After Spinal Fusion for Neuromuscular Scoliosis: 30 Year Experience at a Single Institution

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Summary: Retrospective review of a 30 year period was performed to determine the incidence of surgical site infection (SSI) after posterior spinal fusion (PSF) for neuromuscular scoliosis (NMS), and to identify patient- and treatment-related risk factors.

Introduction: Infection is a serious but common complication of PSF for NMS, with reported rates of up to 20%.

Methods: Retrospective review of consecutive patients treated with PSF for NMS from 1980-2009, with multivariate statistical analysis to calculate odds-ratio (OR) for SSI for significant factors (P>0.05).

Results: There were 462 patients with a Cobb angle of 74.6 degrees. Deep infections occurred in 9.5% at mean 361 days after surgery. Nearly half (45%) were polymicrobial. Organisms were 57% Gram-positive and 43% Gram-negative. Implants were removed in 57%. SSI was more frequent from 1980-1989 (17.6%) than from 1990-2009 (7.9%) (P=0.008). SSI was more common in spina bifida (SB) (20.9%) than other diagnoses (7.6%) (P=0.0006). Other patient factors associated with SSI were BMI >25 (OR 2.5, P=0.04) and bladder/bowel incontinence (OR 2.4, P=0.007). Age, gender, ambulatory or

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nonverbal status, Cobb angle, albumin, lymphocyte count, and zinc level were not significant. Treatment-related factors associated with SSI were prophylactic antibiotics other than cefazolin (OR 2.4, P=0.006), inadequate cefazolin dose (<20 mg/kg) (OR 3.3, P=0.0003), levels fused (P=0.002), length of stay (P=0.006), and other postoperative complications (OR 3.2, P=0.0002). Drain output (P=0.04) and blood transfusions (OR 3.4, P=0.04) were significant in SB patients, and drain use was protective in non-SB patients (OR 0.5, P=0.04). Skin prep, antibiotic duration, type of instrumentation, rod size, implant material, cross-links, curve correction, bone graft, blood loss, surgery time, core temperature, antifibrinolytics, blood salvage, and dressing change were not significant.

Conclusion: Incidence of SSI has decreased over time, but remains relatively high. This study identified modifiable factors useful in this challenging population, especially prophylactic antibiotics and drain use.

45. Comparative Effectiveness and Cost-Benefit Analysis of Topical Vancomycin Powder in Posterior Spinal Fusion for Spine Trauma and Degenerative Spine Disease

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Summary: We introduced local vancomycin powder into our practice of posterior spinal fusion for spine trauma and degenerative spine disease and set out to determine the value and cost benefit of using vancomycin powder in surgical sites to prevent postoperative infections. The use of topical vancomycin powder was associated with significant reduction in incidence of postoperative infection, as well as infection-related cost. Use of adjuvant vancomycin powder is an effective and cost-saving option for preventing postoperative infections in posterior spinal fusion.

Introduction: Surgical site infection (SSI) is a morbid complication with high cost in management of surgical spine patients. In this era of healthcare reforms, adjuvant therapies that not only improve quality, but also decrease cost, are considered of highest value. We introduced local vancomycin powder into our practice of posterior spinal fusion for spine trauma and degenerative spine disease patients and set out to determine the value and cost benefit of using vancomycin powder in surgical sites to prevent postoperative infections.

Methods: A retrospective review of patients undergoing posterior spinal fusion for trauma or degenerative disease was performed. One group (control group) received standard systemic prophylaxis only; another (treatment group) received 1g of local vancomycin powder spread over the surgical wound in addition to systemic prophylaxis. Incidence of infection was the primary outcome evaluated. Billing records were reviewed to determine infection-related cost. The payers cost was estimated to be 70% of billing cost.

Results: A total of 110 patients (Control=54, treatment=56) with spine trauma and 455 patients (Control=318, treatment=137) with degenerative disease were included. Control and treatment groups were similar at baseline.

Use of vancomycin powder led to significant reduction in infection rate [Spine trauma: 13% versus 0% (p=0.02); Degenerative spine disease: 5.7% versus 0% (p=0.001)]. No adverse effects of vancomycin use occurred. Mean cost of post-operative surgical site infection was \$33,705 for spine trauma and \$29,440 for degenerative spine disease. Use of vancomycin powder led to cost savings of \$438,165 per 100 posterior spinal fusions performed for traumatic injuries and \$163,408 per 100 posterior spinal fusions performed for elective degenerative pathology.

Conclusion: The use of topical vancomycin powder was associated with a significant reduction in incidence of postoperative infection, as well as infection-related cost. Use of adjuvant vancomycin powder is an effective and cost-saving option for preventing postoperative infections in posterior spinal fusion.

46. Minimally Invasive Treatment of Adjacent Segment Degeneration via the Lateral Approach

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Summary: In a large single-site series of Minimally Invasive Lateral Interbody Fusions (MI-LIF), 441 patients were treated for ASD. Overall clinical and radiographic outcomes and are reported; results were encouraging.

Introduction: The MI-LIF approach provides a minimally disruptive alternative to anterior column access that allows for large graft placement, disk height restoration, and indirect decompression, while avoiding posterior scar tissue from the previous procedure. Results of ASD treated with MI-LIF are presented.

Methods: Of our single-site consecutive series of 1339 MI-LIF patients, 441 were treated for ASD. Clinical and radiographic measures were prospectively collected and evaluated.

Results: Age ranged from 28-91 years (average 62.9 years). 84.6% had one or more comorbidity. 245 patients (56%) were obese or morbidly obese. All but two cases included supplemental fixation: 38% unilateral pedicle screws, 21% bilateral pedicle screws, 7.3% lateral embroidered plate, and 51% laterally tabbed interbody implant. In 15 cases with prior posterior instrumentation, the pre-existing rods were removed unilaterally and revised on that side; in all other cases with prior instrumentation, adjunctive lateral fixation was used. Hospital stay averaged 1.4 days, with 4 blood transfusions and 4 wound infections. Complications included intraoperative hardware failure (7, revised during same procedure with no incident), ileus (8), gallstone pancreatitis (1), urinary retention (5), kidney stone (1), peritoneal catheter occlusion (1), pulmonary embolism (1), reintubation (2), subcutaneous hematoma (2), delirium (4), atrial fibrillation (4), MI at 6 weeks post-op (1), compression fracture at an adjacent level (6), sacral fracture (1), and postoperative quadriceps weakness (1, resolved within 4 weeks of surgery). Average VAS scores improved by 3.7 points from pre-op to 24 months. Average disk height improved from 5.9 to 10.4 at post-op, settling to 9.3mm at 24 mos; slip from 4.1 to 0.4mm. Definitive signs of fusion (Lenke

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1-2) were present in 76% at 3 months, 92% at 6 months, and 96% at 12 and 24 months.

Conclusion: Our experience using MI-LIF in the ASD population has shown that clinical and radiographic indicators improve commensurately and the overall outcome is encouraging.

47. Medially Misplaced Pedicle Screws in Patients Without Neurological Deficits Following Spinal Deformity Surgery: To Observe or to Remove?

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Summary: Some of pedicle screws (PS) inserted for correction of spinal deformity, may be misplaced medially without any neurological deficits. We still do not know whether they should be observed or removed during postoperative F/U period. This study indicated that medially misplaced PS more than 2 mm might cause of negative effects on the neural structure and should be removed during the early phase of the postop. period, even in patients with no postop. neurological abnormalities.

Introduction: There are a few reports focusing on neurological complications due to medial cortical perforation of PS following scoliosis spinal deformity. However, the long-term effects in those not associated with neurological complications have not been fully investigated and there is no indication whether they should be removed. The purpose of this study was to investigate whether PS medially misplaced into the spinal canal that are not associated with neurological deficits should be removed or not.

Methods: This was a retrospective study. A total of 47 patients with spinal deformity that underwent spinal fusion using 588 pedicle screws were retrospectively reviewed after a minimum follow-up of 2 years. The inclusion criteria included 1) patients with no problems during the insertion of PS; 2) no neurological deficits either intraoperatively or postoperatively, 3) complete removal of all implants after bone union when patients wanted it for themselves. Any potential canal compromise of the PS in the 47 patients was evaluated using immediate postoperative helical CT images. Medial cortical perforations were classified into three grades: Grade 1 (0-2 mm), Grade 2 (2-4 mm), and Grade 3 (over 4 mm). All unexpected events were recorded at the time removal of implants.

Results: CT images obtained 2 years postoperatively exhibited neither loosening of PS nor pseudoarthrosis in all patients.

CSF leakage from screw holes was recognized in 3 of medially misplaced 47 screws (6.4%) at the time of removal of the PS. There was no CSF leakage in Grade 1 (24 screws), 1 CSF leakage (5.9%) of Grade 2 (17 screws), and two (33.3%) of Grade 3 (6 screws). No neurological abnormalities occurred either intraoperatively or postoperatively.

Conclusion: This study indicated that medially misplaced PS more than 2 mm

might cause of negative effects on the neural structure and should be removed during the early phase of the postoperative period, even in patients with no postoperative neurological abnormalities.

48. The Impact of Surgical Timing on Non-Neurological Outcomes Following Complete Traumatic Spinal Cord Injury

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Summary: This retrospective study compared patients with a complete SCI operated ≤ 24 h to those operated >24 h post-trauma. Patients operated earlier had fewer complications and lower cost of acute hospitalization stay than those operated later. Surgical decompression within 24h of a complete traumatic SCI may be cost effective strategy to decrease the rate of complications.

Introduction: It remains unclear whether the benefits of early surgical decompression are important in neurologically complete spinal cord injury (SCI) as compared to patients with incomplete SCI. We wanted to compare the effects of early and late surgical timing on non-neurological outcome in persons with traumatic complete SCI.

Methods: A retrospective cohort study was performed in a single institution specialized in the acute care of SCI. One hundred ninety seven cases of traumatic complete SCI patients were reviewed. The occurrence of pneumonia, urinary tract infection (UTI), pressure ulcer (PU) and all other post-operative complications were recorded for each patient. Cost of hospitalization was calculated for each patients based on administrative data. Patients operated within 24h of the trauma were compared with patients operated later than 24h after the trauma. The effects of surgical timing on complication rate and cost of hospitalization were adjusted for potential confounding variables using multiple regression analyses. Potential confounding variables were the level of SCI, type of traumatic brain injury (TBI - mild or moderate), Injury Severity Score (ISS), Age, Charlson Comorbidity Index (CCI) and Surgical Invasiveness Index (SII).

Results: Our cohort comprised 197 SCI with complete lesions. Fifty-five were operated ≤ 24 h from injury and 142 patients were operated >24 h. Baseline demographic and clinical variable were comparable between the two groups. Pneumonia, UTI and the presence of any complications were significantly higher in the group operated >24 h post-trauma. Cost of hospitalization was higher among patients operated >24 h (≤ 24 h: 22,828\$ \pm 16,098\$ vs >24 h: 29,714\$ \pm 19,433\$). Surgical timing >24 h was a predictor of pneumonia, UTI, total complications and higher cost of hospitalization after controlling for other confounding variables.

Conclusion: This study shows that surgical decompression and stabilization ≤ 24 h following a complete SCI may reduce the complications rate and the costs of health care during the acute phase hospitalization.

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49. The Seattle Spine Team Approach to Adult Spinal Deformity: Significantly Reduced 30, 60 and 90 Day Perioperative Complication Rates

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Summary: Reported perioperative complication rates in adult spinal deformity surgery are unacceptable (40-86 percent). System and team approaches are necessary to increase patient safety in an older frail population. Our data suggests that a concerted team approach consisting of a dual attending surgeon approach in the operating room, a complete live preoperative screening process and a reproducible intraoperative protocol for managing coagulopathy will significantly reduce perioperative complication rates and enhance patient safety in patients undergoing complex spinal reconstructions for adult spinal deformity.

Introduction: Current reported complication rates in adult spinal deformity surgery are unacceptable (40-86 percent). System and team approaches are necessary to mitigate risk and increase patient safety in an older frail population.

Our group has reported on the dual attending surgeon approach, a live multidisciplinary preoperative screening conference and our intraoperative protocol for the management of coagulopathy at previous SRS/IMAST meetings. The positive outcomes of these measures are demonstrated by complication rates before and after the institution of this three pronged protocol.

Methods: 40 consecutive patients in group A were managed without the three pronged approach. 124 consecutive patients in Group B had a dual attending surgeon approach, were presented and cleared by a live multidisciplinary preoperative conference, and managed and resuscitated according to the intraoperative protocol administered by complex spine specific anesthesiologists as previously presented. Readmissions and complications were assessed at 30, 60 and 90 days in both groups.

Results: Group A had an average age of 62 (39-84). Group B had an average age of 64 (18-84). A majority of patients in both groups had multilevel fusions from 9-15 levels. Surgical approach was similar between groups. Overall complication rates in Group B were significantly lower (16 percent versus 52 percent) ($p < 0.001$). Group B showed significantly lower return rates to the OR during the perioperative period (0.8% versus 12.5%) ($p < 0.001$). Group B also had lower rates of wound infection requiring debridement (1.6% versus 7.5%), lower rates of DVT/PE (3.2% versus 10%), and lower rates of postoperative neurological complications (0.5% versus 2.5%) (NS). Group B had significantly lower rates of urinary tract infection requiring antibiotics (9.7% versus 32.5%) ($p < 0.001$).

Conclusion: Our data suggests that a concerted team approach consisting of a dual attending surgeon approach in the operating room, a complete live preoperative screening conference and a reproducible intraoperative protocol for managing coagulopathy will significantly reduce perioperative complication rates and enhance patient safety in patients undergoing complex spinal reconstructions for adult spinal deformity.

50. Incidence and Risk Factors for Venous Thromboembolism after Spine Surgery

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Summary: This is the first prospective comparative study to demonstrate the incidence and identify the associated risk factors of venous thromboembolism after spine surgery. The incidence of VTE was 15.2% in the decompression group, 13.3% in the fusion group, 4.5% in the cervical group, and 22.0% in the tumor group. Advanced age, neurologic deficits, and spinal tumors were all risk factors.

Introduction: There has been no comparative study on venous thromboembolism (VTE) after spine surgery. The goal of this study is to demonstrate the incidence and identify the associated risk factors of VTE after spine surgery.

Methods: Four groups of patients were included in this study.: 1) 79 patients with lumbar spinal stenosis treated with decompression without fusion were defined as the decompression group; 2) 90 patients with lumbar and/or thoracic degenerative disease treated with spinal fusion were defined as the fusion group; 3) 89 patients with cervical degenerative disease treated with decompression and/or fusion were defined as the cervical group; 4) 82 patients with spine tumor treated with total en bloc spondylectomy or piecemeal excision with stabilization were defined as the tumor group. Deep venous thrombosis (DVT) and pulmonary thromboembolism (PTE) screening was performed for all 340 patients 7-10 days after surgery. The binomial logistic regression analysis was used to assess the association of risk factors.

Results: The overall incidence of VTE was 13.5% (46/340 patients). 2.9% (10/340 patients) showed pulmonary embolism (PE), and in 6 of these 10, no deep venous thrombosis (DVT) was found. However, there were no patients with symptomatic DVT, and only 0.59% of the patients (2/340 patients) had symptomatic PTE. The incidence of VTE was 15.2% in the decompression group, 13.3% in the fusion group, 4.5% in the cervical group, and 22.0% in the tumor group. The multivariate analysis showed that old age ($P=0.010$), neurological deficits ($p=0.001$), and spinal tumor ($p=0.046$) were risk factors.

Conclusion: The prevalence of VTE following elective spinal surgery is different in each group studied here. In particular, spinal tumor surgery carries a high risk of VTE, and cervical spine surgery has a low risk attached to it. Advanced age, neurologic deficits, and spinal tumors were all risk factors in elective spinal surgery. No DVT was found in 6 of 10 PTE positive patients. This result indicates that screening for PTE itself is also needed in the case of high risk patients.

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51. Complications in Operative Scheuermann's Kyphosis: Do the Pitfalls Differ from Operative Adolescent Idiopathic Scoliosis?

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Summary: Major complications are 3.1 times more likely to occur in operative Scheuermann's kyphosis than in AIS patients. Surgical site infections are the most common complications in both cohorts. Operative time was an independent risk factor for major complications in both groups.

Introduction: There is a paucity of literature regarding the complications associated with contemporary surgical treatment of Scheuermann's Kyphosis (SK). This study aimed to evaluate complications in SK and compare to those found in AIS patients.

Methods: A prospective database of SK surgical patients with minimum 1 year follow-up was studied for major complications; contemporaneous AIS surgical patients were also studied. Major complications were those that were considered life-threatening, caused spinal cord or nerve root injury or required re-operation. Infections that did not require reoperation but were treated were included in the infection analysis. Complication and reoperation rates were compared between the two patient cohorts using ANOVA and Fischers exact test analyses.

Results: 103 SK patients (57 M, 16.5 yo, mean 75.3° kyphosis) and 806 AIS (622 F, 14.9 yo, mean 55.6° Cobb) patients met the inclusion criteria. SK patients were significantly more likely to have a complication than AIS patients, 30.1% versus 5.5% ($p < 0.001$). SK patients had more major complications (19.4% versus 3%) ($p < 0.001$). The SK group had more infections (14% vs 2.4%, $p < 0.001$) and reoperations (18.4% versus 2.2%, $p < 0.001$) as shown in Table 1. There were no significant differences in levels fused, operative time, LOS or EBL in the major complications category between the 2 groups. SK patients were 3.1X more likely to have a major complication than AIS patients. Operative time is also an independent predictor of major complications; for each increasing minute there is a 0.4% increase in likelihood of major complication regardless of diagnosis.

Conclusion: SK patients are at higher risk for major complications compared to AIS patients, most specifically infections and reoperation. SK diagnosis and increased surgical time are predictive factors for increased incidence of complications.

52. Early Proximal Junctional Failure after Deformity Surgery in Patients Older than 55 Years

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Summary: Early proximal junctional failure is common in older patients after deformity surgery (28%). It occurs most frequently when the upper instrumented vertebrae is in the low thoracic spine, and most often due to fracture. The early revision rate is 10% while late revisions are rare.

Introduction: Proximal junctional failure (PJF) is a well-recognized complication after adult spinal deformity correction. Early PJF (less than 6 months post-op) has been recently reported to be 5.6% when all age groups are included. Age is thought to be a risk factor, however there are no reports focused on PJF following deformity surgery in older patients. The purpose of this study was to evaluate the incidence, mode of failure, location and revision rates of early PJF in patients over 55 years of age following surgery for spinal deformity.

Methods: Retrospective review of 165 consecutive patients, mean age 68 years (55-84) and mean follow-up 28 months (12-83), treated operatively at a single institution for deformity. Early PJF was defined as fracture, implant failure, or new onset myelopathy within 6 months of surgery at the upper instrumented vertebrae (UIV) or UIV+1. Incidence, location, mode of failure and early and overall revision rates were reported. Subgroup analysis was based location of the UIV: upper thoracic (UT), lower thoracic (LT) or lumbar (L) spine.

Results: The incidence of early PJF was 28% (46 of 165), and was significantly higher when the UIV was in the LT spine (39%) as compared to the UT spine (10%) or L spine (21%) ($p = 0.001$). Fracture was the most common mode of failure (96%) ($p < 0.001$). Early onset myelopathy occurred in 7% of patients. The early revision rate was 10.3%, higher in the thoracolumbar spine (LT+L) than the UT spine ($p = 0.05$). Late revisions occurred at a lower rate (2.5%). The revision rate was significantly higher in the thoracolumbar spine (LT+L) than in the UT ($p = 0.03$).

Conclusion: The incidence of early PJF after adult deformity surgery in patients over 55 years of age was 28%, with an early revision rate of 10%. PJF rarely required revision late. Failures and revisions most commonly occurred with early PJF in the thoracolumbar region.

53. Prospective, Multi-Center Assessment of Risk Factors for Early Rod Fracture Following Surgery for Adult Spinal Deformity (ASD)

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Summary: Rod fracture (RF) occurred in 9.0% of adult spinal deformity (ASD) patients and in 22.0% of pedicle subtraction osteotomy (PSO) patients. There was substantial range in the rate of RF with PSO (10.0% to 31.6%) among higher contributing centers, suggesting potential variations in technique that warrant future investigation. Due to higher rates of RF with PSO, alternative strategies should be considered for these cases.

Introduction: Improved understanding of rod fracture (RF) following ASD surgery could prove valuable for surgical planning, patient counseling, and implant design.

Methods: Multi-Center, prospective, consecutive series. Inclusion criteria: ASD, age >18, >5 levels posterior instrumented fusion, and baseline and min 1-yr full-length standing x-rays.

Results: Of 200 patients who met inclusion criteria (mean age=55), 81% were women, 11% were smokers, mean BMI was 27.1 (SD=6.5), mean levels fused was 12 (SD=4), and 50 (25%) had a PSO. Rod material was cobalt chromium (CC; 53%), stainless steel (SS; 26%), or titanium (Ti; 21%), and diameters were 5.5mm (68%), 6.0mm (13%), or 6.35mm (19%). RF occurred in 18 (9.0%) patients at a mean of 14.7 mos (range=3-27 mos); patients without RF had a mean follow-up of 19 mos (range=12-24 mos). Patients with RF were older (62 vs 54 yrs; p=0.036), had greater BMI (30.6 vs 26.7; p=0.019), had greater baseline sagittal malalignment (sagittal vertical axis [SVA]; 118 vs 50mm; p=0.001), pelvic tilt [PT; 29 vs 22°; p=0.016], and pelvic incidence-lumbar lordosis mismatch [PI-LL; 30 vs 12°; p=0.002], and had greater correction of sagittal alignment (SVA [96 vs 28mm; p<0.001] and PI-LL [26 vs 11°; p=0.003]). RF occurred in 22.0% of patients with PSO (all at or adjacent to the PSO level), ranging from 10.0% to 31.6% across centers. CC rods were used in 68% of PSO cases, including all with RF. Smoking, levels fused, rod diameter, and coronal Cobb angle (among those with scoliosis) did not differ significantly between patients with and without RF (p>0.05). On multivariate analysis, only PSO was associated with RF (p=0.001; OR=5.76; 95%CI=2.01-15.8).

Conclusion: RF occurred in 9.0% of ASD patients and in 22.0% of PSO patients. There was substantial range in the rate of RF with PSO (10.0% to 31.6%) across centers, suggesting potential variations in technique that warrant future investigation. Due to higher rates of RF with PSO, alternative strategies should be considered for these cases.

54. Early Proximal Junctional Failure in Patients With Preoperative Sagittal Imbalance

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Summary: Early proximal junctional failure (EPJF) occurred at a fairly high rate in adult spinal deformity patients with sagittal imbalance. This was highest in patients with the upper-instrumented vertebra (UIV) in the lower thoracic spine (TS).

Introduction: EPJF has been identified as a potential complication in patients

undergoing surgery for adult deformity. The purpose of this study is to report the incidence of EPJF in patients who are sagittally imbalanced preoperatively, and to identify risk factors postoperatively that correlate with EPJF using commonly reported sagittal balance parameters.

Methods: We reviewed 197 patients with preoperative sagittal imbalance by at least one of the following: sagittal vertical axis >5cm, global sagittal alignment >45°, pelvic incidence - lumbar lordosis >10°, or spino-sacral angle <120°. Radiographic measurements also included proximal junctional angle, thoracic kyphosis, lumbar lordosis, pelvic parameters, and sagittal balance parameters/formulas, as well as UIV angle, UIV SSA, and UIV plumbline to assess as potential risk factors. EPJF was defined as fracture, implant failure, or myelopathy due to stenosis or instability at the UIV or UIV+1 within 6 months of surgery. EPJF incidence was calculated postoperatively for each of the accepted sagittal balance parameters/formulas.

Results: EPJF was observed in 49/197 patients (25%) with preoperative sagittal imbalance and was more common in fusions with UIV in the lower TS (69%) compared to those with UIV in the upper TS (16%) or lumbar (14%) (p=0.0036). 16/49 EPJF patients (33%) required revision surgery within the first year, for an overall early revision rate of 8%. The incidence of EPJF was no different in patients with or without postoperative sagittal balance. No parameter/formula was more sensitive than another in predicting EPJF.

Conclusion: The incidence of EPJF (25%) is greater in this sagittally imbalanced group than previously reported for adult deformity patients, occurring most often when the UIV is in the lower TS. Sagittal balance correction was not correlated with change in incidence of EPJF. Despite the high incidence, the early revision rate within the first year is low.

55. Sacropelvic Fixation in Adult Spinal Deformity (ASD): A Very High Rate of Mechanical Failure

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Summary: This study aimed to analyze the mechanical failure rate of spinopelvic fixation (SPF) and residual sagittal imbalance as a potential cause. 36 patients w/SPF and were analyzed. 8 mechanical failures of SPF (22.2%), 4 rod breakages and 1 prominence were identified. Of 8 failures, 4 had iliac screw breakages, 5 had set screw dislodgements and 1 had dislodgement of rod. Further analysis revealed that failed cases had inadequate restoration of lumbar lordosis and SVA.

Introduction: Sacropelvic fixation (SPF) is an integral part of ASD surgery. Literature suggests that combination of S1 and iliac screws may be associated with lowest rate of complications.

Aim: To analyze the mechanical failure rate of SPF and residual sagittal imbalance as a potential cause.

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Methods: Of 483 patients enrolled in a prospective multicentric database, 47 (9.7%) were identified as having had SPF. 36 of those with > 6 months (or to failure) f/up constitute the population. There are 5 males and average age is (64.3+/-13.3). All had bilateral S1 screws; type of iliac fixation was S2 alar/iliac (S2AI) screws in 21 (58.3%) and iliac screws with lateral connectors (IwL) in 15 (41.7%). Diagnoses were degenerative in 18, failed back in 7 and other in 11. Average instrumentation length was 11.6+/-4.0 levels.

Results: A total of 13 implant related complications were identified (36%); 8 were mechanical failures of SPF (22.2%), 4 were rod breakages and 1 was prominence. Of the 8 mechanical failures, 4 had iliac screw breakages at the junction of head and tread, 5 had set screw dislodgements (2 pts had both) and 1 had dislodgement of the rod from connector. Failures were identified on an average of 214 days (64 to 408). Failure rate of S2AI screws was 29% vs 13% for IwL screws (p>0.05). Of note, all broken screws were associated with S2AI technique with polyaxial screws (two brands, 3/12 for one and 1/3 for other). Comparison of failed cases to others for residual sagittal plane imbalance revealed that failed cases had inadequate restoration of LL (Table).

Conclusion: Pelvic fixation is still associated with a very high rate of mechanical failure. A major risk factor appears to be inadequate restoration of lordosis and SVA. In cases with suboptimal sagittal plane correction, S2AI with polyaxial screws seem to have higher risk of short term acute failure compared to IwL. 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).

56. A Comparison of Rod Breakage Rates in Adult Idiopathic Scoliosis Patients Treated with Posterior Only Surgery with BMP Versus Anterior/Posterior Surgery Without BMP

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Summary: 48 patients with posterior only surgery and BMP were compared to 67 patients with anterior/posterior surgery without BMP for rod breakage rates. The total rates of rod breakage for the groups were not statistically different. Anterior/posterior surgery without BMP is not associated with statistically greater rates of rod breakage when compared to posterior surgery with BMP.

Introduction: Correction of adult idiopathic scoliosis (ASD) traditionally mandated anterior and posterior (A/P) approaches. With the advent of BMP2 and advances in posterior instrumentation, it has become more common for ASD to be treated by posterior only surgery with BMP. The purpose of this study was to identify the rate of rod breakages between these 2 approaches.

Methods: A prospective and retrospective multi-center database was queried for ASD. 2 groups were formed: Group 1 (G1) was posterior surgeries with BMP and included interbody support by TLIF or PLIF. Group 2 (G2) was A/P without BMP.

Differences were analyzed in demographics, graft usage, implant usage, and rod breakage. P-values are from 2 sample t-test for continuous measures with pooled variance or Satterthwaite approximation as appropriate and Fisher's exact test for discrete measures.

Results: 115 pts were identified: 48 in G1, 67 in G2. The avg age in G1 was 42.3±16.2 compared to 55.4±13.5 in G2 (p<0.0001), with no other significant differences in demographics. The avg interbody levels fused and grafted were 3.4±1.7 in 5 pts from G1. Posterior levels grafted with BMP was 11.3±3.9. Statistically more osteotomies were done in G1, 29/48, compared with G2, 19/67, (p=0.0137). Avg f/u was 15.4±15.9mos. in G1 and 24.8±18.9 in G2 (p=0.0058). G1 used significantly more posterior rods, avg of 2.1, compared to G2, avg of 2 (p=0.0008). More stainless steel rods (p<0.0001) and fewer titanium alloy rods (p=0.004) were used in G1. Rod fracture rate for G1, 10.9%, was not significantly higher than G2, 3.1% (p=0.1239). A statistically significant difference for subsequent surgery was found in G1, 11/48 (22.9%) compared with 5/67 (7.5%) for G2, (p=0.0274).

Conclusion: There is no statistically significant rate of rod breakage when posterior only with BMP is compared to A/P surgery for ASD. The advantages of the posterior approach with BMP are related to familiarity and ease of positioning, and has become a preferred approach for many surgeons. Rates of pseudoarthrosis and rod fracture were identified as higher in raw values, but were not significantly higher when compared to Group 2. Group 1 had more osteotomies and a significantly increased rate of subsequent surgery, which will require further study.

57. Proximal Junctional Kyphosis Following Long Segment Spinal Fusion and Instrumentation: A Look at both Uncemented and Cemented Constructs

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Summary: Vertebroplasty of the upper instrumented vertebrae in long segment fusions does not seem to protect against proximal junctional fracture.

Introduction: Proximal junctional fractures leading to kyphotic deformity can be a devastating complication in long instrumented spinal fusions. The purpose of this study was to evaluate the role of cement augmentation in reducing the incidence of fractures and/or kyphosis following treatment for adult spinal fusions.

Methods: This is a retrospective review of 25 patients who underwent a minimum of 6 levels of instrumented fusion. They were divided into two groups according to whether or not they received cement augmentation at the upper instrumented vertebrae. Dates of inclusion were from July 2007 to April 2012. All patients were observed for a minimum of 6 months. Preoperative and postoperative radiographs were evaluated for changes in proximal junctional angle as well as regional and spinopelvic measurements.

Results: The mean age was 60.0 (range, 33-81), and the mean levels fused was 8.3 (range, 6-12). Average follow-up was 20.4 months (range, 6-55).

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Six patients (24%) had acute proximal junctional kyphosis, two of whom did not receive cement augmentation and four of whom did. Of those failures, one was due to fracture in each group ($P > 0.05$). Spinopelvic and regional spine measurements were statistically insignificant between the two groups.

Conclusion: In our series, cement augmentation of the upper instrumented vertebra levels did not protect the proximal segments from fracture. Larger scale studies are required to further delineate the potential benefits of this practice.

58. Calculating and Defining Minimally Important Clinical Difference (MCID) and Substantial Clinical Benefit (SCB) Values for Adult Spinal Deformity (ASD): A Robust Methodology for Consistent Data Reporting

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Summary: Several limitations exist for previously reported MCID and SCB values as applied to ASD. An alternative technique to calculate MCID and SCB for SRS-22 and ODI is proposed using SF-6D health states as an anchor. Unlike many existing anchor-based methods, our approach allows calculation of MCID and SCB values at follow-up periods beyond one-year and is specific to ASD disease state. The analysis revealed large differences in MCID and SCB values across follow-up periods and patient groups.

Introduction: Methodological limitations exist for previously reported MCID and SCB calculations including: 1) an inability to accurately report >1 year outcomes using traditional anchor questions such as the SF-36 Q2; and 2) lack of disease specific values for ASD. This study proposes an alternative MCID and SCB calculation using an anchor-based approach based on strictly dominant health states from the SF-6D and applies this methodology to the calculation of MCID and SCB values for surgical treatment of ASD.

Methods: Analysis of prospective, multi-center, consecutively enrolled patients surgically treated for ASD. HRQOL (SF36, ODI and SRS-22) was obtained at baseline, 1 and 2 year post-op, with SF-6D health states calculated from the SF-36. Minimum improvement was defined as: 1) no health domain in which follow-up SF-6D were below baseline; and 2) improvement in the lower 50th percentile among those who improved. Substantial improvement defined as total improvement in the upper 50th percentile among those who improved. ODI and SRS-22 MCID and SCB were calculated using the area under the receiver operator curve (AUC).

Results: One-year and two-year follow-up data were available for 217 of 256 (85%) and 149 of 230 (65%) patients, respectively. MCID and SCB values are summarized in Table 1. Compared to traditional SF-36 Q2 anchor results, the proposed methodology generates higher MCID and SCB values and greater sensitivity and specificity (based on AUC). Statistical differences were also

observed in MCID and SCB values between patients with low (below average) versus high (above average) baseline HRQOL scores.

Conclusion: At one-year follow-up, MCID values for ASD surgery were higher than those reported in comparable studies of AIS. The analysis also revealed large differences in MCID and SCB values across follow-up periods and patient groups, highlighting the need to consider such factors in determining if post-op MCID or SCB is achieved.

59. Disease State Correlates for Type and Severity of Adult Spinal Deformity (ASD): Assessment Guidelines for Health Care Providers

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Summary: Multi-center, prospective comparison of baseline SF-36 scores from consecutive ASD patients ($n=497$) to US general and disease specific values demonstrated disability correlated with type and severity of spinal deformity. Patients with isolated thoracic scoliosis reported mild disability, while patients with severe sagittal spinopelvic malalignment (SSM) had greater disability than any disease state reported in the SF-36 manual. Due to the heterogeneous presentation of ASD, health care providers must be educated regarding the types of ASD that correlate with disability.

Introduction: Contradictory information exists for disability associated with ASD creating confusion among medical providers and third party payers. Purpose: compare SF-36v2 Health Survey (SF-36) scores of ASD patients with different types of spinal deformity to United States (US) general population and disease specific values and correlate ASD deformity types with specific disease states

Methods: Multi-center, prospective analysis of consecutive ASD patients (scoliosis $\geq 20^\circ$, sagittal vertical axis (SVA) ≥ 5 cm, pelvic tilt (PT) $\geq 25^\circ$, or thoracic kyphosis $> 60^\circ$), no prior spine surgery. ASD grouped according to type and severity of scoliosis and sagittal spinopelvic malalignment (SSM). Baseline ASD SF-36 physical component (PCS) and mental component (MCS) scores calculated and compared to US normative and disease specific values. SF-36 reported as norm-based values (NBS) and compared to reported means using minimally important clinical difference (MCID) values for PCS and MCS (3 NBS points).

Results: 497 ASD (mean age 50.4 years) patients met inclusion criteria. Mean ASD PCS (41) was 3 MCID values (9 NBS points) below the US general population (50). Mean PCS for ASD with isolated thoracic scoliosis (45.5) was 1 MCID lower than US mean, and similar to PCS for anemia (45.3) and sciatica (45.7). PCS worsened as scoliosis apex moved distally to the thoracolumbar (43.4; $n=149$) and lumbar spine (36.7; $n=16$). PCS for ASD with SVA ≥ 5 cm, scoliosis $< 20^\circ$ (32.4; $n=14$) was >5 MCID worse than US mean. PCS for SVA

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>10cm (28.5; n=40), was > 7 MCID lower than US mean, and was worse than PCS for patients in the 25th percentile for diabetes (31.1), heart disease (30.5), and limited use of arms/legs (29.1). Multivariate analysis demonstrated pelvic incidence- lumbar lordosis mismatch (R=-.44), SVA (R=-.40) and PT (R=-.38) correlated most strongly with worsening PCS (p<0.05).

Conclusion: Analysis of consecutive ASD patients demonstrated varied disability. ASD with SSM had greater disability than any disease reported in the SF-36 manual. Health care providers must be educated regarding the types of ASD correlating with disability.

60. HRQoL Scores and Radiographic Parameters Do Not Drive Patient Satisfaction after Adult Spinal Deformity Surgery

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Summary: Correlation analyses of HRQoL outcome measures and radiographic parameters with patient satisfaction among 157 adult patients undergoing thoracolumbar fusion for adult spinal deformity at minimum 2 year follow-up. Radiographic parameters and HRQoL measures have weak correlations to satisfaction, although there were significant differences between highly satisfied and less satisfied patients for HRQoL scores. Factors driving patient satisfaction appear to differ from surgical goals of pain relief and deformity correction.

Introduction: Fusion surgery is increasingly performed for patients with adult spinal deformity. Drivers of patient satisfaction with these treatments are incompletely understood. This study assessed correlations of HRQoL measures and radiographic parameters with patient satisfaction.

Methods: A prospective cohort of 157 adult patients undergoing fusion for adult spinal deformity was analyzed at minimum 2year follow-up. Correlation analyses were performed between SRS-22 satisfaction scores and final and change from baseline for VAS back/leg, ODI, SRS-22, and SF36 MCS and PCS scores. Satisfaction scores were also correlated to radiographic changes in sagittal vertical axis (SVA), coronal C7 plumbline, lumbar lordosis, pelvic tilt (PT) and the difference between pelvic tilt and lumbar lordosis (LL). We also compared three patient groups: Highly Satisfied (HS; N=123, SRS-22 > 4.0) and Less Satisfied (LS; N=34, SRS-22 < 4.0) and Not Satisfied (NS; N=9, SRS<2.5)- a subset of LS.

Results: Overall SRS-22 satisfaction scores were high (Mean 4.29, range 1-5). There was a moderate correlation between satisfaction and final SRS-22 score (r2= 0.40) and a weak correlation with change in SRS-22 score from baseline (r2=0.32). All other HRQoL data and radiographic parameters showed weaker correlations to SRS satisfaction scores (r2 range 0.00001-0.27). There were significant differences between HS and LS patients with regard to final and change from baseline for ODI, SRS-22, and PCS (p<.0001). There were significant

differences between HS and NS patients in all HRQoLs (p<.0001-.0089). There were no differences in final and change in radiographic parameters between HS, LS and NS patients.

Conclusion: Radiographic parameters have weak correlations to patient satisfaction.

HRQoL scores are also weakly correlated, but differed between high, low and no satisfaction patients. Factors driving patient satisfaction appear to differ from surgical goals and current HRQoL measures. Other factors such as pre-operative expectations, inpatient experience and relationship with surgeon may be stronger drivers of patient satisfaction.

61. Operative and Nonoperative Treatment Approaches for Lumbar Degenerative Disc Disease Have Similar Long-Term Clinical Outcomes Among Patients with Positive Discography

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Summary: The roles of discography and surgical fusion for lumbar degenerative disc disease remain controversial. This study provides comparison of the clinical outcomes of patients with low back pain and concordant lumbar discography who elected for surgical fusion versus nonoperative treatment. At a mean follow-up of 59 months, outcomes of patients with positive, concordant lumbar discograms were not significantly different between those electing for spinal fusion versus nonoperative treatment.

Introduction: The roles of discography and surgical fusion for lumbar degenerative disc disease remain controversial. Our objective was to compare the clinical outcomes of patients with low back pain (LBP) and concordant lumbar discography who elected for surgical fusion versus nonoperative (nonop) treatment.

Methods: Retrospective review of consecutive adult patients with LBP and 1- or 2-level concordant lumbar discography at a single institution between 2003 and 2009. Patients were offered instrumented lumbar fusion versus nonop treatment. Baseline demographics and pain scores, as well as follow-up ODI, SF-12 and satisfaction scores (obtained by telephone/mail in questionnaires), were compared between fusion and nonop groups.

Results: Follow-up was obtained for 96 (48%) of 200 patients meeting inclusion criteria (mean=59 months, SD=20 months), including 53 (55%) fusion and 43 (41%) nonop patients. Compared with patients with follow-up, those without follow-up were older (47 vs 44, p=0.021) and less likely to smoke (28% vs 57%, p=0.013), but did not differ based on sex, baseline pain score, BMI, or 1- vs 2- level positive discogram (p>0.6). Among patients with follow-up (n=96), fusion and nonop groups did not differ significantly based on age, baseline pain score (7.8 vs 8.0), BMI, smoking, length of follow-up, or 1- vs 2-level positive discogram (p>0.25). At follow-up, fusion and nonop groups did not differ significantly with regard to pain score (3.6 vs 4.4, p=0.25), ODI (35

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vs 35, $p=0.95$), SF-12PCS ($p=0.29$), or SF-12MCS ($p=0.34$); however fusion patients had significantly lower mean satisfaction score (1.9 vs 2.4, $p=0.031$). On multiple regression analysis for each outcome measure at follow-up, smoking had a significant negative impact on ODI, SF-12, and satisfaction score; BMI had a significant negative impact on satisfaction score; fusion vs nonop care did not significantly impact any of the outcomes measures.

Conclusion: Long-term outcomes of patients with positive, concordant lumbar discograms were not significantly different between those electing for spinal fusion versus nonop treatment.

62. A Prospective Propensity Matched Cohort Analysis of Minimally Invasive (MIS), Hybrid (HYB), and Open Spine Surgery (OPEN) for the Treatment of Adult Spinal Deformity (ASD)

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Summary: Utility of Minimally invasive surgery (MIS) in adult deformity patients is not well established. Two prospective data sets retrospectively evaluated to determine the effectiveness, outcome and complications of three different surgical strategies for Adult Spinal Deformity (ASD). Our study shows that MIS provides good outcome, effective deformity correction with minimal perioperative morbidity in well selected ASD.

Introduction: Operative intervention for ASD is well established. MIS techniques have been increasingly applied to treat ASD. MIS, OPEN, and HYB techniques were compared in an ASD patient population through propensity matching.

Methods: 280 pts in 2 prospective databases (MIS $n=85$; OPEN $n=195$) were retrospectively reviewed, divided in 3 separate approaches OPEN, MIS, and HYB and propensity matched for age, ODI, SVA and major Cobb ($p>0.05$). Inclusion criteria: age >45 , Cobb $>20^\circ$, min 1 yr Follow-Up. Groups: 1)MIS- standalone lateral transposas (LIF), LIF with MIS posterior pedicle screws (PPS), and MIS TLIF ($n=31$). 2)HYB- LIF with open PPS($n=31$); 3)OPEN- Open PPS +/- interbody ($n= 31$). Group 1 compared with Anova and Intra-group with paired t-test.

Results: At 1yr there was no difference in major Cobb (MC), PI-LL, PT or SVA. OPEN had more LL (52.5) at 1yr than MIS(40.5; $p<0.001$) and HYB (44.4; $p=0.023$). There was no difference between group at preop or 1yr in Schwab-SRS classification. All groups reached significant decrease in ODI at 1yr. Within each group there was significant improvement in MC, LL, and PI-LL. MIS had significantly less EBL and transfusion (563cc; 32.3%) than HYB or OPEN (1802cc, 58.1% and 1974cc, 83.9%; $p<0.003$). OR time was longer with HYB (735 min) than MIS and OPEN (461 and 407 min; $p<0.001$). OPEN was

associated with more levels fused (9.3) than MIS (4.8; $p<0.001$) and HYB (7; $p=0.03$). Open surgery was extended to the pelvis 80.6% versus 22.6% and 67.7% for MIS and HYB ($p<0.001$). Major complications occurred in 12% of MIS, 33.3% HYB, and 44.8% OPEN ($p=0.032$).

Conclusion: This is the first study to evaluate different surgical techniques to treat patients with statistically similar disability and spine deformity. All groups resulted in significant improvement in ODI. MIS was associated with less EBL, transfusion, fusion levels, shorter OR time and a favorable complication profile compared to HYB and OPEN. Our data supports the role of MIS for ASD.

63. Severity and Treatment Response of Back and Leg Pain Differ by Curve Location in Adult Spinal Deformity (ASD)

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Summary: Patient Multi-center, prospective analysis of consecutive surgically treated ASD patients demonstrated high preoperative back and leg pain, however back and leg pain were most associated with sagittal and lumbar deformities. Predominant back pain patients had sagittal and lumbar deformities, while those with predominant leg pain most commonly had lumbar deformities. Two year postoperative back and leg pain was reduced for all deformity types and pain patterns. These data should be used for ASD pain pattern evaluation and surgical counseling.

Introduction: Back and leg pain are common presenting symptoms in ASD patients. Little data exists correlating deformity type with back and leg pain distribution. Purpose: evaluate distribution of preoperative back and leg pain for different curve types in ASD and efficacy of surgery to relieve pain.

Methods: Multi-center, prospective analysis of consecutive patients enrolled into an ASD database. Inclusion criteria: no prior surgery, >4 level spinal fusion for ASD and minimum 2 year follow up. ASD classified by curve type: S=sagittal deformity only, T=thoracic, L=lumbar, D=thoracic and lumbar. Patients grouped according to severity of preop back and leg pain using the numeric rating scale (NRS); BACK=back pain ≥ 7 , leg pain ≤ 6 ; LEG= leg pain ≥ 7 , back pain ≤ 6 ; HIGH= back and leg pain ≥ 7 ; LOW= back and leg pain ≤ 6 . Demographic, radiographic and operative data were evaluated.

Results: 318 of 857 patients enrolled in the database met inclusion criteria: (S=73, T=23, L=85, D=83). Mean age was 56.6 years. Mean preop back vs. leg pain for all patients was 7.1 and 4.2 (S= 7.9 vs. 4.9; T=5.9 vs. 2.8, L=7.0 vs.4.3 and D=6.6 vs. 3.0), respectively.

Back pain was greater than leg pain for all groups; back pain was greatest in S and L groups ($p<0.05$). BACK had higher prevalence of S, L and D curves than T curves (32%, 30%, 32% vs. 7% respectively $p<0.05$). LEG had a higher prevalence of L (43%) than S, T and D curves ($p<0.05$). HIGH had a higher

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prevalence of S (38%) and L (33%) than T, and D curves. LOW had higher prevalence of L (33%) and D (42%) curves than S and T curves ($p<0.05$). Mean 2 year back and leg pain was reduced for all patients (back=3.3, leg= 2.2) compared to preop values ($p<0.05$). Two year postop back pain (S=3.9, T=1.4, L=2.9, D=3.5) and leg pain (S=2.8, T=0.8, L=1.8, D=2.1) was lower than preop values for all curve types except D leg pain ($p<0.05$).

Conclusion: Surgical correction of ASD significantly reduces both back and leg pain at 2yr follow up. Back and leg pain distribution differs according to type and location of deformity. Sagittal and lumbar deformities report higher back and leg pain than T and D curves. These data should be used to counsel patients regarding anticipated postoperative pain relief.

64. Health Impact Comparison of Cervical Sagittal Deformity and Thoracolumbar Sagittal Deformity on Baseline Disability and Surgical Outcomes: Cervical PSO versus Lumbar PSO

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Summary: Thoracolumbar sagittal deformity (TLSD) has a significant negative impact on general health, however, little has been reported on the general health impact of cervical sagittal imbalance (CSD). Matched cohort of operative patients with either TLSD or CSD from a prospective adult deformity database were compared using SF36 PCS and regional neck and back pain. The preoperative impact of CSD and TLSD on general health status is similar and correction of CSD has similar impact on general health as TLSD correction.

Introduction: Thoracolumbar sagittal deformity (TLSD) has been demonstrated to have significant impact on SF-36 general health status. The general health scores for adult deformity patients are similar to those of patients with coronary artery disease and cancer. Studies have demonstrated that cervical sagittal deformity (CSD) has a significant negative impact on general health status; however, the health impact of primary CSD has not been compared to thoracolumbar sagittal deformity (TLSD). The goal of this study was to compare the baseline and postoperative general health SF-36 for patients with primary CSD versus patients TLSD.

Methods: A retrospective review of a cervical PSO database of CSD was compared to a prospectively collected TLSD database (total 363 patients) to identify a matched combined cohort of 19 patients based on age, sagittal deformity and presence of 3 column osteotomy and minimum 1 year follow-up. Patients with concomitant TLSD were excluded from the CSD group and patients with concomitant CSD were excluded from the TLSD group.

Results: The average age was 70yrs in the CSD group and 63 in the TLSD group ($p>.05$). Average cervical c2-c7 sagittal vertical axis (SVA) was 7.9cm in the cervical group and average c7 SVA was 8.1cm in the TLSD group. Both groups demonstrated improved sagittal alignment post op (c2-c7 3.4cm, C7 SVA 1.7cm).

Baseline SF36 PCS values were not statistically different 30.2 vs 28.1 ($p>0.05$). At 1 year follow-up both groups showed statistically significant improvement in PCS scores reaching minimal clinically important difference (CSD 30.2-35.8 vs TLSD 28.1 to 36.6). Regional pain improved significantly in each group. Neck pain improved from NRS 8.1 to 3.9 ($p<0.05$). Back pain improved from NRS 7.9 to 3.3 ($p<0.05$).

Conclusion: The impact of CSD and TLSD on general health status is comparable for similar preoperative sagittal malalignment and age. Surgical correction with 3 column osteotomy demonstrates similar efficacy in improving general health status and regional pain for both primary CSD and TLSD.

65. Cervical Sagittal Deformity Develops after PJK in Adult Thoracolumbar Deformity Correction: Radiographic Analysis Utilizing a Novel Global Sagittal Parameter, the CTPA

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Summary: Cervical deformity develops following proximal junctional kyphosis (PJK) in adults with long fusions to the upper thoracic spine. PJK was prevalent after thoracolumbar PSO in adult spinal deformity (ASD) patients. We introduce two novel global sagittal angular parameters, the Cervical-Thoracic Pelvic Angle (CTPA) and the T1 Pelvic angle (TPA), that define the relative proportion of cervical and thoracolumbar deformities. These global angular measures correlate strongly with established linear measures of deformity such as C2C7 Plumbline (CPL) and C7 SVA respectively.

Introduction: PJK is a prevalent problem following sagittal correction in adult spinal deformity (ASD). In cervical deformity studies, $CPL>4$ cm is associated with poor HRQOL. Reciprocal changes in cervical lordosis have been demonstrated after thoracolumbar three column osteotomy (3CO), but changes in cervical alignment after PJK have not been investigated. This study investigates the changes in cervical alignment with novel radiographic parameters, CTPA and the TPA (Figure 1), and established measures like CPL following PJK after thoracolumbar deformity correction.

Methods: Multi-center, retrospective, analysis of consecutive ASD patients undergoing 3CO with fusion to the pelvis with 1 yr Follow-Up. PJK was defined as ($>10^\circ$ change in UIV and UIV+2 kyphosis). Patients were substratified into upper thoracic (UT) with UIV T6 and above and lower thoracic (LT) with UIV below T6.

Results: 166 ASD patients (mean age 59.1) were enrolled. PJK developed in 62 patients (37.3%). CTPA correlated strongly with CPL as a measure of cervical sagittal balance ($r=0.916$, $p<0.001$). Utilizing a linear regression analysis, a CTPA value of 3.6 was found to correspond to CPL of 4.0 cm. There were no significant differences in PJK patients and those without PJK (NPJK) in terms of

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preoperative thoracolumbar deformity (SVA or TPA), cervical alignment (CPL or CTPA), age, sex and BMI. PJK patients did not differ with NPJK by postoperative thoracolumbar alignment or magnitude of correction. For UT (n=86), patients with PJK at 1 year had larger CTPA (4.7 vs 3.6, p=0.008), CPL (4.83 vs 3.92 cm, p=0.03) and T1 Slope (T1S 26.9 vs 36.0 p=0.03) despite similar global corrections by SVA, TPA and PI-LL. This was not true for LT.

Conclusion: CTPA correlated strongly with C2PL as a measure of cervical sagittal balance. PJK was prevalent, developing in 37.3% of ASD patients undergoing thoracolumbar 3 column osteotomy. Following 3CO, PJK patients with long fusions to the upper thoracic spine (UT) developed cervical sagittal deformities driven by an increase in T1S leading to an increase in their CPL and CTPA.

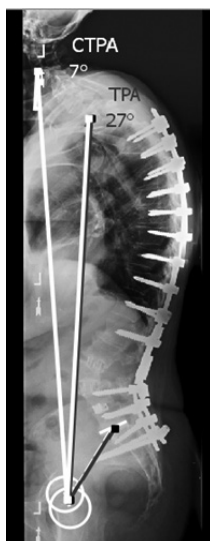


Figure 1: CTPA and TPA define the relative proportion of cervical and thoracolumbar deformities. CTPA is the angle between a line from the center of C2 to the femoral heads (FH) and a line from FH to the center of T1. TPA is the angle between a line from the center of T1 to the FH and a line from FH to the S1 endplate.

66. Effect of Adult Spinal Deformity on Cervical Degeneration

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Summary: We performed radiographic evaluation to determine the relationship between cervical degeneration and adult spinal deformity. Adult deformity patients had significantly severe cervical degeneration and more frequently had coexisting cervical spondylotic myelopathy than those without spinal deformity.

Introduction: Positive sagittal balance is regarded as a source of poor health related quality of life. However, it is unclear how global spinal alignment may be related to cervical degeneration.

Methods: Radiographs of adult deformity patients (DF) of age >40 were

reviewed. All patients had both cervical X ray and full-length standing X ray. Age- and sex- matched cohort was made for comparison (Non-DF). Radiographic parameters included: coronal Cobb angle, coronal imbalance, cervical lordosis (CL), thoracic kyphosis (TK), lumbar lordosis (LL), pelvic tilt (PT), sagittal vertical axis (SVA). Patients with Cobb angle >30°, coronal imbalance >30mm, or SVA>40mm were included as adult deformity. Cervical degeneration was quantified by cervical degeneration index score (CDI) that was previously validated. The number of cases that underwent cervical surgery for cervical spondylotic myelopathy or radiculomyelopathy was recorded.

Results: Radiographs of 72 patients (43 women) in DF group and 71 patients (44 women) in Non-DF groups were reviewed. Mean age was not statistically different between groups (DF: 63.7 years; Non-DF: 63.3 years). Significant differences were observed in coronal imbalance (DF: 21.9mm; Non-DF: 12.7mm), coronal Cobb angle (DF:20.1°; Non-DF:7.3°), SVA (DF:51.8mm; Non-DF: 11.9), and PT (DF:19.9°; Non-DF: 15.0°) (p<0.05). No difference was observed in CL (DF:13.5°; Non-DF:11.5°) and TK (DF: 33.9°; Non-DF: 33.7°). DF group had significantly higher total CDI than Non-DF group (19.6 vs 15.1 P=0.001). Parameters of CDI score that showed significant differences were disc narrowing (4.5 vs 2.9, P=0.003), end-plate and facet sclerosis (6.7 vs 5.5, P=0.003), andolisthesis (1.6 vs 0.8, P=0.003). Significantly more patients underwent cervical surgeries in DF group (38.9%) than in Non-DF group (16.9%) (Odd ratio =3.1 CI 1.4-6.8, P=0.003). The spearman rank order correlation coefficient analysis showed a correlation between CDI score and parameters for age (r=0.43), lumbar lordosis (r=0.27), lumbar coronal Cobb angle (r=0.25), sacral slope (r=0.24) and pelvic tilt (r=0.30) (p<0.05).

Conclusion: Adult deformity patients had significantly more severe cervical degeneration and a higher frequency of cervical spine surgery than non-deformity patients.

67. Evaluation of Spinal Cord Motion in Patients with Normal Sagittal Cervical Alignment Using Kinetic MRI

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USA

Summary: 52 patients with normal, lordotic cervical alignment and mild spondylosis were evaluated using kinetic MRI through a full range of flexion-extension in order to study the motion of the spinal cord and its relationship to the spinal canal. With normal lordotic alignment, the spinal cord shifts posteriorly with flexion and anteriorly with extension and has a maximal angular range of 31° from flex-ext.

Introduction: There are many studies evaluating angular motion of the cervical spine. There are no studies evaluating spinal cord motion in an in vivo model. Evaluating the normal coupling motion of the spinal cord and the cervical vertebral column may help us better understand the origin of spinal cord compression and

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the best method of surgical treatment. The purpose of this study was to examine the motion of the spinal cord and its relationship with the spinal canal in patients with mild spondylosis using kinetic MRI (kMRI).

Methods: 108 patients (mean age 52.9) underwent upright kMRI through a full range of flex-ext. 52 patients with normal, lordotic cervical alignment were selected based on the C2-C7 Cobb angle of sagittal alignment (30-45°). Using kMRI images, we evaluated the following in neutral, flexion and extension: spinal canal diameter (CD), spinal cord diameter (SCD), space available for the cord (SAC), anterior space available for cord (ASAC), posterior space available for cord (PSAC) and global Cobb angle of the spinal canal and cord.

Results: SCD gradually decreased from C2-T1. Relative to the vertebral column the spinal cord translates posteriorly with flexion and anteriorly with extension, with the greatest amount of motion seen at C2/3. There was no significant change in SCD with flexion or extension. ASAC was narrowest at C4/5, C5/6, and PSAC gradually increased from C2/3-C7/T1. In neutral, the mean maximal spinal cord angle was 23°; it increased to 36° in extension and decreased to 5° with flexion. With full flex-ext, the mean angular change of the spinal cord was 31°. The angular motion of the spinal cord tended to follow the angular motion of the spinal column.

Conclusion: With normal lordotic alignment, the spinal cord shifts posteriorly away from the spinal column with flexion and toward the anterior column with extension. The spinal cord moves through a maximal angular range of motion of 31° from flex-ext. Knowing the spinal cord motion in patients with normal lordotic alignment may help us better understand the pathogenesis of spinal cord compression in patients with abnormal (kyphotic) alignment.

68. Vertical Reduction and Fixation Technique of C1-2 Joint for the Treatment of Basilar Invagination

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Summary: We report clinical and radiological outcome of 17 basilar invagination cases with atlantoaxial instability treated by the fixation using the C1-2 segmental fixation, and subsequently, vertical reduction using an autograft iliac bone block or PEEK cage as an atlantoaxial facet joint spacer.

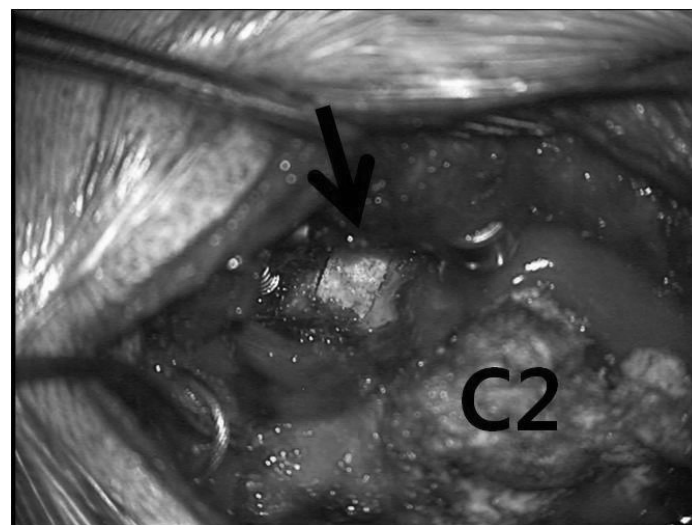
Introduction: To discuss the surgical and radiological outcome of the treatment of basilar invagination that involves vertical distraction of the atlantoaxial joint using autograft iliac bone block or PEEK cage.

Methods: Between May 2010 and Dec 2012, 17 basilar invagination patients underwent the discussed method of fixation at the Department of Neurosurgery, St. Vincent's Hospital. 12 patients had RA, one patient had post-traumatic kyphosis, three patients were related congenital anomaly and one patient did not have any directly related pathology. Twelve patients had myelopathy, sixteen patients had severe headache and three patient combined with dysphagia. The symptoms of all patients were progressive in nature. We evaluated ADI, Ranawat index, cervicomedullary angle (CMA), VAS score and JOA score before and after

the surgery.

Results: The mean follow-up period was 9.4 months (range 3-25 months). Neurological improvement and successful distraction with atlantoaxial stabilization and ultimate bone fusion was achieved in all the patients and was documented with dynamic radiography. C0-1 joint motion was preserved in all cases after surgery. Each radiographical and clinical outcome score was improved after the surgery (Ranawat index; 8.9mm - 14.9mm, CMA; 147.3 - 155.8, JOA; 112.1 - 14.6). Although there were no neurological or vascular complications after surgery, we experienced three cases of motor evoked potential change during the vertical reduction of C12 joint and we had to decrease the amount of distraction during the procedure or change the size of interfacet graft. We also experienced one case of wound infection and a case of graft retropulsion without neurological sequelae.

Conclusion: "Vertical reduction technique" of C12 segment could provide direct reduction of basilar invagination, increase the fusion bed, decrease the level of fixation, minimize the head traction before surgery and avoid transoral decompression surgery. We conclude that the described method of atlantoaxial joint distraction and fixation technique could be an alternative treatment strategy for the cases with basilar invagination.



Intraoperative photograph showing an autograft iliac bone spacer inserted in the C1-2 facet joint (arrow).

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69. Utility of Flexion and Extension Views for Screening of Children with Down Syndrome

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Summary: The sensitivity and negative predictive value of abnormal ADI (>6mm), SAC(<14mm), BAI(>14mm) or WR(>4mm) for detection of clinical and/or MRI evidence of myelopathy or spinal cord compression are not improved by obtaining flexion, extension, AP or open mouth views when screening children with Down Syndrome(DS). Requiring 2 abnormal measurements (of ADI, SAC or BAI) and obtaining only a neutral upright lateral radiograph improves specificity and positive predictive Value.

Introduction: We noted that DS children presenting with myelopathy had abnormal findings on neutral lateral cervical radiographs. This study was done to determine whether flexion, extension, AP or open mouth cervical radiographs were of any value in detecting clinically significant upper cervical instability in DS children compared with an upright neutral lateral view only.

Methods: Cervical x-rays obtained between 2006 and 2012 for purposes of screening in children with DS were identified. Positive measurements for potential atlantoaxial(AAI) or atlanto-occipital Instability(AOI) were defined as ADI>6mm, SAC<14mm, BAI >12mm or WR extension-flexion >4mm. Medical records and advanced imaging studies were reviewed in all patients with any abnormal measurement, for clinical or other imaging(MRI,CT) evidence of myelopathy, or impending cord compression requiring surgical treatment ("Disease State Present"). Sensitivity, specificity, positive predictive value (PPV) and negative predictive value(NPV) of positive x-ray findings were compared between neutral lateral only, and the combination of neutral, flexion and extension views. AP and open mouth views when present were also reviewed for pertinent abnormalities.

Results: 172 DS children had neutral lateral cervical radiographs, and 88 of these also had Flexion and Extension views. Results are shown in table 1. 0/13 patients with abnormal WR measurement (>4mm) between flexion and extension had clinical or MRI evidence of myelopathy. No patient had \geq 3mm larger ADI in flexion than on the neutral film. AP and open mouth radiographs did not identify any other abnormalities.

Conclusion: When radiographic screening of DS patients for AAI or AOI is performed, only a neutral lateral cervical radiograph in the upright position is needed. Also, requiring at least 2 abnormal measurements (ADI>6mm, SAC <14mm or BAI>12mm) improves positive predictive value. Flexion and extension views do not improve sensitivity, specificity or NPV, while leading to much lower PPV, particularly if only a single abnormal measure is considered a positive test. Patients at high risk for myelopathy appear to have subluxation of the Atlanto-axial joint in their neutral position.

70. Clinical Improvement Through Nonoperative Treatment of Adult Spinal Deformity: Who Is Likely to Benefit?

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Summary: Adult spinal deformity patients treated non-operatively were evaluated for clinical improvement at 1-year using SRS-22. Baseline and 1-year minimal clinically important differences (MCIDs) from normative data were calculated. 24% of the patients treated non-operatively improved by more than 1MCID for the SRS Pain domain. Improvement and final outcomes were significantly impacted by the level of baseline disability but not by the radiographic profile.

Introduction: While surgery has been shown on average to be superior to nonoperative (nonop) treatment for significant adult spinal deformity (ASD), nonop care remains a good option for many patients. Our objective was to determine the outcome and risk factors of ASD patients who elected for nonop care.

Methods: Retrospective review of nonop branch of a multi-center prospective database of ASD patients. Only patients with baseline (BL) and 1-year (1Y) SRS-22 and radiographic data were assessed. Changes in SRS-22 were evaluated by domain and expressed in number of minimal clinically important differences (MCIDs) gained/loss; BL and 1Y scores were also compared to age- and gender-matched normative references (NR).

Results: 189 patients (53yo, 86%F) met inclusion criteria. At BL, Pain was the domain with the largest offset from NR for 44% of the patients, followed by Appearance (22%) and Activity (20%). On average there was a gain (improvement) of 0.2MCID in Pain but no gain or loss in Activity or Appearance. Analysis of change in the Pain domain at follow-up revealed that 24% of patients gained >1MCID and 14.2% lost >1MCID. Percentages of patients with gain or loss for Activity were 20% and 24.9%, and for Appearance were 13.3% and 9.3%, respectively. Patients who gained >1MCID had more severe BL scores than those losing >1MCID ($p<0.001$), but had no significant differences in radiographic parameters. For each domain, BL scores had significant impact on final outcomes: 77%-85% of the patients within 1MCID of NR at BL had outcomes less than 1MCID of NR at 1Y; this dropped to 28-37% for patients greater than 1MCID of NR at BL, and 11% to 16% for those between 2-4MCID of NR at BL ($p<0.001$, Table 1).

Conclusion: Patients who received nonop care are significantly more disabled than age- and gender-matched normative references for Pain (44%), Appearance (22%) and Activity (20%). At 1Y, the likelihood for a patient to reach SRS scores similar to normative reference decreases with increased baseline disability. Nonop treatment is a viable option for certain patients with ASD, and up to 24% of patients demonstrated significant improvement over 1Y with nonop care.

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71. Clinical and Radiographic Outcomes following 3-Column Osteotomies at a Minimum 5-Year Follow-Up

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USA

Summary: Patients undergoing 3-column osteotomies (3-CO) were found to have significant and sustained improvements in Oswestry Disability Index (ODI) and Scoliosis Research Society (SRS) scores and spinal alignment at a min. 5 yrs postoperative (PO).

Introduction: Short-term studies have noted improved outcomes and alignment following 3-CO, but no long-term study with a large group of patients (pts) is available.

Methods: Analysis of 118 pts who underwent 3-CO (96-PSO/22-VCR) with a min 5 yr follow-up (F/U) was performed at a single institution. The mean age was 48 yrs (range 8-79) and clinical F/U was 7 yrs (range 5-14). Fixed sagittal imbalance was present in 98% (n=116) and 86% (n=101) had prior spine surgery (range 1-9 procedures). A single stage surgery was performed in 56% (n=66). ODI and SRS scores and radiographic parameters were assessed at baseline, 6 wks and 1, 2, 3 and/or 5 yrs PO and complications through the latest clinical F/U.

Results: The mean operative time was 569 min (range 300-1128) and mean blood loss was 2.1L (range 0.3-6.5). Fusion was performed over an average of 10.5 levels (range 2-17). Sagittal alignment improved at all PO time points from baseline (mean 120mm), but diminished from 6 wks (mean 24mm) to 5 yrs (mean 41mm, p=0.03). Average coronal alignment was improved from baseline (28mm) at 6 wks (19mm, p=0.008) and 5 yrs PO (19mm, p=0.007). Major complications occurred in 58% (n=68) of pts, with the most common being pseudarthrosis in 14% (n=17) and temporary radiculopathy in 11% (n=13). There were no cases of paraplegia. Revision was performed in 23% (n=27), with the most common surgeries being revision posterior fusion (16%, n=19), anterior fusion (4%, n=5) and I&D (4%, n=5). Significant improvements (p<0.05) in ODI and all SRS domain scores were found at each time point (Fig 1). All mean outcomes scores exceeded minimal clinically important difference (MCID) thresholds except the SRS function domain. Improvement in outcomes at 5 yrs PO was similar in groups with complications (ODI: -20, SRS: +0.7) vs without (ODI: -19, p=0.9; SRS: +0.7, p=0.7) and revision (ODI: -16, SRS: +0.6) vs without (ODI: -21, p=0.3, SRS: +0.7, p=0.4).

Conclusion: Patients undergoing 3-CO were found to have significant and sustained improvements in ODI and SRS scores and sagittal alignment at min 5 yr

F/U, thus demonstrating the durability of these complex spinal reconstructions, even surprisingly in those pts having a major complication and/or revision surgery.

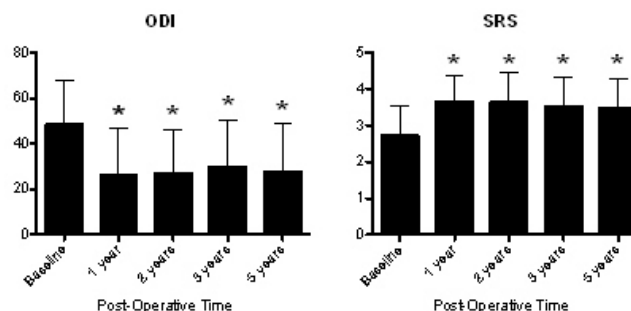


Figure 1: Patients undergoing 3-column osteotomies demonstrated significant and sustained improvements in ODI and SRS scores. *statistically significant improvement from baseline (p<0.05).

72. Impact of Major and Minor Complications on Health Related Quality of Life Following Adult Spinal Deformity Surgery: Multi-Center Prospective Database

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International Spine Study Group
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Summary: Post-surgical complications occur with high frequency following adult spinal deformity surgery. These complications add significant cost and may require additional interventions, however, the impact that these complications may have on health related quality of life measures remains unclear. The degree of complication (major or minor), resolution, pain or timing of complication does not seem to impact 1 year HRQL. However, reoperations significantly increased the length of stay, and led to poorer one-year HRQL measures.

Introduction: Post-surgical complications are typically divided into major and minor based on patient impact. However, while additional intervention and cost may be incurred due to the complication, the impact of the type of complication on Health Related Quality of Life (HRQL) is unclear.

Methods: Prospective, multi-center database. Inclusion criteria age>18, adult spinal deformity, >4 levels fused, min 1yr follow-up. Complications were defined as minor or major per previously published criteria. Health related quality of life measures were determined for each patient for baseline and one year. Outcome measures included Oswestry Disability Index (ODI), SF36, and SRS-22.

Results: 202 patients met inclusion criteria. Mean age is 57.4yrs (SD=14yrs), mean number levels fused 12 (SD=4). Four groups were identified: no complication (n=84, 42%), minor complication (n=87, 43%), major complication (n=65, 32%), and both minor and major complications (n=35, 17%). There was no difference in HRQL measures at baseline or at 1yr for those with and without complications, major or minor. There was no statistical significance for 1

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year HRQL based upon pain, resolution of complication, or time of complication (early<30days, late>30days). Patients requiring reoperation had higher ODI (37.1 vs 25.6, P=0.001) and lower SF36 PCS (33.9 vs 41.3, P=0.01) scores at 1 year. Indications for reoperation included 4/34 infections, 10/34 junctional kyphosis, 10/34 implant failure, 10/34 other.

Conclusion: Major and minor complications are not associated with significant differences in HRQL at one year. However, complications that resulted in reoperation had decreased one-year HRQL outcomes. Further study is needed to assess the quantitative economic impact of perioperative complications.

73. Coronal Imbalance may be Neglected in Patients Undergoing Majority Sagittal Deformity Correction

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Summary: Correction of coronal imbalance continues to be a difficult task. We sought to understand which patients experience a correction of coronal imbalance and which parameters seem to inhibit the ability or desire to correction coronal imbalance. Correction of sagittal malalignment was found to prevent restoration of normal coronal balance and nearly 75% of patients with worsened coronal imbalance underwent pelvic fixation.

Introduction: Achieving coronal balance in ASD patients undergoing long fusions is a challenge. Intraoperative radiographs are helpful, but are not absolutely reliable in avoiding residual coronal imbalance (CI). Using a prospectively collected, multi-center database of ASD patients, we assessed factors contributing to significant (>4cm) postoperative CI.

Methods: Multi-center retrospective review of prospectively collected data of 132 ASD patients. Inclusion criteria age>18, Cobb>20° or SVA>5cm or pelvic tilt>25° or thoracic kyphosis > 60° and minimum 2 year follow-up. Preop and postop standing radiographs were performed on all patients. Coronal balance was defined as C7 deviation from C7PL less than 4cm. Patients were divided into four groups by comparing preoperative and postoperative coronal alignment: persistent balance (PB; C7PL remained <4cm), persistent imbalance (PI; C7PL remained >4cm), iatrogenic imbalance (II; C7PL became >4cm), and corrected (CB; C7PL became <4cm). Demographic, operative and radiographic parameters were analyzed using chi-square and t-test analysis.

Results: 9 patients were PI, 20 patients were II, 80 patients were PB, 23 patients were corrected. Patients with PI had significantly greater SVA preoperatively than CB patients (14.1 cm vs 4.4cm; p=0.007). II patients had moderate preoperative sagittal imbalance compared to those corrected (7.8 cm to 3.1 cm) (p=0.076). 75% of patients with II were fused to the pelvis compared to only 50% of patients with PB who were fused to the pelvis (p=0.056). Despite

postoperative CI in 29 postoperative patients, HRQOL measures, SF-36, SRS-22, and ODI (Table 1), were not statistically different between groups.

Conclusion: Emphasis on attempted correction of significant sagittal imbalance may preclude restoration of coronal balance. Long fusion to the pelvis also influences postoperative coronal balance. However, postoperative CI does significantly influence two-year clinical outcomes measures. It is likely that successful correction of sagittal imbalance outweighs the impact of persistent coronal imbalance. Surgeons should be aware of these factors in the perioperative management.

74. Early and Late Thoracic Kyphosis Following 104 Lumbar Pedicle Subtraction Osteotomies (LPSO) with Un-Fused Thoracic Spine

Eric Klineberg, MD; Virginie Lafage, PhD; Jamie S. Terran, BS; Christopher P. Ames, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Kai-Ming Fu, MD, PhD; Themistocles S. Protopsaltis, MD; Frank J. Schwab, MD; Khaled Kebaish, MD; Munish C. Gupta, MD; International Spine Study Group USA

Summary: Lumbar pedicle subtraction osteotomy is an important option to correct sagittal plane deformity. When the thoracic spine is un-fused, reciprocal changes may occur. We found thoracic kyphosis >5deg occurs in 72% of patients by 3 months, and in 80% by 1 year, but resulted in few reoperations. Risk factors include: greater age, larger sagittal malalignment, and greater correction performed. Surgeons must take these reciprocal changes into account when leaving the thoracic spine un-fused in the older patient with a lumbar PSO.

Introduction: Reciprocal thoracic kyphosis (TK) may occur following LPSO in the un-fused spine and lead to worsening global alignment and additional surgery. The purpose of this study is to determine the prevalence and risk factors for TK after LPSO.

Methods: Retrospective, multi-center database. Inclusion criteria age>18, adult spinal deformity, LPSO, T1-T8 un-fused thoracic spine, min 1yr radiographs. TK defined as >5° change. 3mo patients defined as either No TK (NTK), or Early TK (ETK). At 1 year NTK was divided into NTK or DelayedTK (after 3mo) and ETK was divided into ProgressiveTK (ETK increasing from 3mo to 1yr) or HaltedTK (progression from BL to 3mo, then halted). Parameters studied: sagittal vertical axis (SVA), Lumbar Lordosis (LL), Pelvic Tilt (PT), Pelvic Incidence (PI), pelvic mismatch (PI-LL).

Results: 104 patients met inclusion criteria. At 3 months NTK=29, ETK=75. ETK patients are older (60 v 55, p=0.014), with similar BMI, and levels fused (7). PreOP parameters were similar except for larger C7 plumb lines for ETK (12.2 v 7.6mm, p=0.021). ETK had significantly greater change in pelvic mismatch (31.5 v 21.1, p=0.002) SVA (97.1 v 65.1mm, p=0.045) and LL (31.4 v 21.2, p=0.002), which led to most improved 3mo pelvic mismatch in the ETK group (p=0.005). At 1 year, 8/29 NTK went on to DelayedTK, and 17/75

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ETK went on to ProgressiveTK with corresponding significantly more kyphosis (51 ProgressiveTK v 33 NTK, $p=0.011$). There was no statistical difference in groups for age, BMI, or levels fused. Pre-op HaltedTK vs NTK had larger SVA (16.1 v 88.5mm, $p=0.014$), as well as PSO correction (29.5° v 18.6°; $p=0.01$). ProgressiveTK had a significantly greater correction of pelvis mismatch than NTK (32.6 v 17.5, $p=0.037$). Reoperation for proximal extension was rare: 5.2% HaltedTK, and 0% DelayedTK, 5.9% ProgressiveTK; no statistical difference between groups.

Conclusion: TK >5° occurs in 72% of patients following LPSO at three months and increases to 80% at 1 year. Risk factors are older age and larger deformity correction (SVA, LL, pelvic mismatch) for ETK. DelayedTK is associated with greater spinopelvic correction. In all groups, reoperation rates for TK was rare. When performing LPSO in older patients, reciprocal TK must be considered.

75. Scoliosis is a Risk Factor for Gastroesophageal Reflux Disease in Adult Spinal Deformity

Naobumi Hosogane, MD; Kota Watanabe; Mitsuru Yagi, MD, PhD; Shinjiro Kaneko, MD, PhD; Hitoshi Kono; Masanobu Shioda; Masafumi Machida, MD; Masashi Saito; Yoshiaki Toyama; Morio Matsumoto, MD
Japan

Summary: Gastroesophageal reflux disease (GERD) symptoms were evaluated in 190 spinal disorder patients including 126 degenerative lumbar kyphoscoliosis (DLKS) patients using Quest (Questionnaire for the diagnosis of reflux disease). Fifty-nine patients were GERD positive (Quest 6). Multivariate regression analysis revealed that left lumbar curve larger than 30° was a significant risk factor for the presence of GERD (odds ratio 10.9).

GERD symptoms should also be taken into consideration in the treatment of adult spinal deformity.

Introduction: Patients with DLKS (degenerative lumbar kyphoscoliosis) are at a risk of developing various visceral organ disorders due to their trunk deformity. The aim of this study was to evaluate the influence of the trunk deformity on gastroesophageal reflux disease (GERD).

Methods: One-hundred-ninety patients over 40 years of age (mean 70.2 years, 51 males and 139 females) who had whole standing spine X-ray and answered to the Quest (Q; Questionnaire for the diagnosis of reflux disease) were included in this study. Quest is an 18-point scale and has been developed for the screening of GERD patients. Patients with Q score 6 points or more were defined as GERD positive. Radiological parameters including Cobb angle, sagittal alignment and trunk balances were measured and evaluated the relation to the Q score with Pearson's correlation coefficient analysis. Multivariate logistic regression analysis was performed to evaluate the risk factors for GERD.

Results: The average Q score was 3.7 points (-1 to 15) in whole 190 patients and 59 patients were GERD positive. In order to discriminate the direction of lumbar curve, we defined right convex curve as negative and left convex curve as positive value. There were 42 patients with right convex lumbar curve (mean

-34.1°; -10 to -90°) and 84 patients with left convex lumbar curve (mean +33.6°; 11 to 109°). Q score was significantly correlated with lumbar Cobb angle ($R=0.26$). There were no significant correlations with sagittal parameters. In multivariate regression analysis, lumbar Cobb angle tended to be associated with the presence of GERD (Odds ration 1.02, 95% CI 1.01-1.03, $p=0.06$). Moreover, lumbar Cobb angle larger than 30° was strongly associated with the presence of GERD (Odds ratio 10.9, 95% CI 2.26 - 52.80, $p<0.05$).

Conclusion: This study showed that left lumbar curve larger than 30° was a significant risk factor for the presence of GERD. We should consider that lumbar deformity may affect the visceral organ when evaluating DLS patients.

76. Comparison of S2 Al and Iliac Bolt Pelvic Fixation in the Reconstruction of Adult Spine Deformities

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USA

Summary: 60 adults requiring long fusions to the pelvis utilizing either S2 Al or iliac bolt pelvic fixation were compared at a minimum of 2 year follow-up. Parameters evaluated were radiographic changes at the SI joint (erosions or sclerosis), lucencies around the pelvic screws, failure of sacropelvic fixation and need for screw removal due to pain related to the pelvic fixation.

Introduction: One classic technique to achieve pelvic fixation is to insert an iliac bolt starting at the posterior superior iliac spine. Because of difficulties related to this technique, the S2 alar iliac (S2 Al) screw technique was adopted. These screws do cross the SI joint, though, potentially resulting in joint damage, loosening and pain. We compared the incidences of SI joint changes, loosening, screw related pain and failure of fixation in patients with S2 Al screws and patients with iliac bolts.

Methods: 28 patients who had S2 Al screws placed as part of a long fusion were retrospectively compared to 32 patients who had iliac bolts placed. Radiographs were assessed at 6 weeks, 3, 6, and 12 months and then at least annually thereafter for loosening around the pelvic screws, erosions or sclerosis of the SI joints, or failure of the lumbopelvic fixation. The time to development of these changes was recorded. Patients who required removal of their pelvic implants due to SI joint pain were also noted.

Results: The average follow-up for the S2 Al group was 33 +/- 6 months compared to 45 +/- 15 months for the iliac bolt group. In the S2 Al group 8 patients (28%) developed screw lucencies an average of 17 months postop, compared with 4 patients in the bolt group (12%) an average of 18 months postop ($p=0.19$). SI joint changes were seen in 8 patients in the S2 Al group (28%) compared with 6 in the bolt group (19%) ($p=0.54$). However these occurred an average of 12.5 months postop in the S2 Al group, compared with 27.5 months in the bolt group ($p=0.04$). 3 patients in the S2 Al group had removal of their pelvic screws due to pain compared to 2 in the iliac bolt group. Finally, 2 patients had failure of their lumbopelvic fusion in the S2 Al group (7%) compared to 9 in the bolt group (28%) ($p=0.05$).

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Conclusion: S2 AI screws have similar rates of SI joint changes, lucencies and incidences of screw removal due to pain compared to iliac bolts, but with a lower rate of construct failure. However, the changes in the SI joint occur significantly quicker with S2 AI screws, perhaps due to SI joint penetration. Longer follow-up may reveal that this leads to greater incidences of SI joint pain.

77. Comparison of Standard 2-Rod to Multiple-Rod Constructs for Fixation across Three-Column Spinal Osteotomies

*Seung-Jae Hyun, MD; Lawrence G. Lenke, MD; Linda Koester, BS
Republic of Korea*

Summary: We compare radiographic outcomes following use of a standard 2-rod construct vs a Multi-RC across the 3-CO site in a matched cohort of patients with severe kyphosis and/or scoliosis with a minimum 2-year follow-up. We found no fixation failure of the Multi-RC and no pseudarthrosis at the osteotomy site at minimum 2-year follow-up and recommend using Multi-RC when performing 3-CO of the thoracic and lumbar spine.

Introduction: Three-column osteotomy (3-CO) including pedicle subtraction osteotomy (PSO)/vertebral column resection (VCR) are used for treating severe spinal deformities, typically with a standard 2-rod construct (2-RC) across the highly unstable osteotomy site. Our purpose was to compare radiographic outcomes following use of a standard 2-RC vs a multiple rod construct (Multi-RC) across the 3-CO site in a matched cohort of patients with severe kyphosis and/or scoliosis with a minimum 2yr follow-up (F/U).

Methods: Between 1996-2010, pts undergoing a 3-CO by a single surgeon were matched based on age at surgery (within 10 years), diagnosis, curve pattern, vertebra(e) resected (within 1), levels fused (within 5) and min 2yr F/U. A total of 66 control pts with a 2-RC were identified and appropriately matched to 66 consecutive pts with a Multi-RC (Ave 3.4 rods with a range 3-5 rods across the 3-CO site). Each group included 50 pts having had a lumbar PSO and 16 pts with a VCR. Comparison of the following parameters for the Multi-RC vs 2-RC demonstrated no statistical differences: mean age at surgery: 48.5yrs/49.4yrs ($p=0.78$); vertebrae resected: 1.12/1.08 ($p=0.42$); levels fused: 13.4/12.3 ($p=0.10$); bone morphogenetic protein used: 42 vs 52 ($p=0.06$); ave preop coronal Cobb: 55.6°/53.7° ($p=0.65$), ave preop sagittal Cobb: 39.5°/37.7° ($p=0.69$).

Results: There were no complete instrumentation failures of the Multi-RC noted, but there were 2 (3.0%) pts in the Multi-RC who had asymptomatic partial rod breakage without any symptomatic pseudarthrosis at the osteotomy site. In comparison, the 2-RC group had 13 (19.7%) pts with rod breakage at the osteotomy site ($p=0.002$) with 7 (53.8%) of the 13 pts requiring revision surgery for the implant breakage ($p=0.007$). Five Multi-RC (7.5%) and 4 2-RC (6.0%) pts developed pseudarthrosis above or below the osteotomy site, respectively ($p=0.73$).

Conclusion: The use of a Multi-RC is a safe, simple and effective method to provide increased stability across 3-CO sites in order to significantly prevent

implant failure and symptomatic pseudarthrosis vs a standard 2-RC. We strongly recommend using a Multi-RC to stabilize 3-CO of the thoracic and lumbar spine.

78. Transforaminal Anterior Release for the Treatment of Fixed Sagittal Imbalance and Segmental Kyphosis

Fred A. Sweet, MD

USA

Summary: Fixed sagittal imbalance has been treated most recently by pedicle subtraction osteotomy with great success but is technically demanding, associated with significant blood loss and neurologic risks. We describe a single surgeon series of forty-seven consecutive patients in whom fixed sagittal imbalance or segmental kyphosis was treated with a unilateral transforaminal annular release with a minimum two year follow-up.

Introduction: Pedicle subtraction osteotomy has become a preferred treatment of fixed sagittal imbalance but has a steep learning curve with associated high blood loss and neurologic risk. We describe a single surgeon series of treating fixed sagittal imbalance and segmental kyphosis with a novel transforaminal annular release technique which allows a continuum of sagittal correction, low blood loss and neurologic safety.

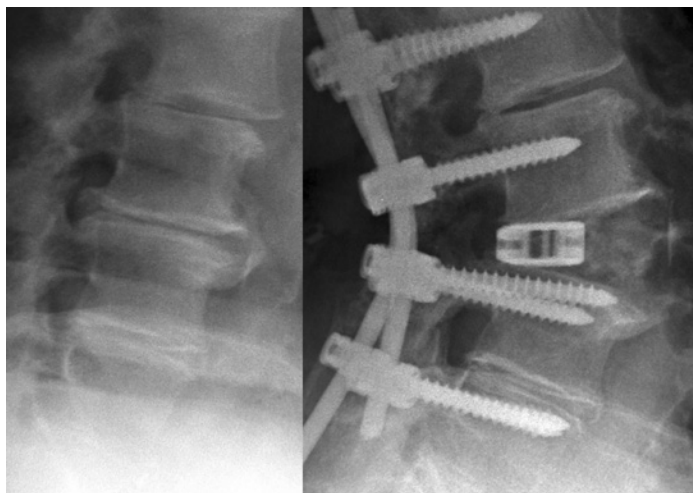
Methods: Forty-seven consecutive patients with fixed sagittal imbalance or segmental kyphosis were treated by a single surgeon with a single level transforaminal anterior release (TFAR) to effect an opening wedge correction. Correction was performed with in-situ rod contouring to the desired degree of lordosis and scoliosis correction. An Inter-body cage was captured in the disc space with rod compression with bone graft and BMP. Radiographs were analyzed for thoracic kyphosis, lumbar lordosis, pelvic incidence, C7 plumb line, lordosis and scoliosis correction at the TFAR site. Pre and post operative radiographs, Oswestry and SF-36 forms were used at minimum of 2 year follow-up. Blood loss and complications were analyzed.

Results: The average increase in lordosis was 36 degrees, (range 24-56). Coronal corrections averaged 28 degrees, range 18 to 48. The average improvement in plumb line was 12.8 cm. There were three pseudarthrosis, none at the TFAR. Blood loss averaged 660 cc, range 280 to 1200 cc. Only three patients required a blood transfusion. One patient had a transient grade 4/5 anterior tibialis weakness. Three patients had post operative neuritis that resolved. There were no vascular injuries or permanent neurologic deficits. There were significant improvements in the Oswestry ($p<0.001$), SF-36 ($p<0.001$) and pain scales ($p=0.003$). 84% of patients reported improvement in pain, self image and satisfaction with the procedure.

Conclusion: Transforaminal Anterior Release (TFAR) is a useful procedure for correcting segmental kyphosis and fixed sagittal imbalance with relatively low

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blood loss and neurologically safe in this single surgeon series. Increased patient comorbidities and pseudarthrosis were associated with worse clinical results.



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79. A Novel Scientific Model for Rare and often Neglected Neoplastic Conditions: AOSpine Knowledge Forum Tumor International Dataset for Primary Tumors of the Spine

Charles G. Fisher, MD, MHS; Michael G. Fehlings, MD, PhD; Mark Bilsky, MD; Mark B. Dekutoski, MD; Luzzati Alessandro; Richard Williams; Sigurd H. Berven, MD; Nasir A. Quraishi, FRCS; Laurence D. Rhines, MD; Chetan Bettegowda, MD, PhD; Ziya L. Gokaslan, MD
Canada

Summary: Due to the rare occurrence of primary tumors of the spine (PST), valid evidence and treatment recommendations can only come from multi-center cooperations providing an appropriate number of cases. AOSpine's Knowledge Forum Tumor built a network of 12 spine centers from around the world contributing 1496 PST cases, the largest cohort in this field. The most prevalent diagnosis was chordoma, median survival for all subtypes 13 years. The network is currently implementing a prospective collection including a PST biobank.

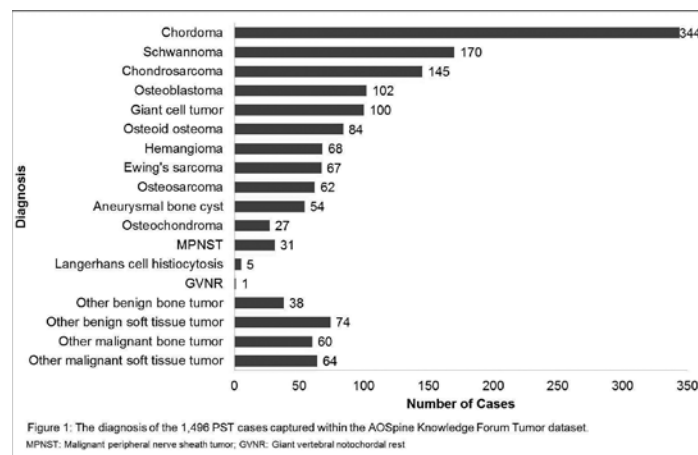
Introduction: Primary tumors of the spine (PST) are often lethal and therefore optimal management is critical. Unfortunately, there is limited evidence to guide clinical management due to their rare occurrence and variable pathology. The objective of this study was to develop a multi-center, international research model and dataset to determine optimal management with respect to minimizing local recurrence and improving overall survival for PST.

Methods: Centers with sufficient patient volumes and expertise in the field of spine oncology were identified and obtained review board approval. A total of 12 spine centers from around the world contributed cases. A database consisting of a

secure, web-based application to support international data capture was implemented. Six modules were developed; demographic, clinical, diagnostic, and therapeutic variables associated with survival, local recurrence, and peri- and post-operative morbidity was collected. Local recurrence and survival was obtained cross-sectionally.

Results: A total of 1496 tumor cases were captured and diagnosed as one of the 18 primary spine tumor sub-types (Figure 1). The most prevalent diagnosis was chordoma (n=344, 23%). There were 675 females and 821 males with a mean age of 43±19 years at the time of surgery. Surgical treatment was performed between the years 1981 to 2012. The survival at five and ten years post-surgery was 71.9% and 53.0%, respectively, with a median survival of 13 years.

Conclusion: This is the largest cohort of PST. Through international collaboration, we have not only aggregated a large amount of PST data, but we have also established a model and network of spine oncology centers and implemented prospective collection including a PST biobank where clinical data will be linked to corresponding biospecimens undergoing molecular analysis. This access to large volumes of data will allow us to generate high level research to guide and enhance the clinical management of PST. The model can also serve as a research template for other rare diseases.



80. A Comparison of the Tokuhashi Revised and Tomita Scoring Systems in a Prospective Cohort of Patients with Metastatic Epidural Spinal Cord Compression (MESCC)

Søren S. Morgen, MD; Dennis Hallager Nielsen, MD; Rikke Søgaard, MSc, MPH, PhD; Claus F. Larsen, MD, DMSci; Svend Aage Engelholm, DMSci; Benny Dahl, MD, PhD, DMSci
Denmark

Summary: This prospective, one-center study shows that the Tokuhashi revised (TR) scoring system is more accurate than the Tomita scoring system, but that both systems may need modification to predict long-term survival.

Introduction: Expected survival in patients with acute symptoms of MESCC is a crucial element in the pre-operative evaluation. Consequently, expected survival is

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a variable in scoring systems such as TR and Tomita. To our knowledge, no study has compared these two systems in a recent, large and prospective cohort of patients with MESCC.

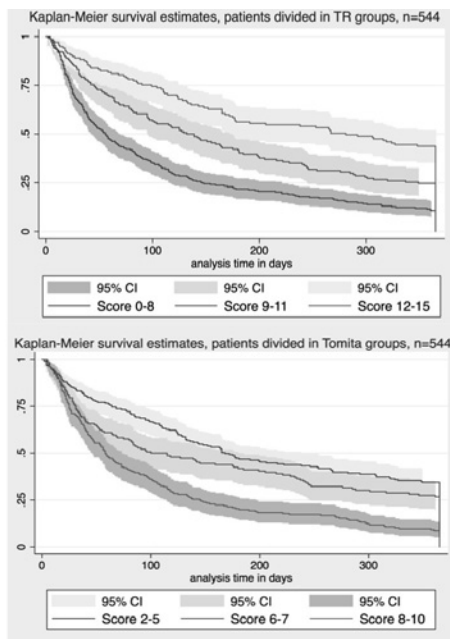
Methods: During 2011 a total of 544 consecutive patients with acute symptoms of MESCC were included in a one-center cohort study. All patients were scored with TR and Tomita scoring systems and were divided into the respective prognostic groups. One-year survival status was obtained in all patients and compared to the estimated survival of each group in the scoring systems.

Results: The mean age was 65 years (range 20- 95) and 57% of the patients were men. The most common primary tumor-sites were lungs (23%), prostate (21%), and breast (18%).

The positive predictive values regarding one-year survival were 55% for TR and 14% for Tomita while the negative predictive values were 68% for TR and 57% for Tomita.

Kaplan-Meier survival estimates showed that the actual survival for each of the TR prognostic groups was separated by non-overlapping confidence intervals (CI). There were some overlaps of the CI's in the Tomita groups. In both the TR and the Tomita groups with an expected survival of more than six months the actual survival was shorter than estimated.

Conclusion: The Tokuhashi revised scoring system was more accurate than the Tomita scoring system regarding one-year survival. Modification of both scoring systems may be necessary to improve prediction of more than six months survival.



81. Spinal Instability Neoplastic Score: An Analysis of Reliability and Validity in Radiation Oncologists: An AOSpine Knowledge Forum Tumor Project

Charles G. Fisher, MD, MHSc; Laurence D. Rhines, MD; Norio Kawahara, MD, PhD; Daryl R. Fourny, MD, FRCSC, FACS; Jeremy J. Reynolds, MBChB; Michael G. Fehlings, MD, PhD; Rowan Schouten; Ziya L. Gokaslan, MD Canada

Summary: The purpose of this study was to evaluate the reliability and validity of the Spinal Instability Neoplastic Score (SINS) in other disciplines than surgeons involved in the recognition and care of patients with spinal neoplasms amongst 33 radiation oncologists, results showed that SINS is a highly reliable and valid tool when focusing on stable versus the combined impending instability and unstable group. This supports appropriate standardized recognition and referral patterns initiated by oncologists for tumor-related spinal instability.

Introduction: Standardized recognition, notification, and referral patterns initiated by oncologists for tumor-related spinal instability are hampered by the lack of a valid and reliable classification system. Therefore, the Spinal Instability Neoplastic Score (SINS) was developed and an initial study in spine surgeons revealed a near-perfect inter- and intra-observer reliability. The next step was to assess SINS in other disciplines involved in the recognition and care of patients with spinal neoplasms

Methods: 33 radiation oncologists from 10 sites and 11 spine surgeons independently assessed 30 de-identified cases. Cases consisted of pre-operative Xrays and/or CT images, MR images, demographic data, clinical and histopathological information. For each case, the assessor performed the SINS evaluation based on a 0-18 point scale (figure 1): stable (0-6), impending instability (7-12), and unstable (13-18). In addition, a binary indicator of "referral instability" was used where conditions were classified either as stable (0-6) or requiring referral for surgical assessment (7-18) (table 1). The radiation oncologists performed the evaluation twice 6-8 weeks apart, while the 11 surgeons performed the evaluation once to determine the "gold standard".

Results: For the first and second assessment, fair inter-observer agreement was observed for the 0-18 SINS ($\kappa = 0.19$ and 0.21), moderate agreement for the 3-point SINS ($\kappa = 0.54$ and 0.53), and substantial agreement for the 2-point SINS ($\kappa = 0.76$ and 0.74). The intra-observer reproducibility for the 0-18 SINS score was fair ($\kappa = 0.33$), substantial for the 3-point SINS ($\kappa = 0.65$) and excellent for the 2-point SINS ($\kappa = 0.80$). The agreement with the gold standard was fair for the 0-18 SINS ($\kappa = 0.28$ and 0.29), moderate for the 3-point SINS ($\kappa = 0.61$, both), and excellent for the 2-point SINS ($\kappa = 0.84$, both).

Conclusion: Among radiation oncologists, SINS is a highly reliable and valid tool

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when focusing on stable versus the combined impending instability and unstable group. This supports appropriate referral patterns.

Figure 1: The SINS scoring system

SINS Component	Description	Score
Location	Junctional (occiput-C2, C7-T2, T11-L1, L5-S1)	3
	Mobile spine (C3-C6, L2-L4)	2
	Semi-rigid (T3-T10)	1
	Rigid (S2-S5)	0
Pain	Yes	3
	Occasional pain but not mechanical	1
	Pain-free lesion	0
Bone lesion	Lytic	2
	Mixed (lytic/blastic)	1
	Blastic	0
Radiogr. spinal alignment	Subluxation/translation present	4
	De novo deformity (kyphosis/scoliosis)	2
	Normal alignment	0
Vertebral body collapse	>50% collapse	3
	<50% collapse	2
	No collapse with >50% body involved	1
	None of the above	0
Posterolateral	Bilateral	3
	Unilateral	1
	None of the above	0

Table 1: SINS categories and corresponding cut-offs (if appropriate)

0-18 SINS	1 2 3 4 5 6	7 8 9 10 11 12	13 14 15 16 17 18
3 points SINS	Stable	indeterminate instability	unstable
2 points SINS	Stable	surgical consultation recommended	

82. Change of Survival in Patients with Metastatic Epidural Spinal Cord Compression According to Primary Cancer Diagnosis

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Denmark

Summary: Patients suffering from metastatic epidural spinal cord compression (MESCC) are routinely evaluated with pre-operative scoring systems using the primary oncologic diagnosis as key variable. Therefore it is relevant to monitor survival in MESCC patients with respect to primary diagnose. This study on 2321 MESCC patients consecutively admitted for surgical evaluation show improved survival for patients with pulmonary or renal cancer as primary diagnose over a six-year period.

Introduction: An increasing number of patients are offered surgical treatment for MESCC. Among the reasons for this development are high evidence clinical studies, improved surgical techniques and an increasing number of patients being treated for an oncologic condition. Pre-operative scoring systems using the primary oncologic diagnosis as key parameter are routinely used in the evaluation of these patients. Changed survival in respect to primary diagnose could have implications on the scoring systems

Methods: All patients referred to a tertiary university hospital with acute

symptoms of MESCC from January 1st 2005 to December 31st 2010 were included in a retrospective cohort. For all patients primary tumor, treatment and one-year survival was registered.

Results: A total of 2321 patients were included. The mean age on admission was 66 years (SD = 12, range 19 - 95) and 54% of the patients were men. The most common primary tumor-sites were lungs (21%), breast (17%), and prostate (16%). The overall one-year survival (33%) and the percentage treated with surgery (21%) did not change significantly, but there was a significant increase in one-year survival for the subgroups of patients with lung cancer: hazard ratio (HR) = 0.93 (P = 0.008, 95% CI: 0.83-0.98) and renal cancer: HR = 0.77 (P = 0.004, 95% CI: 0.56-0.92).

Conclusion: Patients with MESCC from pulmonary and renal cancer experienced improved survival in the study period. No improvement was seen for patients with other oncologic diagnoses. Further studies are needed to assess the impact of these findings on the scoring systems used for the pre-operative evaluation.

83. Modified Posterior Vertebral Column Resection for the Treatment of Osteoporotic Fractures with Neurological Deficit in Elderly Patients

Meriç Enercan; Çağatay Öztürk, MD; Sinan Kahraman; Bekir Y. Uçar, MD; Alaa Zakout; Azmi Hamzaoglu, MD
Turkey

Summary: Decompression of the spinal canal and reconstruction of anterior column via a posterior approach provided satisfactory results in osteoporotic elderly patients.

Introduction: Purpose of this retrospective study was to evaluate the results of spinal canal decompression and anterior column support via modified PVCR in elderly patients having osteoporotic vertebral fractures with neurological deficit.

Methods: Thirty-three consecutive patients (28 female and 5 male) with more than 2 years follow-up were included. Fractures were at thoracic in 11 and thoracolumbar spine in 22 patients. Nine patients had ASIA C and 24 patients had ASIA D neurological deficit. Radiographic analysis included Local kyphosis angle (LKA). Clinical outcome and complications were also evaluated. Surgical technique included placement of cement augmented pedicle screws, followed by hemilaminectomy, unilateral pediclectomy, sacrifice of nerve root between Th2 and Th11, decompression of spinal canal by doing subtotal vertebrectomy and adjacent discs and anterior column support by titanium mesh. Contralateral posterior elements were preserved for fusion. One level above and one level below prophylactic vertebroplasty were performed in all patients.

Results: Av. age was 71.5 (56-88) years and follow-up was 55.5 months (24-96). Av. level of instrumentation was 5.6 (4-8), operation time was 400 (180-600) minutes and blood loss was 640 (450-800) ml. Av. preoperative LKA of 16.5 degrees improved to 3.2 degrees postoperatively and was 3.7 degrees at last follow-up. Preoperative VAS of 8 was 2 postoperatively and 3 at final follow-up. Full neurologic recovery was achieved in all patients. There was no

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pseudoarthrosis. The major complication was adjacent segment fracture requiring revision (3%). The minor complications were superficial wound infection in 2 patients (6%) and dural tear in one patient (3%). The overall complication rate was 12%.

Conclusion: Decompression of the spinal canal and reconstruction of anterior column via a posterior approach provided satisfactory results in osteoporotic elderly patients. This procedure obviated the need for anterior approach which might have caused significant morbidity in these elderly patients. Preservation of contralateral posterior elements (lamina, pedicle, facet joints) might have helped to obtain higher fusion rates so that 270 degrees fusion is provided.

84. Stabilization of the Craniocervical Junction after an Internal Dislocation Injury: An In-Vitro Study

Kristen E. Radcliff, MD; Mir Hussain; Mark Moldavsky, MS; Noelle Klocke, MS; Alexander R. Vaccaro, MD, PhD; Todd J. Albert, MD; Saif Khalil, PhD; Brandon Bucklen USA

Summary: Reconstructive constructs at the occipitocervical (OC) junction have been studied in degenerative fusion. There is a paucity of data on the optimal fixation construct in OC traumatic instability. A biomechanical study to compare posterior instrumentation after replicating severe trauma was conducted to assess the relative advantages of fixation. The strongest construct for stabilization of a craniocervical dislocation includes segmental instrumentation at the occiput, C1, and C2.

Introduction: Prior biomechanical studies of OC fixation have used degenerative models, not traumatic instability. In OC dislocations, segmental fixation may be impossible due to vertebral artery injury or fracture. The purpose of this study was to determine the rigidity of segmental instrumentation versus nonsegmental fixation at the OC junction with or without a cross link.

Methods: Intervertebral motion and translation recorded in seven specimens under the following conditions: intact, OC dislocation model (complete sectioning of the cruciate/alar ligaments and occipitoatlantal/atlasaxial capsules), occiput-C1-C2 instrumentation (O-1-2), occiput-C2 isolated instrumentation omitting C1 fixation (O-2), and occiput-C2 isolated instrumentation with a crosslink (O-2+C).

ELLIPSE® Occipito-Cervico-Thoracic Stabilization System (Globus Medical, Inc., Audubon, PA) was used for all instrumentation constructs. Motion was applied by a custom spine tester (2 N-m) and measured with markers attached to occiput, anterior C1 ring, and C2. Flexion-extension (FE), lateral bending (LB), and axial rotation (AR) motions were applied. Results are presented as a percentage of intact motion (Intact = 100%) unless otherwise stated.

Results: The OC dislocation model increased motion significantly ($p < 0.05$) in FE (169%), LB (292%), and AR (131%) and translations ($>200\%$) in all planes. With O-1-2 instrumentation, motions [FE (12%), LB (17%), AR (4%)] and translations ($<10\%$) were significantly reduced. With O-2 instrumentation, there was a significant increase of motion in FE (165%), and translation (184%)

during FE when compared to segmental instrumentation. With O-2+C instrumentation, there were no statistical differences compared to O-1-2, however, there was increased rigidity compared to O-2 construct.

Conclusion: The strongest construct for stabilization of a craniocervical dislocation includes segmental instrumentation at the occiput, C1, and C2. Skipping instrumentation at C1 significantly increased motion in flexion-extension and translation ($p < 0.05$). The addition of a crosslink resolved some of the instability. All instrumentation constructs were statistically stiffer in terms of rotation and translation than both the intact and injury conditions.

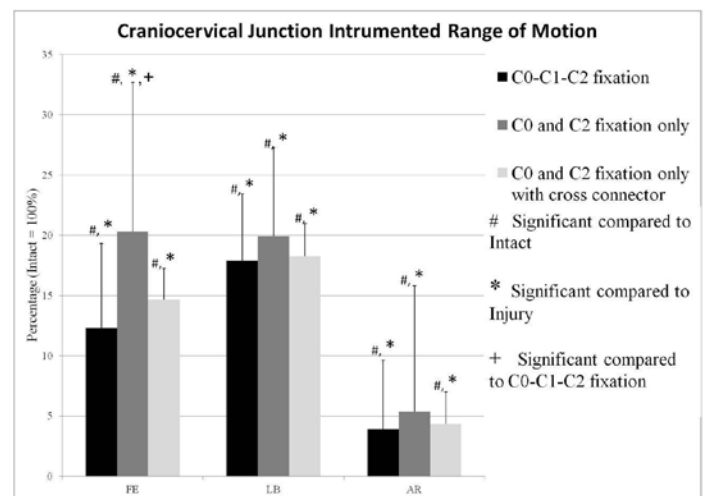


Figure 1: The FE, LB, AR range of motion of instrumented constructs in percentage. Intact is 100%, injured is 169%, 292%, 131% in FE, LB, AR, respectively

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

85. Efficacy and Safety of Riluzole in Acute Spinal Cord Injury (SCI). Rationale and Design of AOSpine Phase III Multi-Center Double Blind Randomized Controlled Trial. (RISCIS)

Michael G. Fehlings, MD, PhD; Branko Kopjar; Robert G. Grossman, MD Canada

Summary: This abstract described rationale and design for ongoing multi-center double-blind randomized controlled trial of efficacy and safety of riluzole in patients with acute SCI.

Introduction: The final degree of neurological tissue destruction that occurs after traumatic SCI is a product of both primary and secondary injury mechanisms. The primary injury that is caused by rapid spinal cord compression initiates an injury signaling cascade of deleterious down-stream events, known collectively as secondary injury mechanisms, and include ischemia, interstitial and cellular ionic imbalance, free radical formation, glutamnergic excito-toxicity, lipid peroxidation and generation of arachidonic acid metabolites. There is convincing evidence from the preclinical realm that the pharmacologic agent riluzole attenuates certain

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aspects of the secondary injury cascade leading to diminished neurological tissue destruction in animal SCI models. Recently, the clinical safety and pharmacokinetic profile of riluzole have been studied in a multi-center pilot study in the context of human traumatic SCI. A total of 36 patients received an oral dose of riluzole 50 mg twice daily for 2 weeks, with treatment initiated within 12 hours of injury for all patients.

Methods: This Phase II/III multi-center double-blind randomized controlled trial will involve up to 35 sites. A total of 351 patients with acute C4—C8 SCI and ASIA Impairment Grade A, B or C will be randomized 1:1 to riluzole and placebo. Primary outcome is the change in ASIA Total Motor Score between baseline and 180 days. Other measures include ASIA Upper Extremity Motor Score; ASIA Lower Extremity Motor Score; ASIA Sensory Score; ASIA grade; Spinal Cord Independence Measure; SF-36v2; EQ-5D and GRASSP. The statistical design utilizes 2-stage sequential adaptive trial. A sample size of 316 subjects (158 in each arm) will have 90% power to detect 9 points difference in the ASIA Motor Score at one-sided $\alpha = .025$. To account for losses to follow-up of up to 10%, the study will enroll 351 subjects.

Results: Subjects enrollment will start on April 1, 2013.

Conclusion: This is a pivotal study of riluzole in acute SCI. This abstract discusses an FDA approved drug in the off-label indication.

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).

86. Comparison of Neurological Improvements in Acute Traumatic Central Cord Syndrome Following Surgical and Non-Surgical Interventions

Naresh S. Kumar, FRCS(Ed), FRCS(Orth), DM; Jason Tay TE; Shi Hui Lee; Effie Chew; Gabriel Liu, MSc, FRCS(Ed&Orth); Joseph Thambiah, FRCS; Hee-Kit Wong Singapore

Summary: Our study aims to compare the functional neurological recovery of Acute Traumatic Central Cord Syndrome (ATCCS) patients after either surgical or non-surgical intervention. Neurological outcomes were measured by the American Spinal Injury Association (ASIA) motor score (AMS) and Neurological Level of Injury (NLI). Comparisons of the scores at time of presentation and discharge showed a greater improvement in the surgical cohort than in the non-surgical cohort. Patients receiving earlier surgical intervention (≤ 24 hours) showed the greatest improvement.

Introduction: Acute Traumatic Central Cord Syndrome (ATCCS) was first described by Schneider in 1954. Since then, there were strong advocates for treatment by non-operative approaches. However recent studies have shown encouraging neurological improvements in patients treated surgically. The purpose of our study is to compare and evaluate functional neurological recovery between surgical & non-surgical intervention cohorts, following an ATCCS.

Methods: We reviewed 59 patients who were treated at our hospital with a

diagnosis of ATCCS from May 2005 to April 2011. Clinical indicators used for assessing neurological outcomes were the American Spinal Injury Association (ASIA) motor score (AMS) and Neurological Level of Injury (NLI). These were obtained at the time of admission, in the immediate post-op period, and at time of discharge. The surgical cohort was further stratified into 3 subgroups with regards to timing of surgical intervention after injury: ≤ 24 hours, >24 hours till 1 week, and >1 week.

Results: The surgical cohort had 38 patients, in which surgery was performed at a mean of 10.4 days (range, 0.6-150 days) following onset of injury. Majority of them (50.0%) were operated on >24 hours till 1 week. Surgical approaches were as follows: anterior approach in 18 patients (47.4%), posterior approach in 19 patients (50.0%), and combined anterior-posterior approach in 1 patient (2.6%). The mean AMS was 52.2 at presentation and 65.8 at discharge; the improvement in mean AMS was 13.6, with 11 patients (29.0%) improving at least one ASIA impairment scale grade from time of admission to discharge.

Among the non-surgical cohort there were 21 patients, with a mean AMS of 75.9 at presentation and 85.5 at discharge; the improvement in mean AMS was 9.6, with 3 patients (14.3%) improving at least one ASIA impairment scale grade.

Conclusion: The surgical cohort had a larger improvement in mean AMS as compared to those who received medical rehabilitation alone. This study also points to potential benefits of early surgical intervention; surgery subgroup ≤ 24 hours had the best neurological recovery.

87. Thoracic and Lumbar Compression Fractures in the Pediatric Patient

Avrum Joffe, MD; Carrie E. Bartley, MA; Tracey Bastrom, MA; Peter O. Newton, MD; Burt Yaszay, MD USA

Summary: Thoracolumbar compression fractures in the pediatric patient are stable injuries. Bracing was not efficacious in stabilizing or improving kyphosis at final radiographic follow-up. Low back pain and stiffness are the most common complaints during recovery

Introduction: There is a paucity of literature reporting on compression fractures of the thoracic and lumbar spine in pediatric patients. A majority of the evaluation and treatment of these injuries has been extrapolated from the adult literature. The purpose of this study was to assess the demographics and treatment, as well as the radiographic and clinical outcomes of pediatric compression fractures.

Methods: A retrospective review of all patients presenting to a single pediatric institution from 2009—2012 with thoracic or lumbar compression fracture(s) was conducted. Patients who sustained insufficiency-type injuries secondary to underlying metabolic/malignant conditions were excluded. The mechanism of injury, degree of initial and final vertebral wedging, treatment employed, and patient reports of any ongoing deficits or pain were recorded.

Results: There were 67 patients and a 134 compression fractures. Patients' ages ranged from 5-20yrs. The majority of fractures sustained resulted from a

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fall (40%), MVA (27%), or collision sports injury (22%). Average f/u was 6mo (range 0-29mo). None required surgery. 39 (58%) patients were treated with a brace vs 28 (42%) treated without a brace. The use of a brace was at the discretion of the treating surgeon and was not related to the number of fractures per patient. There was a trend for the braced patients to have slightly greater initial wedging (130 vs 100, $p=0.068$) but no difference was seen at final f/u (120 vs 100, $p=0.2$). Average brace wear was 9 ± 4 weeks. 32 patients had a CT scan, primarily per trauma service protocol. In 9 of 32 CT's ordered (28%), the CT identified additional fracture levels. The average degrees of wedging on xray were not significantly different from those observed on CT ($p=0.9$). Upon initial exam, 47 (70%) patients had posterior tenderness. At final f/u, 16 (24%) patients continued to report back pain/stiffness for which they were prescribed physical therapy.

Conclusion: Pediatric thoracic and lumbar compression fractures are stable injuries. Advanced imaging can identify additional levels but does not appear to affect treatment of these injuries. Similarly, the use of bracing may be beneficial in easing pain, but did not appear to affect the ultimate residual wedging.

88. The Reported Rate of Adjacent Segment Disease in Cervical Disc Arthroplasty Versus Single Level Fusion: An Analysis of Prospective Studies

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USA

Summary: After a systematic review, data from six prospective studies was used to report an overall rate of ASD for ACDF versus TDR at 2-5 years follow-up. There was no detectable difference in the rate of ASD between these groups.

Introduction: The concern for adjacent segment disease (ASD) has led to the development of motion-preserving technologies such as total disc arthroplasty (TDA). To date, however, no known study has sought to compare the incidence of ASD between anterior cervical decompression and fusion (ACDF) and TDR in major prospective studies

Methods: A systematic review of IDE and non-IDE trials was performed using PubMed and Cochrane libraries. These databases were thoroughly searched for prospective randomized studies comparing ACDF and TDR. Specifically, studies reporting clinical outcomes and symptomatic ASD with at least 2 years follow-up were selected. Six studies met the inclusion criteria and were used to report an overall rate of ASD for both ACDF and TDA. A paired t-test and fishers exact test was used for comparisons between groups.

Results: Pooling data from six prospective studies, the overall sample size at baseline was 1,586 (ACDF = 777, TDA = 809) and at final follow-up was 1,110 giving an overall follow-up of 70% (column A, table 3). Combining all studies, 36 patients required a repeat surgery after an ACDF at 2-5 years follow-up (6.9%) compared with 30 patients after TDA (5.1%). This difference was not statistically significant ($p=0.36$). Assuming a 2.9% yearly incidence of symptomatic disease

at adjacent levels, 50 patients in the ACDF group and 58 patients in the TDA group were expected to require repeat surgery during the follow-up period.

Conclusion: There is no detectable difference in the rate of ASD for ACDF versus TDA patients using data from recent prospective studies. Future prospective studies should continue to focus on excellent patient follow-up and accurate assessment of patient symptoms that are attributable to an adjacent level.

89. Long-Term Evaluation of Dysphagia (Bazaz) with PCM Cervical Disc Compared to ACDF in a Prospective Randomized Clinical Trial: Five-Year Results from US IDE Study

Paul C. McAfee, MD, MBA; Kye Gilder, PhD; Kelli M. Howell, MS; Frank M. Phillips, MD; Fred H. Geisler, MD, PhD; Christopher D. Chaput, MD; John G. DeVine, MD; Christopher J. Reah, PhD
USA

Summary: Compare improvement of dysphagia (Bazaz) in patients (pts) with cervical degenerative spondylosis treated with PCM® Cervical Disc compared to ACDF with allograft/plate.

Introduction: PCM Cervical Disc is a recently FDA-approved non-constrained cervical disc arthroplasty device with a low-profile design. IDE trial conducted is largest reported multi-center prospective randomized trial explicitly evaluating dysphagia in pts treated with anterior cervical approaches.

Methods: Prospective, randomized, multi-center, IRB-approved IDE trial evaluating longitudinal outcomes over 5 years comparatively between arthroplasty and fusion groups. Pts 18-65 years of age with degenerative disc disease at one level between C3 and T1 with neurologic symptoms 404 pts treated (214 PCM, 190 ACDF). Patient sample at 5 yrs included 152 PCM and 123 ACDF. Preoperative and postoperative dysphagia evaluation using Bazaz criteria, patient's self-assessment of dysphagia severity on a 4 point scale (none, mild, moderate, severe) for liquid and solid foods.

Results: At 2 yrs, 87.7% (164/187) of PCM pts and 82.6% (123/149) of ACDF pts reported maintenance or improvement in Bazaz score from baseline ($p=0.214$). At 5 yrs, 86.2% (131/152) of PCM and 78.0% (96/123) of ACDF reported maintenance or improvement in Bazaz score from baseline ($p=0.081$). Of pts with pre-existing dysphasia (baseline mild, moderate, severe), 91.7% (33/36) of PCM pts and 79.3% (23/29) of ACDF pts maintained/improved in Bazaz at 2 yrs ($p=0.278$) and 87.5% (21/24) of PCM pts and 76.9% (20/26) of the ACDF pts maintained/improved at 5 yrs ($p=0.467$). More importantly, in pts with pre-existing dysphasia, 83.3% (20/24) and 65.4% (17/26) of the PCM and ACDF pts, respectively, improved in Bazaz at 5 yrs ($p=0.202$). Also, in subgroup of pt who had a prior cervical fusion and a 5-yr Bazaz assessment, a higher percentage of pts maintained/improved in Bazaz from baseline in PCM compared to ACDF (Table 1).

Conclusion: At both 2 and 5 yrs, greater percentage of PCM pts maintained/improved in Bazaz compared to ACDF. Similarly, of those pts with pre-existing dysphasia, a greater percentage of PCM pts maintained/improved compared to

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ACDF. In both groups, pts with pre-existing dysphasia are more likely to improve than maintain, but more so for PCM. Cervical arthroplasty is a viable reconstruction option resulting in reduced dysphagia, especially patients with pre-existing dysphagia.

Table 1. Percentage of patients maintaining or improving in dysphasia (Bazaz)

Visit	PCM	ACDF
1.5 Month	50.0% (8/16)	50.0% (6/12)
3 Month	81.3% (13/16)	72.7% (8/11)
6 Month	88.2% (15/17)	66.7% (8/12)
1 Year	76.5% (13/17)	69.2% (9/13)
2 Year	75.0% (12/16)	58.3% (7/12)
3 Year	82.4% (14/17)	76.9% (10/13)
4 Year	75.0% (12/16)	61.5% (8/13)
5 Year	58.8% (10/17)	61.5% (8/13)

Note: Subgroup includes only patients who had a prior cervical fusion and 5-year Bazaz assessment.

90. Evaluation of Dysphagia/Dysphonia with PCM Cervical Disc Compared to ACDF in a Prospective Randomized Clinical Trial: Two-Year Results from the US IDE Study

Paul C. McAfee, MD, MBA; Kye Gilder, PhD; Kelli M. Howell, MS; Frank M. Phillips, MD; Fred H. Geisler, MD, PhD; Christopher D. Chaput, MD; John G. DeVine, MD
USA

Summary: Compare incidence/magnitude of dysphagia/dysphonia in patients (pts) with cervical degenerative spondylosis treated with PCM Cervical Disc® compared to ACDF with allograft/plate.

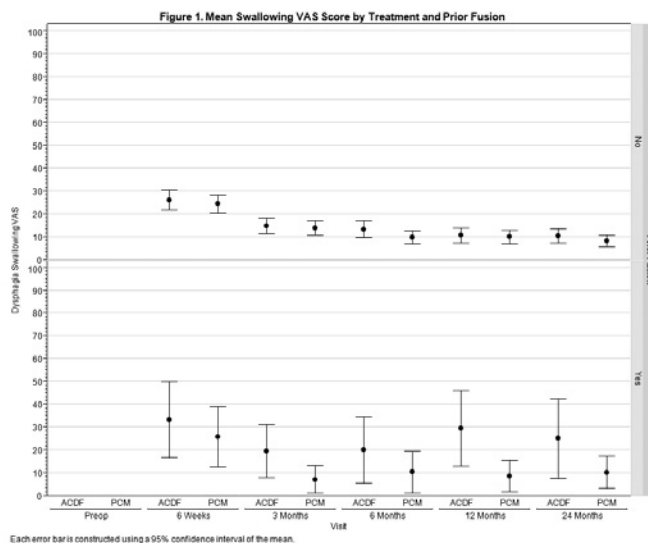
Introduction: PCM Cervical Disc is a recently FDA-approved non-constrained cervical disc arthroplasty device with a low-profile design. IDE trial conducted is largest reported multi-center prospective randomized trial explicitly evaluating dysphagia in pts treated with anterior cervical approaches.

Methods: Prospective, randomized, multi-center, IRB-approved IDE trial evaluating longitudinal outcomes over 5 yrs comparatively between arthroplasty and fusion groups. Pts 18-65 yrs of age with degenerative disc disease at one level between C3 and T1 w/ neurologic symptoms 404 pts treated (214 PCM, 190 ACDF). Per protocol pt sample at 2 yrs was 211 PCM and 184 ACDF. Assessments included visual analog scale (VAS) scores for hoarseness/swallowing (both 0-100mm) and Bazaz criteria. Adverse events (AE) related to soft tissue retraction and dysphasia/dysphonia concurrently recorded.

Results: In both groups, mean swallowing VAS scores highest 6 wks postop (PCM 24.7mm, ACDF 26.9mm) and gradually improved at subsequent postop visits. At 2 yrs, PCM pts had lower mean swallowing (8.8mm versus 12.1mm; P=0.045) and lower mean hoarseness scores (7.3mm versus 10.1mm; P=0.330). 87.7% (164/187) of PCM and 82.6% (123/149) of ACDF pts maintained/improved in Bazaz score from preop (p=0.214). Incidence surgery-related dysphagia/dysphonia AEs was 5.1% (11/214) in PCM pts compared to 10.5% (20/190) in ACDF pts (p=0.060). In both groups, pts with prior cervical fusion generally had higher swallowing/hoarseness VAS and Bazaz scores compared to pts

without prior fusion. At 2 yrs, in pts with prior cervical fusion, impact of subsequent anterior approach was worse for pts undergoing ACDF compared to arthroplasty in swallowing (PCM 10.4mm, ACDF 25.3mm) and hoarseness (PCM 7.7mm, ACDF 19.9mm).

Conclusion: PCM pts had lower swallowing/hoarseness VAS scores and a higher percentage maintained/improved in Bazaz score. Results infer reduced trauma to surrounding soft tissue following treatment with PCM. Unlike previously reported series of BMP-2 used for ACDF, no treated pt in trial readmitted for hospitalization or intensive care unit for acute respiratory distress. PCM Cervical Disc is viable/safe reconstruction option resulting in reduced dysphagia/dysphonia, including pts w/ prior cervical fusion.



91. A Clinical Prediction Rule to Determine Outcomes in Patients with Degenerative Cervical Myelopathy undergoing Surgical Treatment: Data from the Prospective, Multicentre AOSpine North America CSM Study

Lindsay Tetreault; Branko Kopjar; S. Tim Yoon; Paul Arnold; Eric Massicotte, MD, MSc, FRCSC; Alexander R. Vaccaro, MD, PhD; Michael G. Fehlings, MD, PhD
Canada

Summary: Degenerative Cervical Myelopathy (CSM) is the most common cause of spinal cord dysfunction worldwide. Surgery is an effective and common treatment option for mild to severe CSM.

Introduction: The objective of this study is to develop a clinical prediction rule relating a combination of clinical and imaging variables to surgical outcome in patients with degenerative cervical myelopathy (CSM), based on data from a multi-center prospective study.

Methods: Two hundred and seventy eight patients diagnosed with cervical myelopathy and treated surgically were enrolled in the CSM-North American multi-center study at twelve different sites. Univariate analyses were performed to evaluate the relationship between outcome, assessed by the modified Japanese

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Orthopaedic Association (mJOA) score, and various clinical and imaging predictors. A set of important variables for the final model was selected based on author consensus, literature support and statistical findings. Logistic regression was used to formulate the final model.

Results: The dependent variable, mJOA at 1-year, was dichotomized for logistic regression: a “successful” outcome was defined as a final mJOA greater than or equal to sixteen and a “failed” outcome was a score less than sixteen. The final model included age (OR:0.96, 95%CI:0.94-0.99, $p=0.0017$), duration of symptoms (OR:0.78, 95%CI:0.61-0.997, $p=0.048$), smoking status (OR:0.46, 95%CI:0.21-0.98, $p=0.043$), impairment of gait (OR:2.66, 95%CI:1.17-6.06, $p=0.020$), psychological co-morbidities (OR:0.33, 95%CI:0.15-0.69, $p=0.0035$) and baseline severity score (OR:1.22, 95%CI:1.05-1.41, $p=0.0084$) and transverse area of the cord on MRI (OR:1.02, 95%CI:0.99-1.05, $p=0.19$). The area under the receiver operator (ROC) curve was 0.79, indicating excellent model prediction.

Conclusion: The odds of a successful outcome decrease when a patient has psychological co-morbidities, impaired gait, a longer duration of symptoms, a lower preoperative mJOA score, a smaller transverse area and smokes.

92. Outcomes of Single-Level Cervical Disc Arthroplasty Versus Anterior Discectomy and Fusion: A Single Center, Retrospective Review

Ronald A. Lehman, MD; Robert W. Tracey, MD; John P. Cody; Daniel G. Kang, MD; Adam J. Bevevino, MD; Michael Rosner, MD
USA

Summary: Cervical disc arthroplasty (CDA) has been espoused as a safe, segmental motion-sparing alternative to anterior discectomy and fusion (ACDF) in the treatment of cervical radiculopathy and myelopathy. There are few current studies comparing outcomes between the two techniques. To date, this is largest, single center review comparing single-level CDA to single-level ACDF. We found similar rates of symptom relief and low complication rates between the two groups. Our study demonstrates that CDA continues to be a reliable alternative to ACDF.

Introduction: Several studies have established the safety and efficacy of cervical disc arthroplasty (CDA) as compared to anterior discectomy and fusion (ACDF). There are few single center comparative trials, and current studies do not contain large numbers of patients. We set out to perform a single center, review in comparison of CDA to ACDF.

Methods: We performed a retrospective cohort comparison review at a single, military institution to capture all patients who underwent single-level CDA or single-level ACDF. Radiographs and patient charts were reviewed by independent researchers to determine multiple outcome variables. Data were analyzed descriptively and through the use of student t-tests where applicable.

Results: There were 198 patients included in the study. The CDA group contained 110 patients and the ACDF group had 88 patients. Average follow-up time was

9.7 (± 8.8) months. The CDA and ACDF groups demonstrated 90.9% and 86.4% rates of symptom relief, respectively. 93.6% of patients who underwent CDA were able to return to full activity, as compared to 88.6% in the ACDF group. The rates for recurrent laryngeal nerve (RLN) injury and dysphagia were 3.6% and 5.5%, respectively, in the CDA group. The ACDF group had no RLN injuries and 3.4% of patients reported dysphagia. The CDA group had a 16.4% rate of persistent posterior neck pain. The ACDF group had 11 patients (12.5%) with persistent posterior neck pain, and a rate of symptomatic pseudoarthrosis requiring reoperation of 2.3%.

Conclusion: In the largest non-sponsored study of its kind to date, our data suggest that both CDA and ACDF result in approximately 90% (93.6% CDA and 88.6% ACDF) of patients with complete symptom relief and a relatively low complication rate. Patients who underwent CDA had a higher rate of persistent posterior neck pain, and patients who underwent ACDF were at risk for symptomatic pseudoarthrosis.

93. Cervical Posterior Foraminotomy's Effect on Segmental Range of Motion in the Setting of Total Disc Arthroplasty

Ronald A. Lehman, MD; Adam J. Bevevino, MD; Daniel G. Kang, MD; Rachel E. Gaume, BS; Divya V. Ambati, MS; David E. Gwinn, MD; Anton E. Dmitriev, PhD
USA

Summary: The safety of posterior foraminotomy in the setting of a cervical total disc replacement is unknown. The results of this biomechanical analysis indicate that foraminotomy can be performed in conjunction with a pre-existing disc replacement without increasing segmental cervical spine range of motion.

Introduction: Posterior foraminotomy offers the ability to decompress cervical nerves roots while avoiding the need to extend a previous fusion or revise an arthroplasty to a fusion. However, the safety of a foraminotomy in the setting of total disc replacement (TDR) is unknown. With this in mind, the goal of this study was to investigate the effect on cervical segmental stability resulting from posterior foraminotomy following TDR.

Methods: Segmental non-destructive range of motion (ROM) was analyzed in nine human cadaveric cervical spine specimens. Following intact testing, each specimen was sequentially tested according to the following four experimental groups: Group 1=C56 TDR, Group 2=C56 TDR with unilateral C56 foraminotomy, Group 3=C56 TDR with bilateral C56 foraminotomy, and Group 4=C56 TDR with C56 and C45 bilateral foraminotomy.

Results: No differences in ROM was found between the intact, TDR, and foraminotomy specimens at C4-5 or C6-7 ($p>0.1$). There was a step-wise increase in C5-6 axial rotation from the intact state (8°) to Group 4 (12°), although the difference did not reach statistical significance ($p>0.2$). At C5-6, the degree of lateral bending remained relatively constant, 8° in the intact state to 8.8° in Group 4, and was not statistically different in any of the tested groups ($p=0.8$). Flexion and extension at C5-6 was significantly higher in the foraminotomy specimens, Groups 2 (18.1°), 3 (18.6°), and 4 (18.2°),

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compared to the intact state, 11.2° ($p < 0.05$). However, no ROM difference was found within foraminotomy Groups (2-4; $p > 0.8$) or between the foraminotomy groups and the TDR group (Group 1), 15.3° ($p > 0.4$).

Conclusion: Our results indicate that cervical stability is not significantly decreased by the presence, number, or level of posterior foraminotomies in the setting of TDR. The addition of foraminotomies to specimens with a pre-existing TDR resulted in small and insignificant increases in segmental ROM. Therefore, posterior foraminotomy(s) may be considered a safe and viable option in the setting of recurrent or adjacent level radiculopathy following cervical disc replacement.

94. Return to Surgery Does Not Worsen Health Related Quality of Life (HRQOL) or Patient Satisfaction at Two Year: An Analysis of Incidence and Risk Factors for Secondary Surgery in Adult Spinal Deformity (ASD)

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

Summary: Two year, multi-center, prospective analysis of consecutive ASD patients undergoing secondary surgery (SS) due to complications following index surgery versus patients not receiving secondary surgery (NOSS), demonstrated similar demographic, radiographic, operative and hospital data. Implant failure, wound infection and proximal junctional kyphosis were identified as high risk complications for SS. HRQOL at 2 years postoperative was similar for SS versus NOSS. Future research must analyze high risk complications for SS and evaluate potential mitigation techniques.

Introduction: Surgery for ASD is associated with high complications, some requiring secondary surgery (SS). Complications resulting in SS may be due to unalterable patient risk factors. Purpose: Compare profiles and 2 year outcomes for ASD patients undergoing SS versus patients that did not have SS (NOSS), and identify high risk complications associated with SS.

Methods: Multi-center, prospective analysis of consecutive ASD patients (age ≥ 18 years and scoliosis $\geq 20^\circ$, sagittal vertical axis ≥ 5 cm, pelvic tilt $\geq 25^\circ$, or thoracic kyphosis $> 60^\circ$). Inclusion criteria: spinal fusion ≥ 4 levels for ASD, complete demographic, radiographic and operative data, minimum two-year follow-up. Patients divided into SS and NOSS. Risk factors for SS, complications, and timing of SS evaluated. Baseline and 2 year postop HRQOL (SRS-22r, SF-36, ODI) analyzed.

Results: 141 of 189 eligible patients (75%) met inclusion criteria. Mean follow-up=35.8 months (range 24.1-47.9). Two year SS incidence was 21% ($n=29$). SS had similar mean age, BMI, smoking status, ASA grade, Charlson comorbidity index, deformity, deformity correction, EBL, OR time, posterior fusion levels and length of hospital stay as NOSS ($n=112$; $p > 0.05$). Of 18 complications, wound

infection (relative risk=8.7), implant failure (relative risk=4.2) and proximal junctional kyphosis (PJK; relative risk=2.6) were associated with SS versus NOSS ($p < 0.05$). Timing of SS following index surgery was greatest at < 3 months (37.4%) and 12-24 months (37.4%; $p < 0.05$). Two year HRQOL values were similar SS versus NOSS, including improvement in ODI (13.3 versus 15.3), SRS-22r total (0.7 versus 0.9), SF-36 PCS (5.8 versus 9.1) and final SRS-22r satisfaction scores (4.1 versus 4.3), respectively ($p > 0.05$).

Conclusion: Comparison of SS versus NOSS in consecutive ASD patients demonstrated no single patient variable predictive for SS. Wound infection, implant failure and PJK are high risk complications for SS. SS did not have a detrimental impact on 2 year HRQOL or satisfaction versus NOSS. Future research must evaluate high risk complications for SS and prevention techniques.

95. Comparison of QALYs Predicted from the ODI and QALYs Calculated from the SF-6D Following Surgical Treatment for Adult Spinal Deformity (ASD)

Ian McCarthy, PhD; Michael F. O'Brien, MD; Christopher P. Ames, MD; Han Jo Kim, MD; Oheneba Boachie-Adjei, MD; Frank J. Schwab, MD; Eric Klineberg, MD; Christopher I. Shaffrey, MD; Munish C. Gupta, MD; Richard Hostin, MD; International Spine Study Group
USA

Summary: Algorithms have been developed to convert disease-specific HRQOL outcomes (such as the ODI) to utility-based SF-6D scores, but the accuracy of such algorithms has not been studied outside of the initial patient populations. This study compared QALYs calculated from the SF-6D to predicted QALYs from the ODI for patients undergoing ASD surgery, finding that ODI-based predictions are significantly below the observed QALYs based on the SF-6D. This has important implications in studies of the cost-effectiveness of ASD treatment.

Introduction: Algorithms have been developed to convert disease-specific HRQOL outcomes (such as the ODI) to the utility-based SF-6D, but the accuracy of such algorithms has not been studied outside of the initial patient cohorts. This study compares QALYs derived directly from the SF-6D to QALYs estimated from the ODI for surgical ASD patients.

Methods: Single-center, retrospective analysis of consecutive patients undergoing primary surgery for ASD. QALYs were calculated directly from the SF-6D and from the conversion of ODI to SF-6D as per the algorithm in Carreon et al. (2009). Baseline values and QALYs after surgery were compared and differences were assessed using paired t-tests. The distribution of QALYs using the SF-6D was compared to that of the ODI predictions using a Q-Q plot.

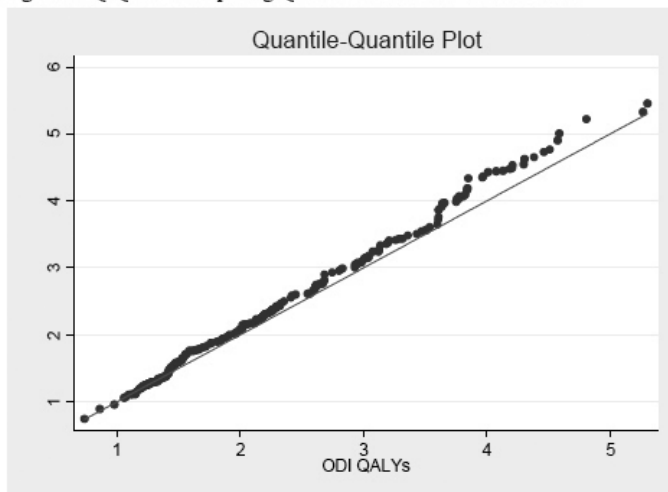
Results: Minimum 2-yr follow-up data for the ODI and SF-6D were available for 218 of 314 potential patients (69%). Patients were predominantly female ($n=185$, or 85%) with average age of 49 (from 18 to 82) and average follow-up of 3.6 years (from 2 to 7.4 years). The SF-6D yielded an average QALY of 2.44 and a baseline index score of 0.61, compared to QALYs of 2.32 based on the ODI ($p=0.00$) and a baseline of 0.60 ($p=0.12$). At minimum 2-yr, 3-yr, 4-yr,

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and 5-yr follow-up, significant differences in average QALYs emerged between the two measures ($p < 0.05$). A comparison of the distribution of QALYs revealed attenuation bias when using the ODI to estimate SF-6D outcomes, with the degree of attenuation increasing with extended follow-up (Figure 1).

Conclusion: QALYs predicted from the ODI were below observed QALYs based on the SF-6D by an average of 0.12 over an average follow-up of 3.6 years. Based on total hospital payments of \$210,000 for ASD surgery, the average cost-effectiveness (CE) ratio using ODI-based QALYs would exceed (higher cost per QALY) the average CE using the SF-6D by nearly \$4,500. Incremental CE would also be impacted since the attenuation bias in the ODI conversion tends to increase over time.

Figure 1. Q-Q Plot Comparing QALYs based on SF-6D and ODI



96. Do Operative Outcomes for Adults with Spinal Deformity Differ Based on the Relative Severity of Back and Leg Pain Prior to Surgery?

Robert K. Eastlack, MD; Justin K. Scheer, BS; Han Jo Kim, MD; Oheneba Boachie-Adjei, MD; Vedat Deviren, MD; Justin S. Smith, MD, PhD; Robert A. Hart, MD; Shay Bess, MD; Gregory M. Mundis, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; International Spine Study Group
USA

Summary: Back and leg pain outcomes were evaluated following surgery for adult spinal deformity. Both back and leg pain improved significantly with ASD surgery and correlated well with HRQOL measures. Those with preoperative predominate leg pain showed greater improvement than those with predominate back pain.

Introduction: Back and leg pain are common among adult spinal deformity (ASD) patients and contribute substantially to overall disability. The purpose of this study is to evaluate the baseline characteristics and outcomes of patients undergoing ASD surgery with respect to the relative severity of pre-operative back and leg pain.

Methods: A prospective database of 318 operated patients with ASD was studied retrospectively. Outcome measures [ODI, SRS 22r, and SF-36 (MCS and PCS)] were evaluated pre-operatively, and at 1- and 2-years postoperatively. Pain scores were reported using the NRS for back and leg pain (0-10 scale). The cohort was broken into 4 groups. Group 1 (n=130) had back pain (≥ 7 NRS) greater than leg pain (< 7), Group 2 (n=21) had leg pain greater (≥ 7) than back pain (< 7), Group 3 (n=82) were patients with both back pain and leg pain ≥ 7 and Group 4 (n=85) had patients with both back pain and leg pain < 7 .

Results: The preoperative mean and standard deviation of NRS (back, leg) were as follows: Group 1 (8.4 ± 1.0 , 2.4 ± 2.3), Group 2 (4.7 ± 1.5 , 7.8 ± 0.8), Group 3 (8.6 ± 1.0 , 8.2 ± 1.4), Group 4 (4.2 ± 1.7 , 2.2 ± 2.2). The average age was higher in the groups 1, 2 and 3 versus group 4 ($61.8/56.2/61$ versus 51.1 years).

Back and leg pain were significantly reduced postoperatively for all groups except leg pain in Group 1, which was unchanged. Group 2 had a significantly larger decrease in NRS scores than those in Group 1. ODI, SRS and PCS parameters in all groups improved significantly. The change in back pain was significantly correlated with all changes in HRQOL measures [1yr: ODI ($r=0.54$), PCS ($r=0.45$), MCS ($r=0.24$); 2yr: ODI ($r=0.52$), PCS ($r=0.47$), MCS ($r=0.22$)]. Significant correlations were also demonstrated between leg pain and changes in HRQOL measures [2yr: ODI ($r=0.34$), PCS ($r=0.28$), MCS ($r=0.28$)].

Conclusion: Both back and leg pain improved with ASD surgery. Patients with predominately leg pain showed greater improvement than those with predominately back pain, although all groups improved significantly. Outcomes in ASD surgery do not appear to be fundamentally different based on predominance of preoperative back or leg pain.

97. Radiographic and Clinical Outcome Comparing Traditional Iliac Fixation to the S2 Alar-Iliac (S2AI) Technique in Adult Deformity Patients Fused to the Sacrum: A Multi-Center Study

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Summary: Retrospective study to compare the clinical and radiographic outcome of the S2AI and Iliac screw techniques for sacropelvic fixation in adult deformity patients fused to the sacrum.

Introduction: Adult deformity patients requiring long fusion to the sacrum usually require additional anchors into the ilium. There are many techniques available, however currently the two most commonly used techniques are the traditional iliac screws and the S2AI method.

Methods: Multi-center, retrospective analysis of 386 patients with long posterior fusion to the Sacrum using either the iliac screw or the S2AI technique. Clinical and radiographic outcomes, as well as complications were collected from a large

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multi-center database. We included patients who had a minimum one-year follow-up. 18 patients had combined technique and were excluded.

Results: The mean age was 59.62 yrs (± 10.8 , 20-86). This was similar between the two groups (Iliac 59.62 vs S2AI 59.25). There were 287 females, 91 males. 248 patients had the traditional Iliac technique and 84 patients had the S2AI technique. Patients that underwent the S2AI technique were more likely to be a revision procedure, 81.0% versus 67.3% ($P=0.016$) in the Iliac group. Preoperative SVA was higher in the S2AI group compared to the Iliac group, 140 mm vs 111 mm ($p=0.019$), post-op SVA and lumbar lordosis (LL) were similar in both groups S2AI/Iliac, 29.7/44.1 mm and 52.9/48.9 degrees respectively ($P<0.05$)

Preoperatively the S2AI patients had significantly more disability than the Iliac screw patients, ODI 51.4 vs 43.9 ($p=0.022$) postoperatively there was no significant difference. There was no significant difference in change in HRQOL scores, however both populations experienced significant improvement in disability from surgery ($p=0.001$).

Overall revision rate related to the instrumentation was 3.9% (13/332); 4.0% (10/248) in the Iliac group and 3.5% (3/84) in the S2AI group, which was not statistically significant.

Conclusion: In a multi-center study the S2 Alar-iliac (S2AI) and the traditional Iliac screw techniques are the most commonly used pelvic anchors. The S2AI was more likely to be done in revision procedures and in patients with more disability. At one year follow-up, both techniques had similar revision rates related to the instrumentation.



Fractured S2AI screw at the Sacro-Iliac joint

98. Stiffness after Fusion for Adult Spinal Deformity Does Not Significantly Impact Patients' Functional Status or Satisfaction

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USA

Summary: Prospective cohort study of 50 adult spinal deformity patients undergoing thoracolumbar fusion to the pelvis evaluated for impact of lumbar stiffness on functional status using the Lumbar Stiffness Disability Index (LSDI). Minimum 2-year results showed significant improvement from baseline in ODI, SRS-22 and SF-36 PCS scores with no significant change in LSDI scores. Adult deformity patients undergoing thoracolumbar fusion to the pelvis demonstrate improved HRQoL scores but do not report significant worsening of functional status due to lumbar stiffness.

Introduction: The Lumbar Stiffness Disability Index (LSDI) is a validated measure of the effect of spinal stiffness on function following lumbar fusion surgery. No prospective evaluations of stiffness impacts following adult spinal deformity surgery have been reported.

Methods: The LSDI, SRS-22, SF-36 and ODI were administered prospectively at baseline and 2-year minimum follow-up to 50 adult patients undergoing thoracolumbar fusions to the pelvis for spinal deformity. Patients with prior history of lumbar fusion were excluded. Patients were divided into two groups based on upper thoracic (UT, T2-5) or thoracolumbar (TL, T10-T11) proximal endpoints. Comparisons of pre-and post-operative HRQoL and LSDI scores as well as correlation of LSDI to SRS-22 satisfaction scores were performed.

Results: Significant improvements were seen in both the UT group ($n=24$) in ODI (36.4 to 21.8, $p=0.0002$), SRS22 (3.1 to 3.8, $p=0.0001$) and SF-36 PCS (32.1 to 45, $p=0.003$), and the TL group ($n=26$; ODI 38.8 to 18.4, $p<0.0001$; SRS22 2.9 to 4.0, $p<0.0001$; SF-36 PCS 30.5 to 44.1, $p<0.0001$). In contrast, LSDI scores did not change from baseline in either group (UT 30.1 to 32.8, $p=0.3993$; TL 27.4 to 23.8, $p=0.3619$). There was a trend toward higher final LSDI scores among UT compared to TL patients which did not reach significance. No correlation was found between 2-year LSDI and overall SRS-22 satisfaction scores ($R^2=0.0193$).

Conclusion: Adult deformity patients undergoing instrumented thoracolumbar fusion to the pelvis report no significant increased difficulty in performing of ADL's as a result of increased stiffness at 2 year follow-up. While patients fused to the upper thoracic spine trended toward higher LSDI scores than patients with thoracolumbar stopping points, both groups experienced significant improvements in ODI, SRS22 and SF-36 PCS scores. In addition, stiffness as measured by LSDI did not correlate with overall patient satisfaction scores. These results suggest that adult deformity patients experience little increased disability due to stiffness, even after fusion of their entire lumbar spine.

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99. Multiple Regression Analysis of Factors Affecting HRQL in Adult Spinal Deformity (ASD)

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Summary: The aim of this study is to understand the ranking of parameters affecting HRQL in ASD using multiple regression analysis. 483 patients enrolled in a prospective multicentre ASD database form the population. Findings reiterate the importance of diagnosis, age and/or the amount of lordosis as the most important factors. Gender, BMI and SVA appear to be consistently important co-variables whereas coronal balance and magnitude of L curves may also be important in SRS22.

Introduction: Previous studies have demonstrated that the ASD population is very heterogeneous. Different age and diagnosis groups present with different problems. Indicators of sagittal misalignment have also been proposed to be good predictors of HRQL. It is probable that these parameters are intercorrelated and may not be key factors per se. In this context, multiple regression analysis may be useful in establishing a hierarchy of importance for these.

Aim: To understand the ranking of parameters affecting HRQL in ASD using multiple regression analysis.

Methods: Four hundred and eighty-three patients enrolled in a prospective multicentre ASD database form the population of this study. Multiple regression analysis using variables listed in Table 1 was performed for SRS22 and ODI separately. The initially proposed primary variables consisted of diagnosis (highest correlation), age, L Gap and coronal curve location (CCL) but age and L Gap could not be used together because of a very high multicollinearity and CCL because it was not found to be significant. A root model with diagnosis and then two separate simple models with age and L Gap were used.

Results: See Table 1 for details of analysis. For ODI; BMI, gender and a number of sagittal and spinopelvic parameters in the root model but only BMI and gender in the model with L Gap and only gender in the model with age proved to be highly predictive. For SRS22; a large number of parameters in the root model but BMI, gender, coronal balance, L curve, and SVA in the model with L Gap and only gender in the model with age proved to be highly predictive. CCL was not significantly predictive in any model.

Conclusion: These findings reiterate the importance of patient diagnosis, age and/or the amount of lordosis as the most important factors affecting HRQL in ASD. Gender, BMI and SVA appear to be consistently important co-variables whereas coronal balance and magnitude of L curves may also be important in SRS22. These findings may prove to be important for a better understanding of the problem in ASD and may prove to be useful in future classifications.

100. A Retrospective, Multi-Center Analysis of the Efficacy of Antifibrinolytics on Intraoperative Blood Loss during Complex Adult Deformity Surgery

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Summary: The effect of antifibrinolytic agent use on the intraoperative blood loss in complex adult spinal deformity (ASD) surgery was investigated. A retrospective cohort of 207 consecutive patients at 5 major centers undergoing corrective surgery for ASD was analyzed and demonstrated a statistically significant decrease in blood loss using aminocaproic acid compared to no intraoperative antifibrinolytic ($p=0.044$). Use of tranexamic acid demonstrated a similar, less statistically significant trend toward decreased blood loss ($p=0.19$).

Introduction: Significant intraoperative blood loss is frequently encountered during complex corrective surgery for adult spinal deformity (ASD). Antifibrinolytic (AF) agents have been studied extensively in pediatric deformity surgery to limit intraoperative blood loss, but have had a more limited investigation for an adult population. We utilized the inclusion criteria from the Scolio-Risk-1 trial to retrospectively select a consecutive, multi-center group of 207 for analysis.

Methods: Enrollment criteria included: 1. Primary deformity with > 80 -deg Cobb angle; 2. Revision deformity having any type of osteotomy; 3. Any type of 3-column osteotomy (3-CO). We analyzed the average blood loss when utilizing no AF ($n=86$) versus tranexamic acid (TXA) ($n=66$) or aminocaproic acid ($n=45$). EBL in groups with ($n=132$) and without ($n=75$) 3 column osteotomies (3-COs) and revision versus primary were also compared. A Pearson correlation coefficient was calculated for EBL versus operative time (OT), age, ASA grade, number of preexisting comorbidities, preoperative deformity (major coronal curve, sagittal balance), and numbers of levels fused.

Results: Use of aminocaproic acid was associated with a statistically significant decrease in EBL compared with no AF agent (1789 versus 2287 mL, $p=0.044$). There was a trend towards significance when TXA was used (2059 versus 2287 mL, $p=0.19$). There was significantly more EBL with a 3-CO than without (2120 vs 1700 mL, $p=0.013$). There was no significant difference in EBL in revision surgery compared with primary surgery ($p=0.84$). EBL demonstrated a moderate correlation to OT ($r=-0.43$). EBL did not correlate to number of comorbidities, age, BMI, ASA grade, major coronal curve, sagittal balance, or number of level fused (all <0.15).

Conclusion: This analysis suggests that both aminocaproic acid and TXA may result in a significant decrease in the amount of intraoperative blood loss encountered in complex ASD surgery. There was a statistically higher intraoperative blood loss in patients undergoing a 3-CO versus those not undergoing a 3-CO. There was no statistical difference in EBL in the revision versus primary group. The EBL moderately correlated to operative time but did not statistically correlate to multiple other patient-specific factors.

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101. Efficacy of Tranexamic Acid and Aminocaproic Acid on Blood Loss in Spine Surgery: A Meta-Analysis

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Summary: A meta-analysis was done to evaluate efficacies of tranexamic acid (TXA) and aminocaproic acid (EACA) in reducing blood loss (BL) in spine surgery. TXA was found to be effective in reducing BL and transfusion rates, with insufficient data available for EACA.

Introduction: Spine surgery is often associated with large BL necessitating transfusions. The antifibrinolytics TXA and EACA have been shown to improve hemostasis in large BL surgeries. This meta-analysis aimed to consolidate the findings of randomized controlled trials (RCTs) investigating use of these drugs in spine surgery.

Methods: RCTs published before January 2013 that examined the effectiveness of IV TXA or EACA on reduction of BL and transfusions in spine surgery were identified. Minimal BL (<200ml) surgeries were excluded. Data for intraoperative BL, total BL, transfusion rates and complications (thromboembolism (TE), pulmonary embolism (PE) and myocardial infarction (MI)) were abstracted.

Results: Eight RCTs were included for TXA (476 total patients) and two for EACA (218 total patients).

TXA reduced intraoperative BL by an average of 398 ml ([-485,-311], $p<0.05$) and total BL by 431 ml ([-587, -275], $p<0.05$). TXA led to a reduction in the proportion of patients receiving a blood transfusion, RR 0.71 ([0.55, 0.92], $p<0.05$), relative to placebo.

EACA reduced intraoperative BL by an average of 83 ml but this was not significant ([-276, 110], $p=0.40$). However, the one EACA study that included total BL data showed a significant reduction in total BL by 325 ml ([-587,-63], $p<0.05$). Transfusion requirements for EACA could not be analyzed due to a lack of available data.

The following complications were noted: for TXA studies, 1 MI in the TXA group ($n=261$) and 1 TE in placebo ($n=255$). For EACA, 2 TEs and 1 PE in the EACA group ($n=127$) and 6 TEs and 3 PEs in placebo ($n=156$).

Conclusion: TXA reduces surgical bleeding and transfusion requirements in patients undergoing spine surgery. Evidence on the efficacy of EACA is weak. Neither antifibrinolytic appears to increase incidence of TE, PE or MI. 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).

102. Comparison of Operative Complications in Posterior Only Surgery Utilizing BMP Versus Combined Anterior/Posterior Surgery with No BMP for Adult Idiopathic Scoliosis Surgery

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Summary: 45 patients with posterior only surgery and BMP were compared to 67 patients with anterior/posterior surgery, without BMP, for operative complications. The total rate of perioperative complications in the groups were discordant in favor of combined anterior posterior surgery without BMP. We found in adult idiopathic scoliosis there are fewer operative complications with the combined anterior posterior approach. BMP in conjunction with posterior only surgery is associated with a significantly higher rate of re-operation when compared to anterior posterior surgery.

Introduction: Correction of adult idiopathic scoliosis (ADIS) traditionally mandated anterior and posterior (A/P) surgical approaches. Complication rates of such surgery were high. Since the advent of BMP2 and improvement in posterior instrumentation, it has become routine for ADIS to be treated by posterior only surgery. The purpose of this study was to identify post-op complications between these 2 approaches, and determine which approach had fewer complications.

Methods: A query of a retrospective and prospective multi-center surgical database was performed for ADIS cases. Two groups were formed: Group 1 was all posterior surgeries with the utilization of BMP and included interbody support by TLIF or PLIF. Group 2 was A/P without use of BMP. Differences were analyzed in demographics, graft usage, implant usage, and complications. P-values are from 2 sample t-test for continuous measures with pooled variance or Satterthwaite approximation as appropriate and Fisher's exact test for discrete measures.

Results: There were 115 patients: 48 in Group 1 and 67 in Group 2. Statistically significant demographic differences were identified only for age. Group 1 had 3.4 ± 1.7 avg. levels of interbody BMP and 11.3 ± 3.9 avg. levels of posterior BMP. There were statistically more osteotomies performed in Group 1, 29/48, versus Group 2, 19/67 ($p=0.0137$). Average f/u was 24.8mos. in Group 2 versus 15.4mos. in Group 1 ($p=0.0058$). There was no statistical difference between the groups for any complications. Operative complications were 5/48 (10.4%) for Group 1 and 7/67 (10.4%) for Group 2 ($p=1.000$). A significant difference in the need for subsequent surgery was observed with fewer required for Group 2, 5/67, versus Group 1, 11/48 ($p=0.0274$).

Conclusion: In ADIS surgery, the use of BMP and posterior only approach is common for deformity correction. While there is no statistically significant difference in complications between these 2 approaches, there is a significantly increased rate of re-operation in our series. There were more osteotomies performed in posterior only surgery with BMP that may explain the higher need for re-operation. It is the authors' opinion that there were more pseudarthrosis and rod failures in the posterior with BMP group, however, further study is required.

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103. Comprehensive Program Aligning Structure, Processes and the Electronic Medical Record Improves Quality and Safety of Complex Spinal Deformity Surgery

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Summary: A comprehensive program to improve outcomes in a complex pediatric spinal deformity practice, utilizing the EMR in a meaningful way, resulted in zero unplanned admissions, reduced infection rates and length of stay with better patient satisfaction. Meaningful use documentation on the chart to inform other practitioners of risks and the system and processes implemented have resulted in significantly improved outcomes without additional expense or personnel.

Introduction: Pediatric spinal deformity surgery is being performed on an increasingly medically complex patient population. Unplanned readmission rates, infections and other complications can influence patient/family satisfaction, surgical outcomes and perhaps reimbursement under upcoming health care laws. The purpose of this study was to investigate results of a comprehensive program implemented to improve surgical outcomes and reduce re-admission rates after complex pediatric spinal deformity surgery.

Methods: A comprehensive program aligning structure, process and the electronic medical record (EMR) was implemented in 2011 for all scoliosis patients at our institution. This involved multiple facets including: presurgical assessment by a specialized pediatrician at least 2 months prior to surgery, a second assessment by anesthesia prior to surgery, medication reconciliation, proper documentation of preoperative antibiotic administration and timing, modified WHO checklist, critical care pathways and a formalized discharge process requiring medication reconciliation, discharge and follow-up appointment instructions and nursing follow-up calls within 48 hours.

Results: 272 children underwent spinal deformity surgery from 2011 to June 2012 for AIS, neuromuscular, syndromic or congenital scoliosis with significant medical co-morbidities. There were no unplanned readmissions within 30 days during the study period of a full year after implementation. There was a significant decrease in infection rates (3.75% versus 2.75%), length of stay and reoperation rates to better-than-benchmark rates. Antibiotic administration and documentation at least 30 minutes prior to incision improved from 72% to 98%. Medicine reconciliation rates improved from 71% to 80% preoperatively and to 100% at the time of surgery. Nursing follow-up calls within 48 hours of discharge improved from 50% to 91%.

Conclusion: A comprehensive program to improve outcomes in a complex pediatric spinal deformity practice, utilizing the EMR in a meaningful way, resulted in zero unplanned admissions, reduced infection rates and length of stay with better patient satisfaction.

104. Pediatric Spine CT Radiation Dose Reduction: Protocol Refinement Based On Measurement Variation at Simulated Lower Radiation Acquisitions

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Summary: Due to potential harmful effects of radiation in children, we evaluated whether radiation could be reduced for spinal CT scans while preserving the surgeons' goals for pediatric surgical planning measurements. We assessed variation in spinal measurements performed by multiple observers on standard, 50%, and 25% simulated-dose CT images. Inter- and intra-reader variability and accuracy was similar at all dose levels. 25% dose scans produced smaller pedicle width measurements than standard dose scans. A 50% dose reduction for CT protocols did not degrade clinical utility.

Introduction: Computed tomography (CT) is a preoperative planning tool for complex spinal deformity surgery. The pediatric population is at high risk to express the harmful effects of ionizing radiation. Preoperative CT scans are presently performed at standard pediatric radiation doses not tailored for surgical planning. We postulated that sufficient detail for preoperative analysis of bony anatomy can be acquired at substantially lower doses than those typically used. To evaluate whether lower dose images could provide equivalent reliability and accuracy for surgical planning, we assessed measurements in five raters across three dose levels.

Methods: We used the validated GE Noise Introducer software to retrospectively modify existing spine and chest CT scans from 10 patients to create CT images that simulated a standard dose, 50% dose and 75% dose reduction CT scans. A total of 90 axial images were extracted from these CT scans to create our sample set. Four orthopedic surgeons and a pediatric radiologist, blinded to dose, measured minimum medial-lateral pedicle width and maximum anterior-posterior bony length along the axis of presumed pedicle screw placement. Intra-class correlation coefficients (ICCs) were calculated to evaluate variation of measurements across dose and between readers.

Results: Inter-rater variability, as measured with ICCs, was similar at all doses (all $p < .05$; length = .46(25%)/.43(50%)/.41(100%); width = .48/.45/.52). Intra-rater variability demonstrated higher concordance without dose effect (length = .93/.92/.91; width = .91/.96/.93). Pedicle width measurements averaged significantly smaller (0.79 mm) at 25% than 100% of standard CT radiation dosing, but were not significantly reduced at 50% radiation dose, suggesting 50% dose was the best compromise between reliability and introduced measurement bias.

Conclusion: Spinal CT scans done for preoperative planning can be performed at 50% reduction of current radiation doses without compromising surgical planning measurements. Further reduction of dose to 25% of standard dose led to an under-estimation of pedicle width compared to standard dose CT scans.

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105. Evaluation of Pedicle Screw Placement by Pedicle Channel Classification in Scoliosis: Is Screw Placement into a Cortical Channel Really Difficult?

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Summary: This study aimed to evaluate screw placement using the pedicle channel classification in scoliosis and to examine the difficulty of screw placement into cortical channels. The subjects were 810 pedicles probed for screw placement using O-arm-based navigation. The failure rate of screw placement was 31.5% for cortical channels with a pedicle inner diameter of less than 1 mm, indicating a high probability of failure.

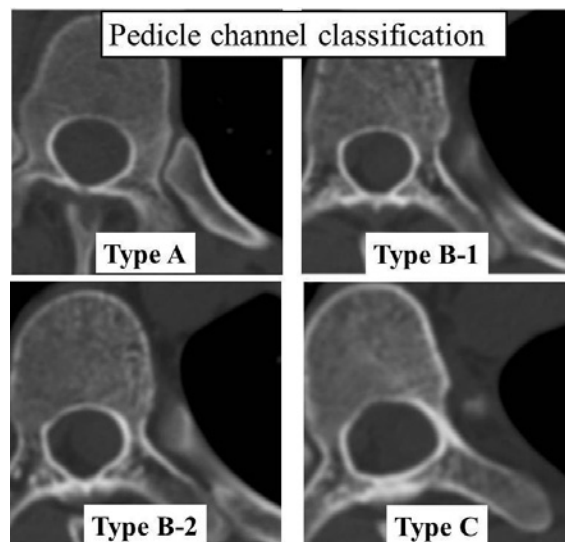
Introduction: Watanabe, Lenke et al. (Spine 2010) proposed a classification system for pedicle channels. However, evaluation of screw placement has not yet been performed clinically by this system. This study aimed to evaluate screw placement using the pedicle channel classification in scoliosis and to examine the difficulty of screw placement into cortical channels.

Methods: The subjects were 810 pedicles (55 AIS patients) probed for screw placement using O-arm-based navigation. For the pedicle channel classification, the inner diameters of pedicles were measured on the preoperative CT scans so that the channels could be strictly classified based on the system of Lenke et al., and the definitions were revised. The channel was defined as type A "large cancellous channel" (inner diameter ≥ 4 mm), as type B-1 "moderate cancellous channel" (inner diameter: 2.0-3.9 mm), as type B-2 "small cancellous channel" (inner diameter: 1.0-1.9 mm), as type C "cortical channel" (inner diameter < 1 mm), and as type D "absent pedicle channel" if there was no pedicle channel. In the evaluation of screw placement, pedicles were considered to have unsuccessful screw placement if probing was performed but screw placement was cancelled because of perforation (cancel), if screws were placed but were subsequently removed intraoperatively because imaging confirmed their malposition (removal), or if postoperative CT showed a deviation of screw of at least 2 mm (deviation). The numbers of pedicles with "cancel", "removal", and "deviation" were added. The failure rate was calculated as the percentage of this sum over the probed pedicles.

Results: According to the pedicle classification, there were 196 type A, 342 type B-1, 183 type B-2, 89 type C, and 0 type D. There were 18 pedicles with "cancel", 7 pedicles with "removal", 36 pedicles with "deviation", and 749 pedicles with successful placement among 810 pedicles with probed pedicles. The failure rate was 0.5% for type A, 2.9% for type B-1, 12.0% for type B-2, and 31.5% for type C. The failure rate was significantly high in type C.

Conclusion: The failure rate of screw placement was 31.5% for cortical channels

with a pedicle inner diameter of less than 1 mm, indicating a high probability of failure.



106. Laminoplasty Versus Corpectomy in the Treatment of Cervical Spondylotic Myelopathy: 5-12 Year Follow-Up

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USA*

Summary: This prospective, non-randomized study compared the outcomes of patients with similar degrees of myelopathy who underwent either laminoplasty or multi-level corpectomy and anterior fusion.

Introduction: It is generally agreed that cervical spondylotic myelopathy is best treated with surgery. Different surgical approaches are available, each with specific indications.

Methods: 2 cohorts of 50 patients with myelopathy and multilevel spondylosis were compared. The choice of surgery was based on surgeon discretion. Preservation of lordosis was a prerequisite for laminoplasty. The cohorts had similar degree of myelopathy, duration of symptoms, degree of axial neck and radicular symptoms, and no significant difference in age or medical co-morbidities. Patients were evaluated with the Nurick Classification, a visual analogue score for neck pain and radicular symptoms, and a questionnaire assessing patient satisfaction and willingness to repeat the procedure. Minimum follow-up was 5 years (range: 5-12 years).

Results: Neurologic improvement was similar in the two cohorts. Average Nurick improvement was 1.1 grade in the laminoplasty cohort and 1.2 in the

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corpectomy cohort. 90% of the laminoplasty cohort and 88% of the laminoplasty cohort improved at least one Nurick grade. Relief of pre-operative radiculopathy was similar between the cohorts, while relief of neck pain was slightly, but not significantly better in the laminoplasty cohort. 92% of the laminoplasty cohort were fully satisfied and willing to repeat the procedure, compared with 86% of the corpectomy cohort, which was not significant. Operative time, surgical blood loss, and hospital stay were significantly greater in the corpectomy cohort, as was the incidence of dysphasia and the need for post-operative narcotics. 6 corpectomy patients (12%) had additional surgery, 4 for adjacent level disease and 2 for prominent plate causing dysphasia. 2 laminoplasty patients had additional surgery for persistent radiculopathy.

Conclusion: Both laminoplasty and multilevel corpectomy with interbody fusion are effective in improving neurologic function in patients with cervical spondylotic myelopathy. When laminoplasty is employed for patients with preserved lordosis, patients have shorter hospital stays and seem to tolerate surgery better than those with a multilevel corpectomy.

107. Prognostic Factors for Neurologic Improvement Following Surgical Management of Cervical Spondylotic Myelopathy

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USA

Summary: This study of 120 consecutive patients who underwent surgery for cervical spondylotic myelopathy was performed to identify prognostic clinical and radiographic factors associated with post-operative neurologic improvement.

Introduction: It is generally agreed that cervical spondylotic myelopathy is best managed with surgery. It is less clear which factors are associated with post-operative neurologic improvement.

Methods: 120 patients (77 males and 43 females) with multi-level cervical spondylosis and myelopathy who underwent surgery over a 7 year period (1999-2005) were studied. Nurick scores were obtained before and after surgery. Neurologic improvement was defined as a drop in Nurick score. Variables were assessed for significance with logistic regression analysis.

Results: The Nurick score improved from a pre-operative mean of 3.6 to a post-operative mean of 2.8. 91 patients (76%) improved at least one Nurick grade, 19 (16%) were unchanged, and 10 (8%) worsened one grade. Factors significantly different in patients with neurologic improvement included: age < 65 years, Nurick grade 3 or less prior to surgery, duration of symptoms less than 12 months, absence of diabetes or cardiac disease which had required surgical intervention, and no history of smoking. Radiographic factors associated with neurologic improvement included: absence of T2 weighted signal changes and cord flattening less than 40% of normal anterior-posterior diameter. Among factors not associated with neurologic improvement included the type of surgical procedure, the occurrence of a peri-operative complication, or the need for further surgery.

Conclusion: The severity and duration of myelopathy can be predictive of the extent of neurologic improvement following surgery for cervical spondylotic myelopathy. While surgery should be offered to most, if not all patients, those with more advanced myelopathy at the time of presentation (Nurick grade 4 or 5) and those with symptoms greater than one year may be less likely to experience neurologic improvement.

108. Prevalence of OPLL and DISH in USA: CT-Based Study of 3403 Patients

Takahito Fujimori, MD, PhD; Hai Le; Cynthia T. Chin; Murat Pekmezci, MD; William Schairer; Bobby Tay, MD; Motoki Iwasaki, MD; Serena S. Hu, MD
Japan

Summary: We performed a CT-based large-scale cross-sectional study to investigate prevalence of ossification of the spinal ligament diseases in USA. Prevalence of OPLL and DISH in the cervical spine was 2.5% and 2.3 %, respectively.

Introduction: Ossification of the posterior longitudinal ligament (OPLL) is one of the causes of cervical myelopathy. OPLL has been recognized as a relatively common disorder in Asians, especially in Japanese. On the other hand, diffuse idiopathic skeletal hyperostosis (DISH) has been regarded as a common disorder in Caucasians. No study has revealed the reason for the discrepancy in prevalence of these diseases.

Methods: This cross-sectional study was performed in medical centers on the West Coast in USA. We reviewed cervical CT of 3403 patients (2200 men) who underwent head and cervical CT for the purpose of trauma investigation from 2009 to 2012. Ethnicity, body mass index (BMI), and coexisting diabetic mellitus (DM) were recorded. Population of this study was composed of 50.8% non-Hispanic white, 14.5% Hispanic, 19.9% Asian, 10.3% black or African American, 1.9% Native Americans, and 2.6% other/unknown race. OPLL was defined as ossification of the posterior longitudinal ligament with thickness more than 2 mm. DISH was defined as contiguous ossification of the anterior longitudinal ligament with thickness more than 4 mm.

Results: Mean age and BMI of the patients was 50±21 years-old and 25.7±5.0 kg/m². The rate of coexisting DM was 9.1%. There were 85 patients with cervical OPLL and 77 patients with cervical DISH. Twenty-two patients had both OPLL and DISH. Prevalence of OPLL and DISH in this area was 2.5% and 2.3%, respectively. The rate of coexisting DM in OPLL patients was 26%. Unadjusted ethnic prevalence of OPLL was 1.4% in non-Hispanic white, 1.8% in Hispanic, 5.5% in Asian, 2.8 % in Black or African American, and 4.7% in Native American. Unadjusted ethnic prevalence of DISH was 1.9% in non-Hispanic white, 1.2% in Hispanic, 3.8% in Asian, 2.3 % in Black or African American, and 6.3% in Native American.

Conclusion: This is the first large-scale study that investigated prevalence of ossification of the spinal ligament in a more ethnically diverse population. We found that OPLL was more commonly recognized in this CT-based study than

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previous reports. Our result suggests that OPLL and DISH may be part of the same disease entity.

109. Cervical Spinal Sagittal Alignment: An Analysis of Young, Asymptomatic Volunteers

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Australia

Summary: A study of asymptomatic volunteers imaged with EOS digital scanning and assessing cervical sagittal balance. The often stated norm of cervical lordosis was not observed. The upper cervical spine tended to balance variations in the lower cervical spine. There was no correlation with limbo-pelvic alignment.

Introduction: Thoraco-lumbar sagittal balance has been the subject of extensive research in recent years and has been found to play a significant role in spinal surgical outcomes. Cervical balance, however, has received relatively little attention. The current study has been undertaken to establish a normative database for measures of occipito-cervical sagittal alignment and to explore patterns of cervical balance & their relationship to overall spinal alignment.

Methods: Results are reported for 54 asymptomatic volunteers, aged 20-45 years, who underwent erect x-ray imaging of their whole spine and lower limbs using EOS digital scanning. X-rays were analysed using KEOPS software, recording parameters of occipito-cervical and thoraco-lumbo-pelvic sagittal alignment. Intra- & inter-observer reliability was tested. Correlations between selected parameters were examined using linear regression analysis.

Results: Cervical lordosis (C2-C7) range: 17.9° kyphosis to 38.2° lordosis (mean=2.9° ±11.9°SD). While inter- & intra-observer agreement regarding spinal shape rating was only moderate (ICCs of 0.691 & 0.719, respectively), only 8/54 subjects were considered to have 'lordotic' cervical spines, 20 were rated as 'straight', 9 were 'kyphotic' & 17 were 'kypholordotic'. Moderate to strong correlations were found between cervical lordosis and both T1 slope (R=-0.595, p<0.0001) and T1-T12 kyphosis (R= -0.566, p=0.005). No significant correlation was evident between cervical lordosis and pelvic incidence or lumbar lordosis. A negative correlation was found (R= -0.502, p<0.0001) between upper-cervical lordosis (C1-C3) and lower-cervical lordosis (C5-C7). Occipital tilt, measured by the angle between McGregor's line and the horizontal, averaged 1.5° (±6.2°SD).

Conclusion: Contrary to previous studies, cervical lordosis was not found to be the norm in this young, asymptomatic population. Upper-cervical lordosis tended to balance variations in lower-cervical alignment. Cervical lordosis correlated strongly with the slope of the T1 vertebral end-plate but not with lumbo-pelvic alignment. Further study is required regarding intra-subject postural variations and the effects of age & pain on cervical balance.

110. Evaluation of Spinal Cord Motion in Patients with Abnormal Sagittal Cervical Alignment Using Kinetic MRI

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USA

Summary: 108 patients were evaluated using kinetic MRI through a full range of flexion-extension in patients with cervical sagittal kyphosis (46) or hyperlordosis (26) in order to study the motion of the spinal cord and its relationship to the spinal canal. With kyphotic deformity, the spinal cord has increased anterior translation at the C5 and C6 level in flexion when compared to patients with normal lordosis or patients with hyperlordosis.

Introduction: There are many studies evaluating angular motion of the cervical spine. There are no studies evaluating spinal cord motion in an in vivo model. Evaluating the coupling motion of the spinal cord and the cervical vertebral column in patients with abnormal sagittal alignment may help us better understand the origin of spinal cord compression and the best method of surgical treatment. The purpose of this study was to examine the motion of the spinal cord and its relationship with the spinal canal in patients with mild spondylosis with kyphotic and hyperlordotic sagittal alignment using kinetic MRI (kMRI).

Methods: 108 patients (mean age 52.9) underwent upright kMRI through a full range of flex-ext. 72 patients with kyphotic (46) or hyperlordotic (26) sagittal cervical alignment were included based on C2-C7 Cobb angle. Using kMRI images, we evaluated the following in neutral, flexion and extension: spinal canal diameter (CD), spinal cord diameter (SCD), space available for the cord (SAC), anterior space available for cord (ASAC), posterior space available for cord (PSAC) and global Cobb angle of the spinal canal and cord.

Results: In patients with kyphotic alignment the spinal cord moves anteriorly at C5 and C6 with flexion and posteriorly at the remaining levels. In neutral, the mean maximal spinal cord angle was 7°; it increased to 24° in extension and decreased to -7° in flexion. With full flex-ext, the mean angular change of the spinal cord was 31°. With hyperlordosis, neutral mean maximal spinal cord angle was 38°, 47° in extension and 8° in flexion; total range of motion was 39°.

Conclusion: With kyphotic sagittal cervical alignment there is paradoxical motion of the spinal cord with increased anterior translation in flexion when compared to a normal lordotic or hyperlordotic cervical spine at the C5 and C6 levels, which correlates with the apex of the kyphotic deformity. This may contribute to pathogenesis of cervical myelopathy.

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111. Restoration of Cervical Lordosis is Associated with Improved Clinical Outcome in One or Two Level Anterior Cervical Discectomy and Fusion (ACDF) Patients

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USA

Summary: The results of 66 one or two level ACDF surgeries were reviewed and the relationship between cervical lordosis maintenance/restoration and patients' clinical outcome was analyzed. The patients with restored cervical lordosis had significantly arm pain improvement and non-significantly neck pain and NDI score improvement. Our study suggests that restoration of cervical lordosis from kyphosis or neutral will contribute to improved clinical outcome in the patients who had one or two level ACDF surgeries.

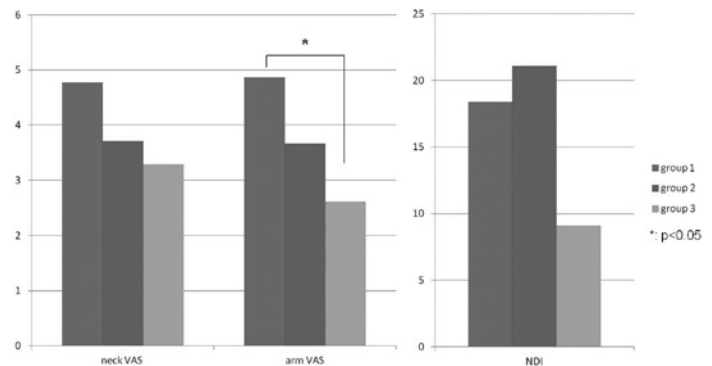
Introduction: Anterior cervical discectomy and fusion (ACDF) remains the standard of care for patients with cervical radiculopathy who are unresponsive to conservative medical care. Normal cervical lordosis (C2-C7) is measured at approximately 34 degrees. However, the maintenance/restoration of cervical lordosis is usually ignored as an outcome factor after ACDF surgeries.

Methods: Data were collected from 66 patients who underwent one or two level ACDF at a single institution. Cervical lordosis/kyphosis angles were measured preoperatively and at follow-up visits. The patients were classified into three groups: Group 1, patients had cervical kyphosis or neutral cervical angle preoperatively and the angle was restored to lordosis postoperatively; Group 2, patients had cervical kyphosis or neutral cervical angle preoperatively and the angle was unchanged postoperatively; Group 3, patients had cervical lordosis preoperatively and the lordosis was maintained postoperatively. VAS scores for neck pain, arm pain, and NDI scores were obtained from each patient preoperatively and at the latest follow-up visit. Statistical analysis was used to compare the clinical outcome scores in the three groups.

Results: There were 13 patients in group 1, 15 patients in group 2 and 38 patients in group 3. The patients' age, BMI, levels operated, follow-up time were not significantly different among the three groups. On average at 13.5 months (range from 6 to 24 months) follow-up, the patients' neck VAS scores improved 4.78, 3.71, and 3.29 respectively in the three groups ($p > 0.05$). The patients' arm VAS scores improved 4.86, 3.67, and 2.61 respectively in the three groups ($p < 0.05$ between group 1 and group 3). The patients' NDI scores improved 18.40, 21.10 and 9.12 respectively in the three groups ($p > 0.05$).

Conclusion: The patients with restored cervical lordosis had significantly arm pain improvement. They also had relatively better neck pain and NDI score improvement although the differences were not statistically significant. Our study suggests that restoration of cervical lordosis from kyphosis or neutral will

contribute to improved clinical outcome in the patients who had one or two level ACDF surgeries.



112. Can Long Fusions Crossing the Cervicothoracic Junction Have Good Outcomes at a Minimum Two Years Follow-Up?

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USA

Summary: When indicated, fusions which extend across the cervicothoracic junction can lead to excellent correction of spinal deformities with significant improvement in SRS outcome scores and relatively low complication rates.

Introduction: Historically, extending a fusion proximally past the cervicothoracic junction (CTJ) has been avoided due to concern that it would lead to poor results. There are no reports in the literature on the outcomes for these patients (pts). We studied pts who had long fusions across the CTJ in order to better delineate the indications, radiographic outcomes and clinical results.

Methods: All pts who had fusions of ≥ 8 levels across the CTJ during primary (P) or revision (R) surgery by one surgeon from 2002-2009, with minimum 2 year follow-up (f/u) were included. Diagnosis, indications, radiographs, proximal (UIV), distal (LIV) levels and outcomes were assessed with SRS scores. Paired t-tests were used for statistical analysis.

Results: 27 pts were included with the mean f/u of 4.0 yrs (range 2-9.5). There were 16 males and 11 females with the mean age of 22.1 yrs (range 3.8-62.9). Surgical indications were inability to maintain forward gaze (n=4), Coronal decompensation (n=4), Proximal Junction Kyphosis (n=9) and progressive sagittal decompensation (n=10).

An all posterior approach was used in 26/27 pts in whom a vertebral column resection (n=8), Smith-Peterson Osteotomies (n=6) and pedicle subtraction osteotomies (n=1) were performed. There were 18 (R) and 9 (P) surgeries. The UIV varied from the occiput (n=4), C2 (n=1), C3 (n=0), C4 (n=2), C5 (n=3), C6 (n=6) and to C7 (n=11) with the use of pedicle screws at C2 and C7 and lateral mass screws from C3-C6 levels.

The mean correction of scoliosis was 55% (range 40-78%, $p < 0.01$), sagittal

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balance improved by 4cm (range 0.8-15cm) and maximum kyphosis improved by 52% (range 30-70%, $p < 0.01$). SRS Outcomes improved from 3.3 to 3.9 ($p < 0.01$) with the most improvements seen in the pain (+1.1) and mental health (+1.7) domains ($p < 0.01$, < 0.01 respectively). Complications occurred in 15% of pts and included pseudarthrosis ($n=1$), vascular injury (thoracic aorta $n=1$), respiratory failure (requiring tracheotomy $n=1$) and major neurologic motor deficit to the lower extremities ($n=1$).

Conclusion: Acceptable deformity correction with improved clinical outcomes can be achieved for fusions extending across the CTJ for the right indications.

113. Does T1 Pelvic Angle (TPA) Effectively Assess Sagittal Imbalance and Can it Predict Sustainable Correction?

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USA

Summary: It is well established that sagittal plane correction is associated with better quality of life among adult spinal deformity (ASD) patients, but optimal correction can be difficult to maintain. T1 pelvic angle (TPA) may offer a new, simplified way to measure global deformity. In ASD patients undergoing three-column osteotomy (3CO), optimal postoperative alignment was associated with less preoperative deformity but larger correction. Patients with deteriorations after successful corrections had worse postoperative alignment prior to deterioration.

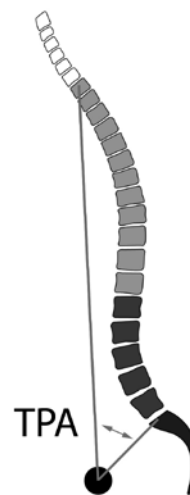
Introduction: T1 pelvic angle (TPA), the angle between the hips-T1 line and hips-S1 endplate line, is a novel global spino-pelvic parameter assessing the combined effect of a loss of lordosis on trunk inclination and pelvic retroversion. We investigate the use of TPA and identify factors that predict sustainable sagittal correction in ASD patients undergoing 3CO.

Methods: A prospective, multi-center database of consecutive ASD patients was queried to identify severe deformity threshold and meaningful change (MC) for TPA by correlation with ODI. A multi-center consecutive retrospective database of ASD patients treated with single lumbar 3CO was then analyzed at baseline, 3month, and 1year follow-up. Subjects were classified as well-aligned (WA) or poorly-aligned (PA), with WA and PA separated by one MC in TPA. Patients "deteriorated" if they lost > 1 MC of correction between 3months and 1year and had TPA consistent with severe deformity at 1year. Subjects who underwent revisions were excluded from analysis.

Results: The severe deformity threshold for TPA was 20° (ODI=41) and the MC was 4.1° (ODI change: 15). The review of the 3CO database identified 179 patients with preop severe deformity (TPA $>20^\circ$); 89 (50%) were WA (TPA $<20^\circ$) and 56 (31%) were PA (TPA $>24.1^\circ$) at 3months postop. 86 WA subjects (97%) had no marked deformity in PHLL, SVA, or PT and 43 PA patients (77%) had

marked deformity in at least 1 modifier. Preop, PA patients had more severe deformity than WA patients (TPA 46° vs 32° , $p < 0.001$). At 3months, WA had received more correction than PA (change: TPA -20° vs -14° , $p = 0.002$). From 3months to 1year, 11 WA (12.4%) and 12 PA (21.4%) patients deteriorated. At 3months, WA patients who later deteriorated had greater deformity than those who maintained correction (TPA 17° vs 12° , $p < 0.001$).

Conclusion: TPA accounts for both SVA and PT. ASD patients with poor corrections after 3CO had more severe preop deformities but showed less improvement at 3months, indicating undercorrection among patients with more severe deformity. Patients who deteriorated from optimal correction had larger deformity at 3 months.



114. Occipito-Cervical Fusion in Skeletal Dysplasia: A New Surgical Technique

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USA

Summary: This study describes a new technique for occipito-cervical fusion in children with skeletal dysplasia when the posterior elements are not of a size or quality that allows the use of other instrumentation. All 27 patients who were treated by this technique had successful occipito-cervical fusion with minimal complications.

Introduction: This study describes a new technique for occipito-cervical fusion (OCF) with cables in children with skeletal dysplasia (SD).

Methods: Retrospective review of patients with skeletal dysplasia who underwent OCF between 2001 and 2011 with the new surgical technique. This technique was designed to be used when the posterior elements were of a size or quality that did not allow other instrumentation. The cable technique provides compression across a graft that is prevented from entering the canal and resists lordosis. Outcome measures were fusion rates and complications. Data evaluated include: demographics, type of SD, estimated blood loss, hospital and ICU stays

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and level of fusion. Fusion was defined on the plain radiographs and confirmed by the reports of the radiologist and the senior author.

Results: 27 patients, 10 boys and 17 girls, had the above technique as a primary procedure in 23 (85%) and a revision procedure in 4 (15%) patients (index procedure done elsewhere). Diagnoses included: Morquio's syndrome (7), Spondyloepiphyseal dysplasia (12), Spondyloepimetaphyseal dysplasia (4), Metatropic dysplasia (3) and Kniest syndrome (1). At presentation, 10 (37%) patients had features of cervical myelopathy while remaining 17 (63%) had instability on routine screening. Mean age at surgery was 6 years (SD 4.7) and mean follow-up was 4.2 years (SD 2.3). The level of fusion was: occiput-C2 (20, 74.1%), occiput-C3 (6, 22.2%) and occiput-C6 (1, 3.7%). Upper cervical decompression was needed in 24 (88.9%) patients. The mean blood loss was 211 ml (SD 171.3). The mean hospital and ICU stays were 4.3 (SD 1.5) and 2 (SD 1.6) days respectively. Postoperatively, all patients were immobilized in a halo vest for a mean duration 11.9 weeks (SD 1.9). Fusion was achieved in all patients. Two patients had transient loss of motor signals during the procedure which returned to baseline. Complications included halo pin tract infections in 8 patients (treated with oral antibiotics).

Conclusion: This new cable technique is a viable alternative for occipito-cervical fusion in skeletal dysplasia patients who may have altered anatomy at the craniocervical junction. This technique can be used safely with good fusion rates even in revision cases.

115. Effect of Cervical Spinal Deformity on Skull Position and Upper Cervical Motion with Horizontal Gaze

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USA

Summary: This study uses kMRI to evaluate skull position and upper cervical motion for maintenance of horizontal gaze (HG) in patients with abnormal sagittal cervical alignment. The occiput plane with normal lordosis is in slight extension to maintain HG but moves toward a more neutral position with progressive subaxial kyphosis. Global cervical sagittal balance in relation to the plumb line correlates with the alignment of C5-T1. Oc-C2 compensates for increasing C2-C5 kyphosis, providing the ability to maintain HG.

Introduction: Maintaining horizontal gaze (HG) is essential to activities of daily living. Cervical deformity may affect the normal angular relationship of the occiput (Oc) to C2 and maintenance of HG. It is important to understand the position and angular relationship of Oc-C2 and how it changes with sagittal cervical deformity. The purpose of our study is to elucidate the relationship of Oc-C2 and the subaxial cervical spine with abnormal sagittal alignment.

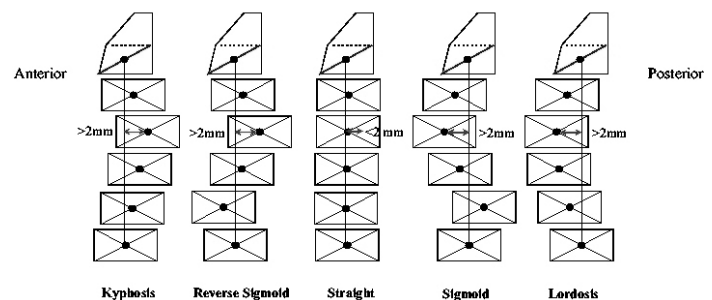
Methods: 505 symptomatic patients (mean age 49.4) underwent upright kMRI in neutral, flexion and extension. Patients were classified into 5 groups based on neutral sagittal alignment: Kyphosis (n=58); Sigmoid curve with lordotic upper

cervical and kyphotic lower cervical spine (n=30); Straight (n=88); Reverse sigmoid curve with kyphotic upper cervical and lordotic lower cervical spine (n=39); Lordosis (n=290). Oc-C7 sagittal vertical axis (SVA), Cobb angle and horizontal plane angle of Oc-T1 were measured. Correlations of Cobb angles and Oc-C7 SVA were evaluated.

Results: With lordotic sagittal alignment in neutral position, Oc horizontal plane is in 9.1° extension. As sagittal alignment becomes kyphotic, Oc horizontal plane moves from its extended position to a more neutral position. With increasing subaxial kyphosis, there is a corresponding increased flexion between C1 and C2. Overall the Cobb angle of Oc to C2 is more lordotic in the presence of subaxial kyphosis (31.3°) than subaxial lordosis (26°). Lower subaxial (C5-T1) kyphosis correlates with an increase in distance between SVA, dropped from the basion, and C7 (Pearson correlation coefficient=0.43). The total angular motion (flex-ext) at Oc-C2 is not affected by subaxial deformity.

Conclusion: With lordotic cervical sagittal alignment, HG is achieved with slight extension of Oc and C1. With progressive kyphotic subaxial cervical alignment, HG is maintained with reduction of extension toward a neutral position relative to the floor. Global cervical sagittal balance in relation to the plumb line correlates strongly to the alignment of C5-T1. Oc-C2 complex compensates for increasing C2-C5 kyphosis thereby providing the ability to maintain HG.

Classification of Sagittal Cervical Alignment



116. Reconstruction of Complex Subaxial Cervical Spine Pathology using Pedicle Screws Inserted with Stealth Navigation Guidance

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USA

Summary: Cervical spine pedicle screws can be used to stabilize the cervical spine. They are biomechanically superior to other posterior cervical fixation techniques; however, their use is limited by the risk of neurovascular injury. Computer-assisted placement of these pedicle screws theoretically decreases the risk of neurovascular injury, although few clinical reports on their accuracy and safety exist. This study presents clinical data of patients who underwent posterior subaxial cervical spine instrumentation with pedicle screws inserted using O-Arm

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imaging and Stealth Navigation.

Introduction: Since their first use in 1964 to treat traumatic spondylolisthesis of the axis, cervical spine pedicle screws have been used to treat multiple conditions of the cervical spine. Despite their biomechanical advantage over other posterior cervical fixation techniques, cervical spine pedicle screws' risk of injury to the vertebral artery and/or nerve roots is of great concern. Computer-assisted placement of cervical spine pedicle screws decreases the risk of neurovascular injury, although few clinical reports on these techniques exist. The objective of this study is to present clinical data of patients who underwent posterior subaxial cervical spine instrumentation with pedicle screws inserted using O-Arm imaging and Stealth Navigation.

Methods: 13 patients [female: 8; male: 5; average age: 63 years (48-83 years)] who had cervical pedicle screws inserted using O-Arm imaging and Stealth Navigation (Medtronic Navigation, Louisville, Colorado) for cervical deformity or subaxial revision operations between December 2007 and May 2012 were retrospectively studied. Outcome variables were accuracy of pedicle screw insertion, surgical complications, and need for re-operation.

Results: Cervical pedicle screws were used to reconstruct the subaxial cervical spine in 6 primary operations for cervicothoracic kyphosis and in 7 revision operations (posterior hardware revision - 4, stenosis, instability, or pseudarthrosis after previous anterior cervical decompression and fusion - 3). All operations were performed by a single surgeon. A total of 77 pedicle screws were placed using Stealth Navigation. The average number of screws placed per case was 6 (range 2-10). Placement accuracy was 97.4%. No complications, including vertebral artery or neurologic injury, occurred intraoperatively. Average radiographic follow-up was 15.2 months (range 0.2-37 months). No patients required revision posterior cervical fusion for any indication, including progression, implant failure, or procedure-related complication.

Conclusion: The placement of cervical spine pedicle screws using O-Arm imaging and Stealth Navigation is an extremely safe, accurate, and effective method for posterior stabilization in deformity and revision operations of the subaxial cervical spine.

117. Less Invasive Surgery for Treating Adult Spinal Deformities (ASD): Ceiling Effects for Cobb Angle Correction with Three Different Techniques

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USA

Summary: Recent trends in treatment of adult spinal deformity include the application of various minimally invasive techniques. It has become apparent that limitations exist in the ability of these techniques to correct the coronal plane

deformity and that there may be a ceiling effect. Stand alone LIF seems to be limited to 23°, circumferential MIS to 34°, and Hybrid techniques 55°. This data is useful in preoperative planning to guide the surgeon in selection of approach based on desired deformity correction.

Introduction: Minimally invasive surgery (MIS), including transposas lateral interbody fusion (LLIF), transforaminal interbody fusion (TLIF), and percutaneous pedicle screw instrumentation (PPI) are being increasingly applied to treat ASD. Ceiling effects (the maximum coronal curve correction) for ASD via MIS have become apparent. This study was undertaken to evaluate current limitations of MIS approaches for ASD.

Methods: A retrospective review of multi-center prospectively collected data of 85 consecutive patients with ASD undergoing MIS surgery. Inclusion criteria: age >45yrs; minimum 20° coronal lumbar Cobb; 1 year follow-up. Procedures were classified as: 1) Stand alone (saMIS): MIS LIF only (N=7); 2) cMIS: LIF or MIS TLIF with PPI (N= 43); or 3) Hybrid (HYB) - LIF with open posterior instrumented fusion (N=35).

Results: An average of 4.2 discs (range 2-7) were fused with mean follow-up of 26.1 months. saMIS: mean Cobb changed 34.3° to 29.5° (p>0.05). Cobb range was 23° to 81.5°, with 57% (n=4) greater than 30° and 28.6% (n=2) greater than 50°. A ceiling effect of 23° for curve correction was observed, regardless of preoperative curve severity.

cMIS: mean preop Cobb was 31.1° (18.6°-62°), corrected to 10.3° (p<0.05). 44% (19/43) had a coronal curve greater than 30° and 4.7% (2/43) greater than 50°. Coronal corrections ranged from 9° to 34°. A ceiling effect of 34° for curve correction was observed.

HYB: mean preop Cobb was 42.4° (23°-81.5°), corrected to 14.9° (p<0.05). 74% (26/35) had a coronal curve greater than 30° and 23% (8/35) greater than 50°. Coronal corrections ranged from 4° to 61°. A ceiling effect of 55° for curve correction was observed.

Conclusion: The ability to correct a scoliotic curve was directly related to the surgical technique utilized in this series. The addition of posterior fixation seems essential to affect coronal plane deformity. Our data indicate that MIS platforms for curve correction are currently limited based upon their ceiling effects. Surgeons employing MIS techniques should use these limitations in preoperative planning to guide their surgical approach for desired deformity correction.

118. Assessment of the Insertional Torque of Screws During Posterior Spinal Surgery

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Japan

Summary: Multi-center, biomechanical analysis of maximal insertional torque for cervical or upper thoracic spine intraoperatively. The maximal insertional torque (MIT) of LMS (C3-6) or PS (C7-T7) during the surgery was compared in cervical or upper thoracic vertebrae. The average MIT of Magerl technique was significantly

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higher than that of Roy-Camille technique.

Introduction: In posterior subaxial cervical fixation system, screws are usually inserted into the lateral mass. But in recent years, some papers revealed that pedicle screw fixation was the biomechanically strongest. Many authors have reported only on the stiffness and pullout strength of lateral mass screws (LMS) or pedicle screws (PS). None of the previous studies tested the insertional torque of LMS during the surgery. The purpose of this study was to assess, in cervical or upper thoracic vertebrae, the maximal insertional torque (MIT) of LMS (C3-6) or PS (C7-T7) during the surgery.

Methods: During posterior spinal fusions, cervical or thoracic multi-axial screws (Alphatec Spine, Carlsbad, CA) were placed at various cervical and thoracic levels after drill of 2.0mm, final (MIT) was recorded for each screw revolution with an analogue torque wrench. The number of PS at C7 were 11, LMS were 145 (Magerl technique: 70, Roy-Cammille technique: 64), thoracic PS were 33. LMSs at C1 and laminar screws at C2 or C7 were also used but they were excluded because of the small number of screws.

Results: The average MIT for PS at C7 (diameter: 3.5mm) was 45.3 ± 21.9 cNm in male group and 60.0 ± 20.1 cNm in female group ($p=0.28$). The MIT for Magerl technique was 69.0 ± 20.5 cNm in male and 58.6 ± 15.7 cNm in female ($p=0.13$). The MIT for Roy-Camille technique was 51.0 ± 17.9 cNm in male and 42.4 ± 15.9 cNm in female ($p=0.52$). The MIT for thoracic PS (diameter: 3.5mm) was 55.0 ± 11.6 cNm in female (no data in male). The MIT for thoracic PS (diameter: 4.0mm) 64.8 ± 18.3 cNm in male and 52.7 ± 9.6 cNm in female ($p=0.18$). The average MIT of Magerl technique was significantly higher than that of Roy-Camille technique ($p<0.01$ in male, $p<0.01$ in female).

Conclusion: Some cadaveric studies reported that IT was correlated with bone mineral density of the vertebrae, especially posterior cortex bone was important for screw purchase. Intraoperative IT is one of the good indicators to evaluate the purchase of screws. If intraoperative MIT is very low, we can change the screw size or trajectory, or use some additional implants. Further postoperative assessments with sequential X-rays were needed to reveal the meaning of MIT during the surgery for posterior spinal fusions.

119. Osteocel® Plus in Anterior Cervical Discectomy and Fusion (ACDF): Evaluation of Patient Outcomes from a Prospective Multi-Center Study

*Robert K. Eastlack, MD; Craig Meyer, MD; Chris R. Brown, MD
USA*

Summary: 2-year clinical outcomes of patients treated with ACDF and Osteocel Plus

Introduction: Osteocel Plus (O+) is an allograft cellular bone matrix containing native mesenchymal stem cells (MSCs) and osteoprogenitor cells which is intended to mimic the biologic performance of autograft without the morbidity associated with autograft harvest. This abstract summarizes the 2-year clinical outcomes of patients treated with O+ as part of an ACDF procedure.

Methods: 181 patients, across 17 centers were treated with ACDF using O+ and anterior plating (Helix) at one or two consecutive levels as part of a prospective, Multi-Center, non-randomized, IRB-approved study. Clinical outcomes included visual analogue scale (VAS) for neck and arm pain, neck disability index (NDI), and SF-12 physical and mental component scores (PCS, MCS). Additional data collection included patient demographics, procedure details, and complications. Per protocol, radiographic outcomes will include restoration and maintenance of disc height and lordosis over time, segmental range of motion, and bridging bone assessed by CT scan. Final radiographic results are not yet available; this partial analysis reports the 2-year clinical outcomes.

Results: 235 levels were treated in 181 patients. Mean age was 51 years, mean BMI was 29 kg/m², 25% of patients were smokers, and 49% were female. Mean procedure time was 100 minutes, blood loss was <50cc in 93% of patients and hospital stay was one day or less in 84% of patients. Postoperative swelling that required intervention presented in 2 patients. Significant ($p<0.05$) improvements in clinical outcomes from pre-op to 24 months included NDI: 21.5%, VAS Neck: 34mm, VAS Arm: 35mm, SF-12 PCS: 11.2, SF-12 MCS: 6.8. At 24 months 93% of patients were satisfied with their procedure and 94% stated they would repeat their procedure. Revision procedures at the index level were performed in 4 patients (2.2%) for incomplete resolution of pain (n=1), vertebral body collapse (n=1), dysphagia (n=1), and residual stenosis (n=1). There were no revisions for pseudoarthrosis.

Conclusion: Improvements in clinical results at 2 years, limited revision rate, and high patient satisfaction provide confidence in Osteocel Plus as an autograft alternative in ACDF procedures. Radiographic results from this study are forthcoming.

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).

120. 5 Year Outcome of Minimally Invasive Versus Open Transforaminal Lumbar Interbody Fusion

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Singapore*

Summary: MIS TLIF is comparable to Open TLIF in terms of mid term clinical outcomes and fusion rates with the additional benefits of less initial postoperative pain, less blood loss, earlier rehabilitation and shorter hospitalization.

Introduction: Open TLIF is a proven and reliable technique to achieve fusion in symptomatic spinal deformities and instabilities. The advantages of MIS TLIF include reduced blood loss, less pain and shorter hospitalization stay. Till date, there is no published data comparing the mid term outcomes of both surgical approaches.

Methods: From 2004-2007, 40 cases of open TLIF were matched paired

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with 40 cases of MIS TLIF in terms of age, gender and spinal levels operated on. All patients underwent single spinal level surgery for either grade 1/2 spondylolisthesis or degenerate disc with mechanical lower back pain and radicular symptoms Clinical assessment in terms of Oswestry Disability Index (ODI), neurogenic symptom score (NSS), SF-36 and Visual Analogue scores (VAS) for back and leg pain were performed before surgery, 6 months, 2 years and 5 years after surgery. Fusion rates were assessed using the Bridwell classification.

Results: Fluoroscopic time (MIS: 55.2 seconds, Open: 16.4 seconds, $p < 0.01$) and operative time (MIS: 185 minutes, Open: 166 minutes, $p = 0.085$) were longer in MIS cases. There was less blood loss in MIS (127 mL) versus Open (405 mL, $p < 0.01$) procedures. Morphine used for MIS cases (8.5 mg) was less compared to Open (24.2 mg, $p < 0.05$). MIS patients (1.5 days) ambulated earlier compared to open (3 days, $p < 0.01$). MIS (3.6 days) patients have shorter hospitalization compared to open (5.9 days, $P < 0.05$). Both MIS and Open groups showed significant improvement in ODI, NSS, back and leg pain, SF 36 scores at 6 months till 5 years with no significant differences between the 2 groups. Grade 1 fusion was achieved in 97.5 percent of both MIS and Open TLIF groups at 5 years. There were 4 cases of adjacent segment disease (ASD) in each of the groups, with 1 patient in the MIS group and 2 patients in the open group requiring decompression and fusion at the adjacent level within 5 years of the index surgery. Peri-operative complication rate is 10% for the open group and 5% for MIS ($p > 0.05$)

Conclusion: MIS TLIF is comparable to Open TLIF in terms of mid term clinical outcomes and fusion rates with the additional benefits of less initial postoperative pain, less blood loss, earlier rehabilitation and shorter hospitalization.

121. High Grade Spondylolisthesis Reduction Using Temporary Alar Distraction Rods and Sacral Dome Osteotomy

Dennis Crandall, MD

USA

Summary: High grade spondylolisthesis in 26 consecutive patients was surgically reduced using a translational technique with pedicle screw instrumentation. For grade 4 or 5, temporary distraction rods from L1-sacral ala, and with sacral dome osteotomies were used to assist in the correction. Complications included permanent neurologic deficits in 2 patients, and all 5 with cauda equina syndrome improved. VAS and Oswestry scores significantly improved from preop.

Introduction: High grade spondylolisthesis (HGS) is usually treated with decompression along with some amount of instrumented reduction to correct lumbosacral kyphosis and sagittal plane imbalance. Purpose of the study is to describe the use of temporary alar distraction rods and sacral dome osteotomy to assist in the gradual instrumented reduction of HGS.

Methods: Data from 26 consecutive patients who underwent surgery for HGS were reviewed. Age averaged 31 yrs (10-50 yrs). All patients underwent posterior only approach, Gill laminectomy, slow incremental translational correction of lumbosacral kyphosis and listhesis, and instrumented posterolateral arthrodesis.

For grade 4 and 5, sacral dome osteotomy was performed to loosen L5 and allow correction. Temporary contoured rods were placed from L1 and the sacral ala to distract and begin to lift L5 from lumbosacral kyphosis, and begin the reduction process as the laminectomy and construct assembly were completed.

Results: Meyerding grades: Grade 3- 13, Grade 4- 3, Grade 5- 10. Follow-Up: 2-10 years. For grades 4 and 5, 3-column sacral dome osteotomy rendered L5 more mobile, and temporary alar distraction rods were effective at improving lumbosacral alignment while remaining out of the way during laminectomy and screw insertion. Complications included 2 foot drop, 1 temporary quadriceps weakness (resolved by 1 year) and 3 infections. The 5 patients with cauda equina syndrome improved. VAS averaged 6.2 pre-op, improved to 2.0 at 2 years ($p < 0.01$). Oswestry averaged 35 pre-op improved to 17.2 at 2 years ($p < 0.01$).

Conclusion: A strong flexion moment and kyphosis at the lumbosacral junction along with significant ligament and bony obstacles impede reduction of HGS. Translational correction of high grade spondylolisthesis, restoration of lumbosacral alignment and sagittal balance produces significant long-term clinical improvements (ODI and VAS). For grade 4 and 5 listhesis, sacral dome osteotomy and temporary alar distraction rods were helpful in facilitating safe decompression and gradual translational reduction. Neurologic complications occurred in 10%, all with spondyloptosis.

122. Cost-Effectiveness of Lumbar Spondylolisthesis Surgery at Two-Year Follow-up

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USA

Summary: The purpose of this study is to determine the cost per quality adjusted life year of degenerative lumbar and isthmic spondylolisthesis treated with multiple surgical techniques and to identify pre-operative factors that lead to cost-effectiveness at 2 years follow-up. Spondylolisthesis surgery is cost-effective with a cost/QALY of \$78,098. Higher pre-operative leg pain was associated with increased cost-effectiveness and improved outcome, while surgical technique, degree of preoperative back pain, and fusion material were not associated with any difference in cost effectiveness.

Introduction: Comparative effectiveness and cost analysis research are gaining popularity in the field of spinal surgery. Studies have shown that surgical interventions with cost/QALY (Quality Adjusted Life Year) $< \$100,000$ are cost-effective. The purpose of this study is to determine the cost/QALY of lumbar spondylolisthesis treated with multiple surgical techniques and identify pre-operative factors that lead to cost-effectiveness at 2-year follow-up.

Methods: We performed a retrospective analysis of prospectively collected data on 44 patients (average age 59.7 years) who underwent surgery for degenerative (30 cases) or isthmic (14 cases) spondylolisthesis. The change in QALY was determined from 2-year outcome scores using EQ5D. Outcomes were assessed using Oswestry Disability Index. Hospital DRG codes were used to assess Medicare

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based hospital costs. Surgical, neuromonitoring, and anesthesia CPT codes were used to determine direct care costs of surgery. Analysis was performed to determine which factors were associated with a cost/QALY <\$100,000, making the procedure cost-effective.

Results: The average length of follow-up was 2 years (SD 0.82). The average postoperative ODI improvement was 24.5 (SD 23.9) and change in QALY was 0.4449 (SD 0.2984). The average cost/QALY was \$78,098. Patients were grouped into cost/QALY <\$100,000 (n=22) or >\$100,000 (n=22). Higher pre-operative leg pain was significantly associated with a cost/QALY <\$100,000 (p<0.005). The ODI change (p<0.005) and leg pain change (p<0.028) were greater for cost/QALY <\$100,000. Surgical technique (presence of interbody fusion, use of direct posterior decompression), type of spondylolisthesis, degree of pre-operative back pain, change in back pain, prior surgery, age, gender, intra-op complications, post-op revisions, and fusion material were not associated with a difference in cost effectiveness or outcome.

Conclusion: Spondylolisthesis surgery is cost-effective at 2-year follow-up with a QALY change of 0.4449 and a cost/QALY of \$78,098. Higher pre-operative leg pain was associated with increased cost-effectiveness and improved outcome. Surgical approach was not associated with any difference in cost effectiveness.

123. New Formulation of Demineralized Bone Matrix Putty Performs Substantially Equivalent to Iliac Bone Graft in Rabbit Posterolateral Lumbar Spine Arthrodesis

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USA

Summary: DBM's emergence as a significant BGS is related to its osteoconductive and osteoinductive potential. DBM provides an osteoconductive scaffold which maintains the space within the fusion bed to facilitate denovo bone formation in posterolateral spinal fusions, while its bone morphogenetic protein components (BMPs) are thought to be responsible for the osteoinductive stimulus.

DBM putty is a new, malleable formulation of DBM which has been designed to enhance DBM's surgical handling characteristics, while maintaining its osteoconductive and osteoinductive potential.

Introduction: Autogenous iliac crest bone graft (ABG) has long been considered the gold standard for grafting as it possesses osteoconductive, osteoinductive, and osteogenic potential. Many new bone graft substitutes (BGS) have been developed over the past two decades as alternatives to autograft for posterolateral spine fusion, including demineralized bone matrices (DBM).

The objective of this current study was to compare the efficacy of DBM putty against the "gold standard" ABG using the established posterolateral spine fusion rabbit model.

Methods: Twenty four (24) male New Zealand White (NZW) rabbits, weight range at the start of the study 3.5-4.0 kg, underwent bilateral posterolateral spine arthrodesis of the L5-L6 intertransverse processes, using either ABG (control

group, n= 12) or DBM (DBM made from rabbit bone) putty (test group, n =12). The animals were sacrificed 12 weeks after surgery. Analysis included high resolution radiographic imaging, four-point mechanical testing in flexion, right and left lateral bending, and extension to determine stiffness of the fusion mass and micro-computed tomography (micro-CT) imaging to determine bone volume. Finally, undecalcified histologic analysis was performed.

Results: Fusion was scored by the Lenke scale with 10 of the DBM and 9 of the ABG specimens (p>0.05) graded as Lenke A score. Biomechanical testing showed no significant difference in stiffness between the control and test groups on flexion, extension, left lateral and right lateral bend, with p values accounting for 0.79, 0.42, 0.75 and 0.52, respectively. Bone volume/total volume was greater than 85% in DBM treated fusion masses. Histological evaluation revealed normal bone formation activity in both groups.

Conclusion: Fusion rates of 72-81% were seen in our autograft group which is consistent with previous studies, and validates our technique in this animal model. Our study however demonstrated that higher fusion rates of 81-91% were seen in the DBM group.

The DBM putty proved equivalent to ABG in the posterolateral intertransverse rabbit model, and deserves consideration as an alternative to iliac crest autograft in spinal arthrodesis, avoiding donor site morbidities associated with bone graft harvesting

124. Influence of Patient Expectations and Depression Symptoms on Clinical Outcomes in the Surgical Management of Spinal Stenosis

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Mexico

Summary: Patients with diagnosis of lumbar spinal stenosis at one level that surgically treated. Patient expectations, presence of depression symptoms and clinical outcomes were captured preoperative and at 12 months. 58 patients were included and divided in two groups of 29 patients based on the presence or absence of depression symptoms Surgery had a relief effect over depression symptoms at 1 year. Patients with persistent depressive symptoms after surgery have worst clinical outcomes and higher rate of unmet expectations.

Introduction: Individual patient characteristics are related to surgical outcomes. The aim of the study is to determine the influence of depressive symptoms and patient expectations in the results of the surgical management of lumbar spinal stenosis

Methods: Prospective cohort study patients with diagnosis of lumbar spinal stenosis at 1 level with indication of decompressive surgery. All measures were completed before surgery and at 12 months. Age, sex, maximum study grade, and work status, Reasons for Surgery, Expectations scale (NASS lumbar spine Questionnaire), Global Effectiveness of Surgery (Likert scale), Depression Symptoms (Beck depression inventory), Disability (Oswestry disability index), back pain and

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leg pain (Visual Analogue Scale).

Results: 58 patients were included. Patients were divided into two groups based on the presence (Group 1) or absence of depressive symptoms (Group 2), both groups had 29 patients. The main reason to undergo surgery was "Other therapies have not helped". The most prevalent expectations were to improve social life and mental health. The surgery had a relief effect over the depressive symptoms in 14 patients (48%). This means that in the postoperative period the patients free of depressive symptoms were 43 versus 15 depressed ($P=0.001$). If we make a comparison between the 15 patients that remained depressed vs the 43 subjects free of depressive symptoms in the postoperative period we have different outcomes in lumbar pain ($P=0.001$), leg pain outcome ($P=0.001$) and disability outcome ($P=0.001$). In terms of expectations patients with persistent depressive symptoms at follow-up were less satisfied in of leg pain improvement ($P=0.001$), walking ($P=0.001$), independency ($P=0.001$), physical duties ($P=0.05$). The satisfaction was similar ($P=0.14$) when the patients were asked about expectations of social activities and mental improvement ($P=0.43$).

Conclusion: Depressive symptoms and patients expectations affect clinical outcomes of surgical treated spinal stenosis.

Surgery for spinal stenosis had a relief effect over preoperative depression symptoms at 1 year follow-up.

Patients with persistent depressive symptoms after surgery have worst clinical outcomes and higher rate of unmet expectations.

125. Characteristics Associated with Active Defects in Juvenile Spondylolysis

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USA

Summary: In 56 patients with 108 pars defects, Active or early juvenile spondylolysis appears to be associated with male patients and the absence of an associated listhesis. These clinical and radiographic characteristics may be important in identifying patients with a higher potential to achieve osseous healing with non-operative treatment.

Introduction: Early-stage lumbar spondylolysis can achieve osseous healing with conservative treatment making diagnosis important. Single photon emission computed tomography (SPECT) has traditionally been the most sensitive modality for diagnosing "active" or early spondylolysis. More recently, high signal change in the pedicle or pars interarticularis on fluid-specific (T2) magnetic resonance imaging (MRI) sequences has been shown to be important for diagnosis of early spondylolysis and, subsequently, a good predictor of bony healing. The purpose of this study is to determine clinical and radiographic characteristics associated with the diagnosis of early or active spondylolysis.

Methods: Fifty-six patients (29 males, 27 females) with a total of 108 pars defects (6 unilateral, 102 bilateral) and a mean age of 14.64 years were identified. Defects with a positive SPECT and/or high signal change on T2-MRI

were classified as active, while all other defects were classified as inactive. Patient and radiographic characteristics compared between patients who had an active defect versus those with an inactive defect. Independent t-tests were used to compare continuous variables and Fisher's test was used to compare categorical variables. Threshold p-value was set at 0.01 to account for the small sample size and multiple concurrent comparisons.

Results: There were 49 active and 59 inactive defects. There was no difference between active and inactive groups in terms of age (14.7yrs vs 14.6yrs, $p=0.930$), BMI (24.2 vs 21.7, $p=0.034$), duration of symptoms (236.3 vs 397.4 days, $p=0.016$), lumbar lordosis (27.4° vs 32.1° , $p=0.097$) pelvic incidence (29.0° vs 61.2° , $p=0.488$), slip percentage (9.5% vs 14.2%, $p=0.034$) and laterality (right vs left, $p=0.847$) (unilateral vs bilateral, $p=0.281$). There was a significant difference between the active and inactive groups in terms of gender (35 vs 19 males, $p=0.000$) and presence of listhesis (16 vs 35, $p=0.006$).

Conclusion: Active or early juvenile spondylolysis appears to be associated with male patients and the absence of an associated listhesis. These clinical and radiographic characteristics may be important in identifying patients with a higher potential to achieve osseous healing with non-operative treatment.

126. Establishing the Efficacy of Lumbar Discectomy and Single Level Fusion for Spondylolisthesis -Experience with the AANS' NeuroPoint SD Registry

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USA

Summary: We aimed to establish a multi-center registry to assess the efficacy of common lumbar spinal procedures. An observational prospective cohort study at 13 academic institutions was undertaken for single-level fusion for spondylolisthesis or single-level lumbar discectomy. Both procedures were associated with significant improvement in ODI, VAS, and SF-36 scores at 30 days ($p=0.0002$), which persisted at 1-year ($p<0.0001$). QALY's gained for discectomy were 0.256 over the 1-year study period, and 0.208 for fusion.

Introduction: There is significant practice variation and considerable uncertainty amongst payers as to whether surgical treatments are effective in actual spine practice. Our aim was to establish a multi-center registry to assess the efficacy of common lumbar spinal procedures using prospectively collected outcomes. Outcomes and QALY data were collected on 198 patients.

Methods: We completed a observational prospective cohort study at 13 academic and community sites. Patients undergoing single-level fusion for spondylolisthesis or single level lumbar discectomy were included. We obtained SF-36 and ODI data pre-op and at 3, 6, and 12 months post-op. Power analysis estimated a needed

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sample size of 160 patients: lumbar disc (125 patients) and lumbar listhesis (35 patients). QALY data was calculated by using SF-6D utility scores. Cost data for surgical management was estimated using Medicare reimbursement values generated from the SPORT trial: \$20,237 for lumbar discectomy and \$ 31,938 for surgery for lumbar spondylolisthesis.

Results: There were 198 patients enrolled over 1 year. Median age: 45.0 years (48% female) for lumbar discectomy (N=148); 58.0 years (58% female) for lumbar spondylolisthesis (N=50). At 30 days, 12 complications (6.1%) were identified. Ten disc herniation patients (6.8%) and 1 listhesis patient (2%) required re-op. The overall 1 year follow-up rate was 88%. At 30 days, both lumbar disc and single-level fusion procedures were associated with significant improvements in ODI, VAS, and SF-36 scores (P=0.0002) which persisted at 1-year (P<0.0001). By 1 year, over 80% of patients in each cohort who were working pre-op had returned to work. Lumbar discectomy was associated with a gain of 0.256 QALYs over the 1-year study period (\$ 79,051/QALY gained). Lumbar spinal fusion for grade I listhesis was associated with a gain of 0.208 QALYs over the 1-year study period (\$ 153,548/ QALY gained).

Conclusion: We were able to build a national spine registry which assessed QALY's gained of spinal procedures in actual practice. This type of data is being requested by payers to demonstrate efficacy and justify reimbursement.

127. Cost-Utility and Comparative Effectiveness Analyses of Surgery Versus Comprehensive Medical Management for Lumbar Spondylosis in Elderly

Scott L. Zuckerman, MD; Saniya S. Godil, MD; Scott L. Parker, MD; Stephen Mendenhall; David Shau; Clinton J. Devin, MD; Matthew J. McGirt, MD USA

Summary: In this prospective multidisciplinary real-world registry, surgery versus medical management for degenerative spine disease was shown to be cost-effective and provide greater two-year improvement in pain, disability, and quality of life in elderly population. From a short-term cost-based purchasing prospective, prolonged medical management appears favorable (cheaper) in the elderly population. From a value-based purchasing and patient-centered perspective, prolonged medical management is an inferior treatment option in the elderly population with surgical degenerative lumbar disorders.

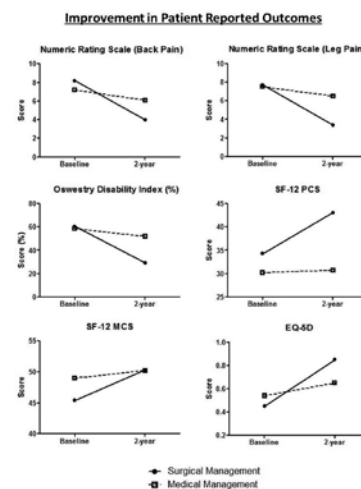
Introduction: Surgical treatments of structural low back diseases are facing increasing scrutiny on whether their cost justifies the benefit to patients. This is particularly true in the management of the elderly, where perceived risk is higher and clinical utility less known. We performed a comparative effectiveness and cost-utility analysis of surgery vs medical management in elderly with degenerative lumbar disorders utilizing a prospective registry in a real-world setting.

Methods: Patients(≥65yrs) with degenerative lumbar spondylosis(disc herniation, stenosis or spondylolisthesis) managed at a single institution's Multidisciplinary Spine Center were entered into a prospective registry. Surgical management

consisted of lumbar discectomy, laminectomy or fusion, while medical management included spinal steroid injections, physical therapy, oral medications, etc. 2-yr patient-reported outcomes(PRO), medical resource utilization, and work-day losses were assessed and used to calculate Medicare fee-based direct cost and indirect costs from occupation loss. Difference in mean 2-yr cost per QALY gained was assessed as incremental cost-effectiveness ratio(ICER).

Results: A total of 95 patients were included(surgery=45, medical management=50). Baseline characteristics were similar between the two cohorts. Surgical management resulted in a significant(p<0.001) 2-yr improvement in all PROs(VAS, ODI, SF-12, EQ5D:QALY), while comprehensive medical management failed to provide significant improvement. Two-year gain in QALY was significantly greater after surgery (0.67) versus medical management (0.18). Total 2-yr cost was significantly greater for surgery(\$41,500) versus medical management(\$14,000). The cost per QALY gained for surgery versus medical management(ICER) was \$56,437.

Conclusion: In this prospective real-world registry, surgery versus medical management for degenerative spine disease was shown to be cost-effective and provide greater 2-yr improvement in pain, disability, and QOL in elderly population. From a short-term cost-based purchasing prospective, prolonged medical management appears favorable in the elderly. From a value-based purchasing and patient-centered perspective, prolonged medical management is an inferior treatment option in the elderly.



128. The National Neurosurgery Quality and Outcomes Database (N2QOD) Pilot: Interim Analysis of Registry Feasibility, Data Integrity, and the Safety and Effectiveness of Surgical Spine Care

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USA

Summary: In March of 2012, the AANS launched the National Neurosurgery Quality and Outcomes Database (N2QOD) Lumbar pilot with the aim to develop a valid and accurate platform to measure the safety and effectiveness of everyday neurosurgery and spine care. Nine months after registry launch, 31 practice-groups had contracted with N2QOD. 3000 patients were enrolled, from 175 surgeons, 43 hospitals & 23 U.S. states. Of 378,000 clinical variables, missing data was <2%. 3-month follow-up was 84%. N2QOD is feasible with a high degree of data integrity. Early results suggest that effectiveness of spine surgery cannot be accurately measured without robust risk adjustment.

Introduction: As publically promoted by all stakeholders, quality measurement registry platforms lie at the center of all emerging evidence-driven reform models and will be used to inform decision makers in care delivery. Hence, the AANS launched the National Neurosurgery Quality and Outcomes Database (N2QOD) Lumbar pilot.

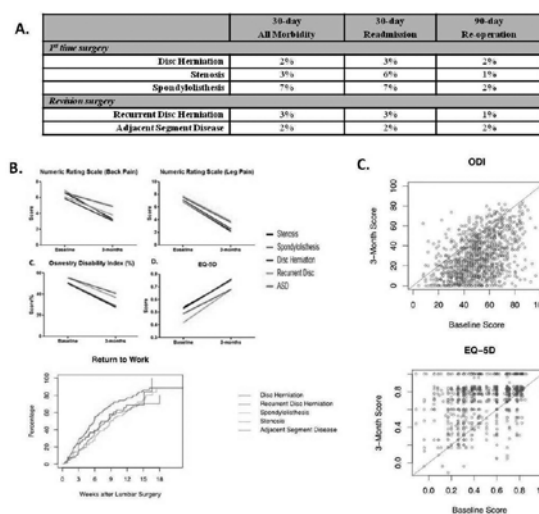
Methods: A nationwide, web-based, prospective, one-year outcomes registry (lumbar spine module) was introduced into neurosurgery and orthopedic spine practices in 24 U.S. states. Using a standardized process of representative sampling, baseline, peri-operative, 3- and 12-month medical record and patient-reported outcomes data was entered prospectively into the REDCap web-based portal. For quality control, automated missing data reports were communicated to sites weekly, targeted site education was instituted, and 10% of sites audited.

Results: Nine months after registry launch, 31 practice-groups had contracted with N2QOD. 3000 patients were enrolled, from 175 surgeons, 43 hospitals & 23 U.S. states. Of 378,000 clinical variables, missing data was <2%. 3-month follow-up was 84%. 12-month accrual is pending. Site audits demonstrated chart/interview data extraction accurate in all (56/56) cases and case sampling/inclusion accurate in 97% (113/116) audited cases. Surgical safety and effectiveness are given Figure 1. Significant improvement in all outcomes domains occurred by 3mo postop and 75% of patients had returned to work. For all surgical morbidity and outcome measures, the risk-adjusted expected norm (benchmark) for each site varied significantly (4-fold) across sites based on the risk adjustment of 32 disease-specific clinical variables unique to each center's patient population.

Conclusion: N2QOD is feasible with a high degree of data integrity. Early results suggest that the safety and effectiveness of surgical spine care cannot be accurately measured in the real world setting without robust risk adjustment of disease-specific clinical variables, something current administrative data-driven platforms lack. Lumbar surgery is highly effective in the real-world setting. Durability of surgical utility is pending. The N2QOD registry platform generates

accurate evidence for informed decision support for patients, surgeons, and policy makers.

Figure 1. A) Mean peri-operative 90-day surgical morbidity within the N2QOD network. B) Real-world effectiveness of surgical spine care for five common lumbar diagnoses three months postoperatively. A significant improvement in back pain, leg pain, functional disability (ODI), and quality adjusted life year gain (EQ-5D) were reported by patients undergoing surgery in a real-world setting for all five disease states. Overall, 75% of patients planning to return to work (RTW) returned to their pre-operative job by three months after surgery. C) Variation in surgical effectiveness in real world care. Marked variation in early (3mo) outcome was observed at the patient level despite standardized diagnosis criteria. Identifying the clinical, radiographic, and surgical characteristics of the patients not responding to surgical intervention will allow for improvement in patient selection and surgical care delivery, ultimately facilitating practice based learning and quality improvement. Patients not improving or worsening 3months after lumbar surgery are represented by plots on or above the bisecting diagonal line for ODI and by plots on or below the bisecting diagonal line for EQ-5D.



129. A Novel 6-Item Outcome Instrument (VBI-6) for Assessing the Effectiveness of Lumbar Surgery in Registry Efforts

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USA

Summary: Prospective registries utilizing validated patient reported outcomes (PRO) have been promoted as the ideal platform to generate evidence to inform decision making. Validated PRO instruments for spinal disorders may be too lengthy to feasibly apply to large scale registry efforts, resulting in poor patient compliance. The 10-item ODI and 12-item SF-12 PCS were the most valid and responsive measures for assessing effectiveness of lumbar surgery. However, a more valid and responsive PRO instrument VBI-6 can be constructed using 6 out of 22 items.

Introduction: Validated patient reported outcomes (PROs) for spinal disorders may be too lengthy to feasibly apply to large scale registry efforts. We set out to determine which PROs and their items are most valid and responsive, as well as which domains have closest correlation (overlap). Our aim was to introduce a shorter, valid and responsive, and more feasible questionnaire for measuring effectiveness of lumbar surgery.

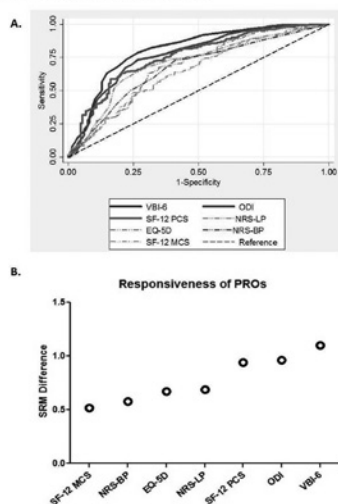
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Methods: A total of 520 patients undergoing elective surgery for degenerative lumbar spine disease were enrolled into our prospective registry. Baseline and 1-yr PROs were assessed. In order to assess the validity of PROs and their individual items, ROC analysis was performed. In order to assess responsiveness, difference between standardized response means (SRM) was calculated. Health Transition Index and NASS Satisfaction were used as anchors. Correlation between items was assessed via Spearman rank. For PROs and their items demonstrating high validity (AUC >0.70), and for individual items with similar dimensions and high correlation, items with maximum validity were included in the final questionnaire, Vanderbilt Back Index (VBI-6).

Results: ODI (AUC: 0.77; SRMDiff: 0.96) and SF-12 PCS (AUC: 0.76; SRMDiff: 0.94) were found to be most valid and responsive instruments. For ODI, pain intensity, mobility, social life and travel had highest AUC. For SF-12 PCS, general health, climbing stairs, less accomplishment, limitation from pain, effect on work and social activities had the highest AUC. 6 of these 12 most valid and responsive items were found to have significant correlation ($r \geq 0.48$, $p < 0.0001$). Thus, 6 items out of 22 (sitting, standing, social function, general health, accomplishment due to pain, effect on usual work) comprised of VBI-6. VBI-6 (AUC: 0.81; SRMDiff: 1.10) demonstrated better validity and responsiveness and strongly correlated with ODI ($r = 0.84$; $p < 0.0001$) and SF-12 PCS ($r = 0.81$; $p < 0.0001$).

Conclusion: The 10-item ODI and 12-item SF-12 PCS were the most valid and responsive PROs for assessing effectiveness of lumbar surgery. However, a more valid, responsive and feasible instrument VBI-6 can be constructed using 6 out of 22 items, which can be utilized in large scale registry efforts.

Figure 1: A. Receiver operating characteristic curve (ROC) demonstrating area under the curve (AUC) for different outcome instruments. Our modified instrument VBI-6 (AUC: 0.81) demonstrated better validity and responsiveness than ODI (AUC: 0.77) or SF-12 PCS (AUC: 0.76). B. A graph depicting responsiveness of various outcomes instruments. VBI-6 had the greatest responsiveness (SRM Difference: 1.10).



130. Disc Space Preparation in Unilateral Transforaminal Lumbar Interbody Fusion: A Comparison of Minimally Invasive and Open Approaches

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USA

Summary: There is little data on the adequacy of disc space preparation in a minimally invasive TLIF compared to an open approach. In this cadaveric study, 40 lumbar levels were randomly assigned to open and MIS groups, and disc preparations were performed for each group. MIS and open approaches to TLIF are equally effective at disc space preparation.

Introduction: Minimally invasive surgical (MIS) approaches to transforaminal lumbar interbody fusion (TLIF) have been developed as an alternative to the open approach. The purpose of this study is to compare the adequacy of disc space preparation through MIS and open approaches to TLIF. We hypothesize that there is no difference in disc space preparation comparing the two approaches.

Methods: 40 lumbar levels (i.e. L1-2 to L5-S1 in 8 fresh cadaver specimens) were randomly assigned to open and MIS groups. The MIS approach/disc space preparation was performed through a tubular retractor. Time of discectomy, number of instrument passes, and endplate violations were recorded for each level. The percent disc removed by volume and mass was determined for each approach. A digital imaging software program (ImageJ, U.S. National Institutes of Health, Bethesda, MD) was used to measure the percent disc removed by area for the total disc and for each quadrant of the endplate (i.e. anterior ipsilateral, anterior contralateral, posterior ipsilateral, and posterior contralateral). Measurements were made by two independent observers in a blinded fashion.

Results: The open approach was associated with a shorter discectomy time (9.3 minutes versus 11.5 minutes, $p = 0.01$) and fewer endplate violations (1 versus 3, $p = 0.04$) when compared to an MIS approach. No significant difference was found in number of instrument passes (33.5 versus 31.1, $p = 0.42$), percent disc removed by volume (79.5% versus 76.8%, $p = 0.41$), percent disc removed by mass (77.1% versus 75.1%, $p = .55$), and percent total disc removed by area (72.8% versus 71.1%, $p = 0.63$) between the open and MIS approaches, respectively. The percent disc removed by area for each of the 4 quadrants was similar in both the MIS and open groups. The posterior contralateral quadrant was associated with the lowest percent of disc removed compared to the other 3 quadrants in both open and MIS groups (49.9% and 59.7%, respectively).

Conclusion: MIS and open approaches to TLIF are similar in regards to the adequacy of disc space preparation. The least amount of disc by percentage is removed from the posterior contralateral quadrant, regardless of the approach.

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131. Risk Factors for the Need of Surgical Treatment of a First Recurrent Lumbar Disc Herniation

Ratko Yurac, MD; Juan J. Zamorano, MD; Fernando Lira, Resident; Diego Valiente, MD; Vicente Ballesteros, MD; Alejandro Urzua, MD; Francisco Ilabaca, MD; Jose Fleiderman, MD; Milan Munjin, MD; Miguel Lecaros, MD; Sergio Ramirez, MD; Carlos Tapia
Chile

Summary: Recurrent disc herniation is the most frequent etiology for new radicular pain after surgery for disc herniation-induced sciatica. Previously described risk factors include age, gender and smoking. We performed a retrospective case/control study to identify risk factors for the need of surgical treatment of recurrent herniation. Subligamentous herniations and age at the time of the first surgery of less than 35 years were identified as risk factors.

Introduction: Lumbar disc herniation recurrence is the most prevalent cause for new radicular pain after surgery for disc herniation-induced sciatica. Age, gender and smoking are among the multiple described risk factors and its surgical treatment is associated to a higher rate of complications and costs. The aim of this study is to identify factors that increase the risk of requiring surgical treatment for a first recurrent lumbar disc herniation in workers' compensation patients.

Methods: Nested case-control. We included 109 patients operated for a recurrent lumbar disc herniation (cases) between June 1st 1994 and May 31st 2011 (minimum follow-up 1 year) and randomly selected 109 patients among those operated for a first disc herniation with no recurrence during the study period (controls). Age, gender, smoking, type of work and MRI characteristics of the index herniation (level, axial and sagittal location, type and relationship with the posterior longitudinal ligament) were evaluated as potential risk factors. Statistical analysis using Fisher's exact test, chi-square test and Student's t test was performed.

Results: Patient's age of less than 35 years ($p=0.01$) and a subligamentous herniation ($p<0.05$) at the time of the index surgery were identified as risk factors for requiring surgical treatment of a recurrent herniation. No statistical differences were observed between both groups regarding the other evaluated factors.

Conclusion: A subligamentous disc herniation and patient's age inferior to 35 years at the time of the first surgery are risk factors for requiring surgical treatment of a recurrent disc herniation among workers' compensation patients.

132. Changes in Foraminal Dimensions Following Anterior Lumbar Interbody Fusion (ALIF): A 3D-CT and Clinical Analysis

Sergio A. Mendoza-Lattes, MD; Bethany Harpole, BS; Rachel C. Nash, BS; Andrew Pugely, MD
USA

Summary: The foraminal area of patients with symptomatic foraminal stenosis is <50% of normative values. Anterior Lumbar Interbody Fusion effectively increases the foraminal cross-sectional area, as well as the inter-vertebral angle.

Introduction: To describe the anatomical changes of the foraminal spaces following Anterior Lumbar Interbody Fusion (ALIF).

Methods: Retrospective case/control study (Level-III): 30 patients with isthmic spondylolisthesis or spondylotic disc space collapse, radiculopathy and evidence of foraminal stenosis were subject to ALIF: 220 foraminal spaces were classified as "symptomatic" (S=40) or "asymptomatic" (AS=180) according with the side, dermatome/myotome distribution of the symptoms at presentation. Radiographic measurements and 3D CT-reconstructions (Vitrea 6.0 workstation) was used to measure: foraminal height, foraminal area, disc space height and inter-vertebral angle. Chi-square, T-test and Pearson's coefficients were calculated. Data is presented as mean (95%CI).

Results: The area of asymptomatic foraminal spaces (AS) was significantly larger than that of the symptomatic (S) (112.6mm^2 (107.2mm^2 - 118.0mm^2) versus 63mm^2 (55.8mm^2 - 70.2mm^2), $p<0.0001$). Following ALIF, S areas increased significantly to 117.8mm^2 (106.1mm^2 - 129.5mm^2), and were then comparable to AS (Figure 1). Similarly, the AS pre-operative foraminal height was significantly taller than that of S (15.3mm (14.7mm - 16.0mm) versus 8.2mm (7.2mm - 9.2mm), $p<0.0001$). Following ALIF, the foraminal height changed significantly in S, an average of 4.4mm (50%), to a final height of 12.4mm (95%CI: 11.7mm - 13.5mm), $p<0.0001$. The posterior disc height was also significantly taller for the AS (6.24mm (5.91mm - 6.59mm) versus 4.51mm (3.87mm - 5.14mm), $p<0.0001$), and increased significantly after surgery, to 8.3mm (7.27mm - 9.32mm), $p<0.0001$. Anterior disc height correlates with inter-body angle ($r=0.806$, $p<0.0001$), and foraminal area correlates with foraminal height ($r=0.856$, $p<0.0001$) and posterior disc height ($r=0.651$, $p<0.0001$). We did not find any clear correlations between implant geometry (height and lordosis) with post-operative inter-body height or inter-body angle.

Conclusion: ALIF surgery significantly increases foraminal cross-sectional area. These changes correlate with increases in posterior disc space height and foraminal height. ALIF also increases anterior disc space height and inter-vertebral angle, but does not clearly correlate with implant geometry.



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133. Total Hospital Costs of Surgical Treatment for Adult Spinal Deformity (ASD): An Extended Follow-up Study

Ian McCarthy, PhD; Michael F. O'Brien, MD; Christopher P. Ames, MD; Han Jo Kim, MD; Justin S. Smith, MD, PhD; Oheneba Boachie-Adjei, MD; Frank J. Schwab, MD; Eric Klineberg, MD; Christopher I. Shaffrey, MD; Munish C. Gupta, MD; David W. Polly, MD; Richard Hostin, MD; International Spine Study Group
USA

Summary: This study summarizes the total hospital cost of ASD surgery through 8-year follow-up, which averaged \$118,000. Adopting estimates from the literature, ASD surgery was similar to that of CABG and five times more costly than total hip replacement (THR). During the follow-up period, average per-patient costs increased annually until the 5-year time point where costs plateau. Future studies involving costs of surgery are encouraged to seek 5-year follow-up for an accurate picture of the total hospital cost of surgical care.

Introduction: While the costs of primary surgery, revisions, and selected complications for ASD have been individually reported in the literature, the total costs over several years following surgery have not been assessed. Understanding the total per-patient cost of surgical care is critical in accurately measuring the cost-effectiveness of surgical treatment for ASD.

Methods: Single-center, retrospective analysis of 523 consecutive patients undergoing surgical treatment for ASD prior to January 2011. Costs were collected from hospital administrative data on the total hospital costs incurred for the operation and any related readmissions, expressed in 2010 dollars and discounted at 7% per year. Comparative costs on total hip replacement (THR) and CABG were collected from the literature.

Results: Patients were predominantly female (n=446, or 85%) with an average age of 49 (18 to 82) and average follow-up of 4.6 years (2 to 8). Total hospital costs averaged \$117,876 (std=\$60,550), with primary surgery averaging \$103,766 (std=\$41,707) and total readmission costs averaging \$70,722 per patient (std=\$64,320, n=145, or 28% of all patients). Average costs across all patients significantly increased (p<0.03) after primary surgery, from \$110,282 at one-year follow-up to \$122,077 at five-year follow-up. Per-patient costs did not significantly increase in successive follow-up years beyond five years (p>0.05).

Conclusion: Per-patient costs were similar to previously reported long-term costs for CABG and five times higher than that of THR, although the relative cost of revision compared to primary surgery was lower for ASD than for THR. The incidence of readmissions increased the average cost of ASD surgery by more than 170%, illustrating the financial burden of revisions/re-operations; however, the cost-burden resulting from readmissions was relatively acute, tapering off within 5 years following surgery. This has important implications for the lifetime cost-effectiveness of ASD surgery, as benefits of surgery likely extend beyond 5 years while average per-patient costs remain steady.

134. A Comparison of SHILLA™ GROWTH GUIDANCE SYSTEM and Growing Rods in the Treatment of Spinal Deformity in Children Less than 10 Years of Age

Scott J. Luhmann, MD; Richard E. McCarthy, MD
USA

Summary: The SHILLA™ GROWTH GUIDANCE SYSTEM compares favorably with traditional growing rod constructs in terms of correction of the major curve, spinal length and growth, and maintenance of sagittal alignment. The greater than four-fold decrease in additional surgeries makes the SGGs an attractive alternative to minimize comorbidities associated with additional surgeries.

Introduction: The purpose of this study was to compare the outcomes of the SHILLA™ GROWTH GUIDANCE SYSTEM (SGGS) and growing rods (GR) in the treatment of children (<10 years of age) with progressive spinal deformity.

Methods: This was a multi-center retrospective study of the SGGs used as an alternative treatment to GR to support an HDE submission for FDA approval. Inclusion criteria were progressive scoliosis in a patient less than 10 years of age at index procedure. The study population consisted of 19 SHILLA™ and 6 GR patients whose mean age was 6.1y and 5.8y, respectively. Group demographics were similar between the two groups.

Results: Mean operative time for the index procedures: SHILLA™ 5.2 hrs, GR 4.4 hrs. Mean intraoperative EBL: SHILLA™ 389cc, GR 235cc. Mean hospital stay: 5.1 days SHILLA™, 6.7 GR days. The initial major curve magnitude was 70.3 deg. for SHILLA™ and 68.3 deg. for GR, which decreased postoperatively to 22.4 deg. (66.9% improvement) and 32.2 deg. (59.7% improvement). During the first four years the correction for SHILLA™ varied from 40.5% to 53.4% and for GR from 40.9% to 56.9%. At last f/u T1-S1 length was 32.9 cm for SHILLA™ (4.2 increase from preop) and 34.0 cm (5.0 cm increase from preop) for GR. Average growth per month from T1-S1: SHILLA™ 0.14 cm, GR 0.11 cm. Sagittal T2-T12 preoperatively was 36.3 deg. for SHILLA™ and 30.0 deg. for GR. At 3 yr f/u SHILLA™ was 51.0 deg. (14.7 deg. increase) and GR 35.5 deg. (5.5 deg. increase). Sagittal T12-S1 preoperatively was -44.6 deg. for SHILLA™ and -55.0 deg. for GR. At 3 yr f/u SHILLA™ was -57.0 deg. (12.4 deg. increase) and GR 52.0 deg. (3.0 deg. decrease). There were 29 reoperations in 12 of the 19 SHILLA™ patients (63.2%) and 43 reoperations in all 6 of the GR patients (100%) related to the index procedure.

Conclusion: The SHILLA™ GROWTH GUIDANCE SYSTEM compares favorably with traditional GR constructs in terms of correction of the major curve, spinal length and growth, and maintenance of sagittal alignment. The greater than four-fold decrease in additional surgeries makes the SGGs an attractive alternative to minimize comorbidities associated with additional surgeries.

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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135. Introduction of Shilla Surgery into Japan: A Report on the First 18 Patients

Teppei Suzuki; Koki Uno, MD, PhD
Japan

Summary: We retrospectively reviewed the Shilla surgery. Although initial correction rate of main curve for this series was high, most patients had gradual recurrence of deformity without longitudinal growth of spine. The number of the surgery was obviously less comparing other distraction-based growing surgeries.

Introduction: The purpose managing early-onset scoliosis (EOS) is to prevent curve progression during spinal growth. However, the distraction based surgeries (growing rods, VEPTR) require repetitive surgical interventions to lengthen the implants in Japan. We retrospectively reviewed the "Shilla" which is a growth guidance system that does not require repeated surgical lengthenings.

Methods: Since 2008, a total of 18 consecutive patients who had Shilla procedure were analyzed. There were 8 boys and 10 girls. Average age was 8.5 ± 2.3 years at the initial surgery. Patients were observed with an average follow-up of 3.5 ± 1.5 years. Radiographic evaluation included changes in Cobb angle, T1-S1 length and Lung space over treatment. Analysis included number and frequency of complications. Because of the Shilla screws are not available in Japan, we substituted the poly-axial screws loosely connected to the smaller diameter rods.

Results: Cobb angle improved from 88 ± 15 degree to 46 ± 15 degree at post-initial and 64 ± 15 degree at final follow-up. Percent corrections were $45 \pm 18\%$ at initial and $22 \pm 25\%$ at final follow-up. T1-S1 length increased 51 ± 15 mm at post-initial and -5 ± 13 mm at final follow-up. Eleven patients (61%) had 18 complications; 16 loosening or dislodgments, 2 infections, 1 rod breakage. Eight patients (44%) required 14 unplanned surgeries. Three patient had undergone definitive fusion.

Conclusion: Initial correction rate of main curve for this series was higher than that of our growing rod series. After the initial surgery, most patients had gradual recurrence of deformity without longitudinal growth of spine. Most of the complications included the loosening or the dislodgement of the gliding anchors especially at the lower end of the construct. The number of the surgery was obviously less comparing other distraction-based growing surgeries.

136. Hybrid Constructs for the Growing Spine

Elias Dakwar, MD; Amer F. Samdani, MD; Anuj Singla, MD; Michael Auriemma; Joshua M. Pahys, MD; Randal R. Betz, MD; Patrick J. Cahill, MD
USA

Summary: The treatment of scoliosis in the growing spine is difficult. We report our experience using vertebral body stapling and posterior fusionless hybrid constructs.

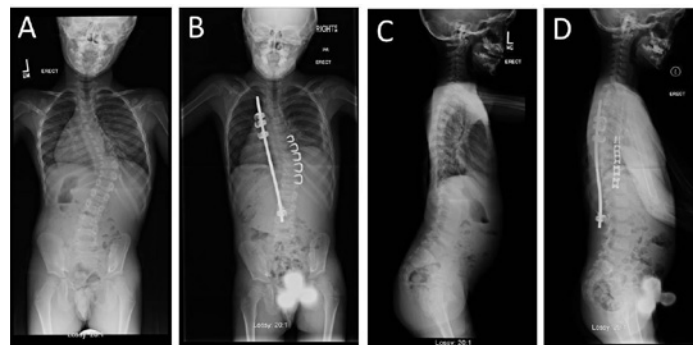
Introduction: The management of scoliosis in the skeletally immature patient presents challenges. Studies have demonstrated that the vast majority of immature patients with curves $>30^\circ$ eventually require a fusion. Multiple

techniques have been developed which include growing rods, vertebral body stapling (VBS), short fusions, and the vertical expandable prosthetic titanium rib (VEPTR). The objective of this study is to report our experience with patients undergoing VBS in addition to other posterior fusionless (hybrid) constructs.

Methods: We retrospectively reviewed all patients who underwent VBS at our institution from 2001-2009 with a minimum of 2 years of follow-up. We identified all patients who underwent a VBS in addition to growing rods, short fusions, or VEPTRs. Clinical and radiographic data were analyzed.

Results: 22 patients underwent anterior VBS hybrid constructs for scoliosis from 2001 to 2009 at our institution and were followed for a minimum of 2 years. There were a total of 27 curves (thoracic 20, lumbar 7) in this study group. The primary diagnosis was idiopathic scoliosis in 15, and 7 had other diagnoses such as neuromuscular and syndrome-associated scoliosis. There were 12 girls and 10 boys. The mean age was 9.3 years (3.8 to 14.9 years) and the mean follow-up was 2.8 years (2 to 8.4 years). The mean preoperative Cobb angle was 40.9° (thoracic 42° , lumbar 38°) prior to VBS. One patient had a preexisting growing rod, 12 patients had concomitant placement of the hybrid constructs at the same time as VBS, and 9 patients had the addition of their hybrid constructs at a later date. 4 patients had progression of their curve and required a fusion. At last follow-up, 9 patients remain skeletally immature. The overall mean postoperative Cobb angles at 1 year, 2 year, and last follow-up were 33.2° , 31.9° , and 28.7° , respectively.

Conclusion: Scoliosis in the growing spine presents a challenge to spine surgeons. We report 22 patients who had hybrid constructs in addition to the VBS. In immature patients with moderate curves, the combination of VBS and posterior hybrid constructs has been shown to avoid the natural history of progression to severe deformity.



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137. Are Complications in Adult Spinal Deformity (ASD) Surgery Related to Approach or Patient Characteristics? A Prospective Propensity Matched Cohort Analysis of Minimally Invasive (MIS), Hybrid (HYB), and Open (OPEN) Approaches

Juan S. Uribe, MD; Gregory M. Mundis, MD; David O. Okonkwo, MD, PhD; Adam S. Kanter, MD; Robert K. Eastlack, MD; Michael Y. Wang, MD; Praveen V. Mummaneni, MD; Neel Anand, MD; Richard G. Fessler, MD, PhD; Frank La Marca, MD; Paul Park, MD; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Vedat Deviren, MD; International Spine Study Group
USA

Summary: Complications occur frequently in ASD surgery. The recent trend to apply MIS technology to ASD has led to the belief that complication rates are lower for this cohort. In an attempt to neutralize patient factors and to make conclusions based on approach 2 prospective databases were propensity matched and analyzed. Complication rates were significantly lower for MIS than HYB and OPEN procedures. Despite a 45% overall complication rate at 1 yr, ODI was significantly improved.

Introduction: Complications (COMP) are common in ASD surgery. MIS and HYB techniques have been utilized to reduce them. The goal of this study is to analyze COMPs in a cohort of similar patients in an attempt to isolate the effects of approach.

Methods: 280 pts in 2 prospective databases (MIS n=85; OPEN n=195) were retrospectively reviewed, divided in 3 separate approaches OPEN, MIS, and HYB and propensity matched for age, ODI, SVA and major Cobb. Inclusion criteria: age >45, Cobb >20°, min 1 yr follow-up. COMPs were defined as per Glassman et al. 93 patients were available for analysis. Groups: 1) MIS- standalone lateral transposas (LIF), LIF with MIS posterior pedicle screws (PPS), and MIS TLIF (n=31). 2) HYB- LIF with open PPS(n=31); 3) OPEN- Open PPS +/- interbody (n= 31).

Results: There was no difference in groups with regard to gender, age (mean 62.9 yrs), ASA (avg. 2.2), BMI (mean 27.5) and revision cases. The MIS had significantly less co-morbidities than HYB (1.87 v 3.1; p<0.05). EBL was less in MIS than HYB/OPEN (p<0.002) and OR time more in HYB than MIS/OPEN (p<0.001). OPEN had more levels fused (9.3) versus HYB (7; p<0.03) and MIS (4.8; p<0.001). Among patients with complete data overall COMP was 45.2% (38/84). There was a significant difference in rate among MIS, HYB and OPEN (20%, 87%, 131%; p<0.001). The occurrence of at least 1 intraop COMP was 0%, 16.7% and 27.6% (p<0.02), at least 1 postop 20%, 36.7%, and 55.2% (p<0.03), and 1 major 12%, 33.3%, and 44.8% (p=0.032). All patients had significant improvement in ODI and VAS from pre to post (p<0.001) and the occurrence of COMP had no impact on ODI.

Conclusion: Approach did matter when evaluating for complications. MIS had a significantly fewer intra-, post-, and major complications than HYB or OPEN. Despite an overall 45% COMP rate there was no adverse effect on HRQOL at 1

year. If the goals of ASD surgery can be achieved, consideration should be given to less invasive techniques to reduce complications.

138. Predictors of Early Postoperative Discharge Following Minimally Invasive Lateral Interbody Fusion (MI-LIF)

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USA

Summary: Extended hospitalization following spine surgery has been shown to increase the potential for postoperative complications, namely infection, and substantially increase costs. In interbody fusion procedures, namely MI-LIF, where minimal approach morbidity has been shown to allow for early postoperative functionality and early discharge, though patient characteristics which may predict early discharge following MI-LIF are heretofore unreported. Factors including but not limited to lower age, elevated preoperative hemoglobin, elevated preoperative disc height at the index level, having fewer indicated levels with single-incision fixation may predict early discharge following MI-LIF.

Introduction: Extended hospitalization following spine surgery has been shown to increase the potential for postoperative complications, namely infection, and substantially increase costs. In interbody fusion procedures, namely MI-LIF, where minimal approach morbidity has been shown to allow for early postoperative functionality and early discharge, though patient characteristics which may predict early discharge following MI-LIF are heretofore unreported

Methods: Prospective data on 1033 consecutive MI-LIF patients from October 2006 through June 2011 were reviewed. Of these, 873 were discharged in <23 hours (outpatient), and 160 were discharged in >23 hours (inpatient). Within the outpatient group, 45 patients were discharged within 8 hours of surgery (ambulatory). Demographic data were compared between outpatient and inpatient groups, as well as between ambulatory and outpatients.

Results: Factors impacting early discharge (out- versus in-patient) were age, gender, smoking, deformity, preop hemoglobin (Hgb) level, preop disc height, number of levels treated, and fixation type. Mean age for out- and in-patients was 61.9 and 66.7 years, p<0.001. More males were outpatients (88.2%) compared to females (81%), p=0.012. Smoking was, surprisingly, more frequent in out- compared to in-patients (34.3% & 22%), p=0.003. Preoperative Hgb and disc height were higher in outpatients (13.8g & 6.3mm) than inpatients (13.1g & 5.4mm). More levels treated predicted being in patient (p<0.001), and non-pedicle screw fixation favored outpatient discharge, p<0.001. No differences were seen between out and inpatients in terms of number of comorbidities or having had prior surgery. Ambulatory patients were younger than both out- and in-patients (53.2 years, 62.4 years, and 66.7 years), p<0.001, had even higher preoperative Hgb (14.4g, 13.7g, and 13.1g), p=0.001, and preoperative disc height (7.6mm, 6.3mm, and 5.4mm, all respectively), p=0.002.

Conclusion: These data suggest that factors including but not limited to lower age,

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elevated preoperative hemoglobin, elevated preoperative disc height at the index level, having fewer indicated levels with single-incision fixation may predict early discharge following MI-LIF.

139. Pedicle Screw Insertion with a Cortical Bone Trajectory (CBT) - Is it a Less Invasive Alternative to a Traditional Trajectory?

*Takashi Kaito, MD, PhD; Hiroyasu Fujiwara, MD; Takahiro Makino; Kazuo Yonenobu, MD, DMSc
Japan*

Summary: Cortical bone trajectory (CBT) is a new pedicle screw (PS) trajectory which is originally invented to acquire better fixation by the increased cortical purchase in patients with osteoporosis. However, the more cranial and lateral oriented trajectory of CBT PS is also expected as a less invasive technique by a smaller incision and less muscle distraction. This study demonstrated that Pedicle screw insertion with a cortical bone trajectory (CBT) is a less invasive alternative to a traditional trajectory.

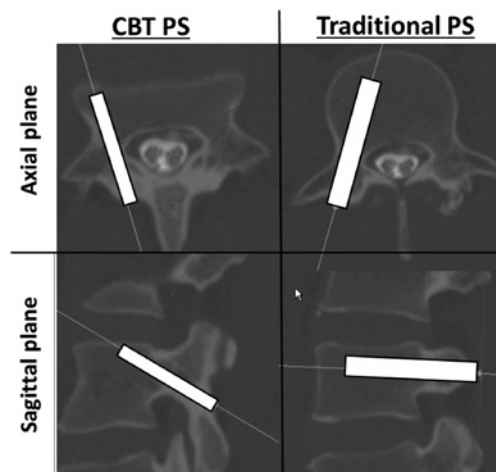
Introduction: Cortical bone trajectory (CBT) is a new pedicle screw (PS) trajectory which is originally invented as an alternative of the traditional PS in patients with osteoporosis to acquire better fixation by the increased cortical purchase. However, the more cranial and lateral oriented trajectory of CBT PS (fig.1) is also expected as a less invasive technique by a smaller incision and less muscle distraction. In this study, a less invasiveness was compared between posterior lumbar interbody fusion (PLIF) with the CBT PS and with the traditional PS.

Methods: Fifty one patients with lumbar canal stenosis treated by one segment PLIF were enrolled in this study. The patients were assigned to the CBT group (n=26) or the traditional group (n=18). Outcome measures relating surgery are estimated blood loss, length of surgery, the pre- and postoperative (1, 7, 14 days) serum levels of WBC, CRP and CPK. Clinical assessment parameters included Visual Analog Scale (VAS) of low back pain, Japanese orthopaedic association (JOA) score and JOA-back pain evaluation questionnaire (JOA-BPEQ) were collected at before surgery and post-op. 1 week, 2 weeks and 1 month.

Results: The average operating time was 121 min. in the CBT group and 140 min. in the traditional group, and the average blood loss was 153ml in the CBT group and 195ml in the traditional group. Both of them are shorter or fewer in the CBT group, but not statistically significant. The mean VAS score of low back pain at 1 month was significantly lower in the CBT group (7mm versus 14mm, $p < 0.05$). On post-op. 1 day, the mean CPK level was significantly lower in the CBT group (181U/L) than in the traditional group (301U/L) ($P < 0.01$). JOA score was not significantly different between the groups. However, all domains in JOA-BPEQ at 2 weeks showed superior recovery in the CBT group than that of the traditional group.

Conclusion: This first clinical study relating CBT demonstrated the less invasiveness of PLIF with the CBT PS than PLIF with the traditional PS in postoperative low

back pain, postoperative CPK level and patient-based evaluation questionnaire possibly because of less damage to the paraspinal muscle. PS insertion with the CBT is an attractive less invasive alternative to the traditional PS.



140. What is the Impact of Adding 3D Information to Pre-Operative Fusion Level Determination?

*Stefan Parent, MD, PhD; Jean-Marc Mac-Thiong, MD, PhD; Kariman Abelin-Genevois, MD, MSc; Ibrahim Obeid; Jacques Griffet, MD, PhD; Keyvan Mazda; Tamás Illés; Isabelle Turgeon, BSc; Marjolaine Roy-Beaudry, MSc
Canada*

Summary: The objective of this study was to evaluate the impact on the selection of fusion levels by adding 3D information to pre-operative radiographs. Five surgeons determined fusion levels on pre-operative radiographs for 28 patients in 2D and in 3D. Fusion level selection was affected by the addition of 3D information with three out of 7 surgeons including more levels in their fusion. This may be due to new information available in 3D that is not present on standard radiographs.

Introduction: Selection of fusion levels remains a difficult process that relies heavily on surgeon's experience, expertise and published rules. Surgeons rely therefore heavily on spinal imaging to determine the best fusion levels. With the advent of new imaging system giving access to 3D reconstruction and new ways to evaluate the spinal deformity, the objective of this project was to evaluate the impact of adding three-dimensional information to the standard imaging performed pre-operatively on the selection of fusion levels.

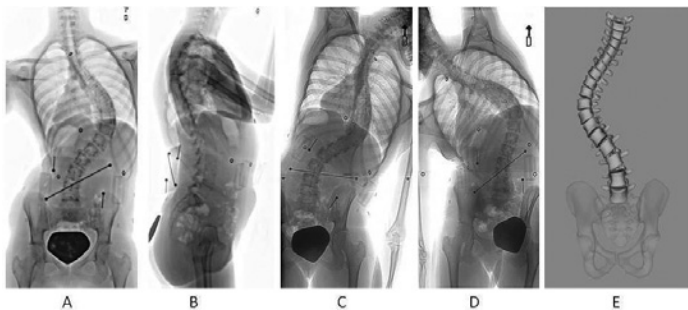
Methods: The radiographic images of 28 patients with AIS were reviewed by 7 pediatric spine surgeons treating routinely spinal deformities. A first set of images containing PA, lateral and bending radiographs was used (2D) to determine the levels of fusion for each patient. This was repeated two weeks later with the same patients in alternate order. The 3D dataset was composed of the same images but with the addition of 3D data provided under the form of 3D representations in different planes of view as well as a 3D object that the user could rotate in space.

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Vertebral axial rotations as well as top-view representation were also made available. These images were reviewed twice a two weeks interval. Kappa statistics was used to determine intra-observer agreement for 2D and 3D level selections and to evaluate agreement between 2D and 3D level determination. Fusion length (# of fused levels) was finally compared between the 2D and 3D readings.

Results: Intra-rater agreement was high for 6 out of 7 surgeons both for 2D and 3D. This level of agreement decreased between 2D and 3D measurement. Fusion length was on average 0.5 levels longer in the 3D group for 4 observers, unchanged for 2, and decreased by almost one level for the last reviewer. Factors affecting level selection included CSVL (38.2%), PA radiograph (31.8%) and Bendings (20.8%) and for the 2D dataset. When using the 3D dataset, observers reported that the 3D PA images (26.4%), face view (22.2%) and CSVL (15.8%) played an important role in level selection.

Conclusion: the addition of 3D images does affect the perception of clinicians as to what their fusion levels should include. This study highlights the need for new guidelines to determine fusion levels using 3D information.



Images A, B, C & D were sent for first and second 2D reading by spine surgeons. 3D Image E is an example of what type of information was added in third and fourth reading.

141. Single Institution Results of Anterior Vertebral Body Tethering for Immature Idiopathic Scoliosis

Amer F. Samdani, MD; Robert J. Ames, BA; Joshua M. Pahys, MD; Jeff S. Kimball; Harsh Grewal, MD, FACS, FAAP; Glenn J. Pelletier, MD; Randal R. Betz, MD USA

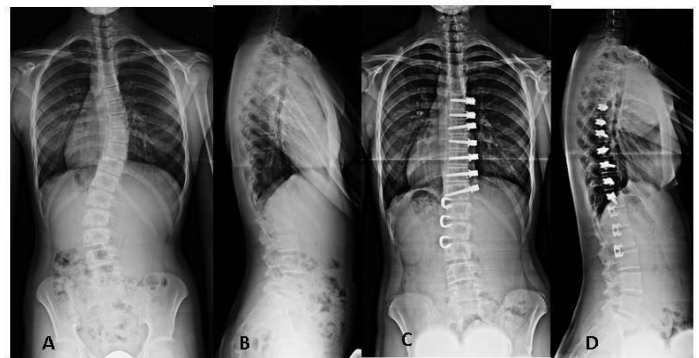
Summary: Anterior vertebral body tethering offers a fusionless option for children with scoliosis as an alternative to fusion or bracing. To date, very little clinical data have been published on this technique. Here we describe our initial experiences with this novel technique on our first 28 patients.

Introduction: Anterior vertebral body tethering (AVBT) is a promising new technique with abundant preclinical studies but very limited clinical results. It is a growth modulation technique which utilizes the patients' growth to attain progressive correction of their scoliosis, thus avoiding spinal fusion. In this report we describe our perioperative and early results on our first 28 patients.

Methods: After obtaining IRB approval, we retrospectively reviewed clinical and radiographic data on a consecutive series of 28 patients between February 2011 to July 2012 having had AVBT of the thoracic spine. We collected pertinent pre-op/intra-op/most recent clinical and radiographic parameters.

Results: There were a total of 28 patients (F=79%) identified with a mean age of 12.3 ± 1.4 years. 5 patients concomitantly underwent intervertebral body stapling of their lumbar curves. At the time of this review, patients had a mean follow-up of 6 months. Preoperatively, all the patients were \leq Sanders stage 4 for bone age, with all but one patient being \leq Risser 2. Pre-op thoracic Cobb angle averaged $43.5 \pm 12^\circ$ ($31-66^\circ$), with a lumbar curve of $27 \pm 8^\circ$ and a rib prominence of $13 \pm 4^\circ$. Patients underwent an average of 6.6 levels tethered with the most proximal being T5 and most distal L2, with median blood loss being 150cc. Most recent x-rays revealed a mean thoracic Cobb angle of $21 \pm 7^\circ$ ($p < .05$), representing 53% correction. The lumbar curve measured $15.6 \pm 9^\circ$ and rib prominence of $8 \pm 4^\circ$ ($p < .05$). One patient required a return to the ICU for marked atelectasis, but no other major complications were seen.

Conclusion: AVBT is a promising technique for skeletally immature patients with idiopathic scoliosis. This technique can be performed safely and effectively and results in good correction. Longer term follow-up is needed to further assess the utility of this technology.



(A) PA erect film of an 11-year old girl, Risser 0, Sanders Stage 3, with a 38° right thoracic curve and a 37° left lumbar curve. (B) The lateral profile shows no spondylolisthesis. The thoracic spine is hypokyphotic, with an apex at approximately T9. (C&D) One year post-surgery. The standing PA shows the thoracic spine to measure 0° and the lumbar spine to be $+8^\circ$. 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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142. The Use of Suspension Radiographs to Predict LIV Tilt

Hanneke van West, MD; Jean-Marc Mac-Thiong, MD, PhD; Hubert Labelle, MD; Diane Moulin, B. Ing; Isabelle Turgeon, BSc; Marjolaine Roy-Beaudry, MSc; Nathalie Bourassa; Yvan Petit, PhD; Stefan Parent, MD, PhD
Canada

Summary: This study investigates the possibilities of suspension radiographs to predict the lowest instrumented vertebra (LIV) tilt comparing standing preoperative, suspension and postoperative radiographs from pedicle screw constructs in 30 patients with AIS.

The strong correlation that was found for the LIV tilt between suspension and postoperative radiographs suggests that the LIV tilt in suspension can predict LIV tilt postoperatively. This result suggests that the vertebra tilt in suspension radiographs can help the surgeon in preoperative LIV planning.

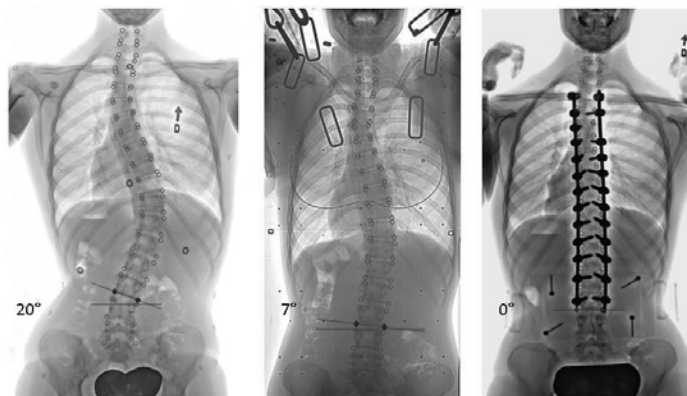
Introduction: In AIS surgery the goal is to obtain a well-balanced correction of the spine while preserving as much mobility as possible. Due to the powerful effect of pedicle screw constructs in correcting scoliosis the Lowest Instrumented Vertebra (LIV) tends to be chosen higher, leaving more lumbar mobility. Suspension radiographs have been proposed to assess curve flexibility, but their ability to predict the LIV has not been studied. The objective of this study was to evaluate the correlation between pre-operative, suspension and postoperative LIV tilt and to try to determine a threshold value for LIV tilt in suspension to help the surgeon identify an appropriate LIV.

Methods: Thirty patients with AIS surgically treated using pedicle screw constructs were prospectively evaluated by preoperative standing, suspension, as well as postoperative standing radiographs. Vertebra tilting, disc wedging and vertebra translation were compared for the LIV at each time point (preoperative, suspension, postoperative).

Results: Mean tilt of the LIV was $22,7^\circ (\pm 6,1)$ preoperatively, $12,8^\circ (\pm 5,5)$ in suspension and $6,3^\circ (\pm 4,3)$ postoperatively. The assessment of LIV tilt from suspension and postoperative radiographs demonstrated a strong correlation ($r=0,5$ with $p=0,005$). All but one of the eleven patients with a postoperative LIV < 5 degrees had a suspension LIV under 15° whereas 10 out of 19 patients with a postoperative LIV $> 5^\circ$ had an LIV in suspension $> 15^\circ$. The LIV disc wedging and vertebra translation didn't show any correlation between the suspension and the postoperative radiographs.

Conclusion: There is a strong correlation between suspension and postoperative radiographs looking at LIV tilt, whereas the LIV tilt in the suspension radiograph seems to correctly predict the postoperative LIV tilt by a factor of 50%. This suggests that the LIV selection could be improved with the addition of a

suspension radiograph. In our cohort, when LIV tilt in suspension was $< 15^\circ$, the postoperative LIV tilt was less than 5 degrees.



143. Geometric Torsion in AIS: A New Method to Differentiate Between Lenke 1 Sub-Types

Jesse Shen; Samuel Kadoury; Hubert Labelle, MD; Marjolaine Roy-Beaudry, MSc; Carl-Éric Aubin, PhD, PEng; Stefan Parent, MD, PhD
Canada

Summary: A clinically significant 3D classification remains to be established for AIS. By developing geometric torsion as a 3D descriptor, this research attempts to find new potential sub-groups of AIS. The results show two new potential 3D sub-groups of Lenke 1 deformities.

Introduction: AIS is a 3D deformity of the spine. However, the most widely accepted and used classification systems still rely on 2D aspects of x-rays. Yet, a 3D classification of AIS remains elusive as there is no widely accepted 3D parameter in the clinical practice. The goal of this study is to propose a true 3D parameter that quantifies the torsion in thoracic AIS in order to identify new 3D Lenke 1 sub-groups.

Methods: This is a consecutive case series analysis of 141 patients with Lenke 1 deformations recruited in our institution. The Lenke classification was identified by two observers and 3D reconstructions were obtained using bi-planar radiographs. Geometric torsion measuring the twisting effect of the spine was estimated using a novel technique by approximating local arc lengths at the neutral vertebra in the thoraco-lumbar segment. An inter- and intra-group (1A, 1B, 1C) statistical analysis was performed to evaluate the torsion index, and how it relates to other 3D indices.

Results: A statistically significant increase in torsion (mm-1) was observed between Lenke 1A (1.15) and Lenke 1C (2.10) sub-groups with a confidence interval of 95%. No statistically significant difference was found between the Lenke 1B (1.75) sub-group with either of the other two sub-groups. An automatic classification based on torsion indices identified two groups: one with high torsion values (3.02) and one with low torsion values (0.83). Statistically significant differences were found between the Main Thoracic (MT) planes of maximum

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curvature (PMC) orientation of the high torsion group (73.72) and the low torsion group (79.85) with a confidence interval of 95%. Statistically significant differences were also found for the Thoracolumbar/Lumbar (TL/L) PMC orientation (56.41 vs 49.25) between the high torsion group (56.41) and the low torsion group (49.25) with a confidence interval of 95%. (table 1).

Conclusion: These results show an increase in torsion as a function of the associated lumbar modifier (A, B, C) in Lenke 1 deformities. They also suggest the existence of two sub-groups of 3D deformations based on torsion values (high and low) with links to PMC orientation. This new torsion parameter could help differentiate different types of scoliotic deformities.

144. An Expandable Crescent Shaped TLIF Cage to Improve Segmental Lordosis: Safety, Efficacy, and Early Clinical Outcomes

Dennis Crandall, MD; J. Abbott Byrd, MD; Sigurd H. Berven, MD; Neel Anand, MD; Murali P. Kadaba, PhD, MBA; Jan Revella, RN; Lynette Taylor USA

Summary: An FDA approved hydraulic expandable TLIF cage increased disc height and segmental lordosis in 266 patients undergoing lumbar arthrodesis and TLIF at 4 centers. There were no cage-related complications, and early clinical results showed improved VAS and ODI at 1 year. Radiographic analysis of the first 15 patients was compared to a matched cohort treated with fixed height cages. Patients treated with the expandable cages showed significantly improved lumbar lordosis and disc height compared to fixed height control cages.

Introduction: Expanding TLIF cages (EC) have the potential to improve interspace fit and fill, disc height, and segmental lordosis. This is the first report of clinical safety, efficacy, outcomes and radiographic improvement of an EC that is FDA approved for use in TLIF.

Methods: 266 consecutive adults undergoing primary or revision arthrodesis were treated with TLIF using 356 crescent shaped, hydraulic EC by 4 surgeons at 4 centers. Age: 58yrs(19-86yrs); Diagnoses split between deformity, degenerative, and spondylolisthesis. Levels treated: single - 191; 2 levels - 63; 3 levels - 14. Posterior fusions averaged 3.5 levels(2-9 levels). Technique: EC were placed front and center in the disc, expanded an average 3.4mm (0-6mm) to lift the anterior interspace, to act as a fulcrum to increase segmental lordosis. Backfill bonegraft was used in all cases. Radiographs from the first 15 expandable cages were compared to matched controls with fixed cages for comparison of disc height and lordosis data.

Results: Both expandable cage and Control cage increased anterior, mid, and posterior disc height ($p<0.001$) from pre-op, and increased segmental lordosis (EC $p<0.001$; control $p=0.019$). Regional lordosis was not affected in either group. EC group improved segmental lordosis, anterior and mid disc height more than control ($p=0.002/0.002/0.001$); EC posterior disc height also improved more than control but was not significant ($p=0.14$). Clinically, early complications included infection - 2, neuro deficit - 0, PE - 1, loss of cage expansion height - 0.

Revision surgery was required in 3 for unrelated adjacent level fractures in the thoracolumbar spine in deformity patients. For 38 patients with more than 12 months follow-up, improvement was noted in VAS: pre- 7.0, 1 year - 3.8; ODI scores improved: pre - 48.5 ($P<0.05$), 1 year - 28.9 ($P<0.05$).

Conclusion: This study supports the safety, efficacy, and ability to improve segmental lordosis with a new hydraulic expandable TLIF cage. Early clinical outcomes suggest similar improvements with VAS and ODI as with other TLIF cages, with the advantage of increase segmental lordosis at the levels the cage was used.

145. Anterior Column Realignment (ACR) has Similar Results to Pedicle Subtraction Osteotomy (PSO) in Treating Adults with Sagittal Spinal Deformity: A Multi-Center Study

Gregory M. Mundis, MD; Behrooz A. Akbarnia, MD; Nima Kabirian, MD; Jeff Pawelek; Robert K. Eastlack, MD; Christopher I. Shaffrey, MD; Eric Klineberg, MD; Shay Bess, MD; Christopher P. Ames, MD; Vedat Deviren, MD; Virginie Lafage, PhD; International Spine Study Group USA

Summary: 17 patients who underwent anterior column realignment (ACR), a minimally invasive retroperitoneal lateral interbody fusion with ALL release, were propensity matched to pedicle subtraction osteotomy (PSO) patients. ACR was equally as effective in correcting lumbar lordosis, T1 pelvic angle (TPA), more effective in correcting PT, and less effective with T1 spinopelvic inclination (T1SP). ACR had less EBL and equal complication profile. This MIS technique is a suitable alternative to traditional PSO for the surgical correction of adult sagittal plane spinal deformity.

Introduction: Anterior column realignment (ACR) has recently been described as a minimally invasive retroperitoneal lateral interbody fusion with anterior longitudinal ligament release for correction of adult sagittal plane deformity (ASD) in an effort to minimize the morbidity associated with PSO. This study aims to compare ACR with a PSO cohort from a retrospective consecutive multi-center database.

Methods: A consecutive series of 17 ACRs from a multi-center database was propensity matched (by pelvic incidence (PI), lordosis (LL) and thoracic kyphosis (TK)) to a retrospective consecutive multi-center PSO dataset (N=100). Inclusion criteria: Adult sagittal plane deformity requiring ACR or PSO and minimum 1-year follow-up. Differences between groups were investigated using unpaired t-test and change within groups using paired t-tests (N=17 in each group).

Results: All ACR underwent 2nd stage open posterior instrumented fusion. There were no differences in baseline demographic or radiographic parameters (Table). Both groups were found to have significant improvement from pre- to final follow-up for LL, T1 spinopelvic inclination (T1SP) and T1 pelvic angle (TPA). PT did not improve in PSO (31 to 28) at 2-year but did improve in ACR (34 to 25; $p<0.01$). No differences were identified between ACR or PSO at 3-month or 2-year for LL (51° versus 47°), PT (25° versus 28°), and TPA (23° versus

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24°). PSO had more T1SP correction (8° versus 1.9°). There was no difference in SRS-Schwab Classification modifier (PI-LL or PT) between groups at any time point. ACR saw significantly less blood loss (EBL: 1.6L versus 3.6L; $p < 0.007$) but no difference found in overall complication rates (41.2% versus 47.1%).

Conclusion: ACR appears to achieve similar radiographic results as PSO in a propensity matched multi-center study with significantly less EBL and equal complication profile. While ACR has more PT correction, PSO patients have more trunk correction (T1SP). The lack of difference in TPA suggests equal spinopelvic correction and the difference is likely postural.

		Preop	3-Month	2-Year
PI	ACR	60	59	61
	PSO	63	63	63
PT	ACR	34	24	25
	PSO	31	27	28
LL	ACR	-16	-45	-51
	PSO	-21	-47	-47
T1SPi	ACR	1.4	-0.4	-2.3
	PSO	4.3	-3.6	-3.8
TPA	ACR	36	23	23
	PSO	35	24	24

146. Apical Short-Segment Correction in Adolescent Idiopathic Scoliosis: A Multi-Center Study of a New Innovative Posterior Technique

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Czech Republic

Summary: A new posterior correction technique has been developed and used in 20 patients.

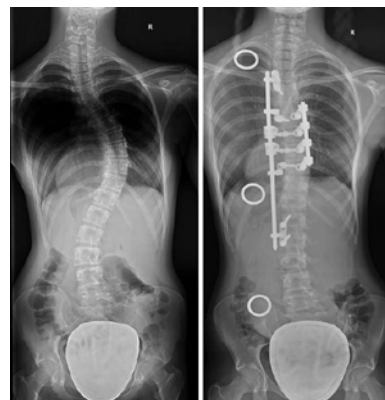
Introduction: Posterior instrumentation with fusion is the most common surgical treatment used for severe adolescent idiopathic scoliosis (AIS). A posterior correction system that requires less fusion would present an advance compared to current techniques. We report early results from a multi-center clinical study of a new technology that employs apical short-segment correction and requires minimal fusion.

Methods: AIS patients with Lenke type 1A or 1B curves and a Cobb angle between 40-80° were included. The surgical skill set required did not differ from that of a trained scoliosis surgeon. The technology corrects and stabilizes spinal deformity by combining segmental translation and derotation of the apical region with the rigidity of pedicle screw and rod systems. Apical correction was accomplished utilizing proprietary transverse couplers at the apex and pivoting connectors at select vertebrae proximal and distal to the apex. Once satisfactory correction was achieved, the corrected apical region was held in place with locking

connectors. A stabilizing rod spanned the entire length of the instrumented region, but only select levels were stabilized to promote fusion.

Results: Twenty female patients across 4 sites underwent the surgery without operative complications. Average age was 14Y,1M ($\pm 1Y,7M$). A mean of 10.5(± 9.6) levels were stabilized. Only 5.0(± 0.4) levels were fused representing 47.8%($\pm 6.1\%$) of the stabilized region. Cobb angle improved from 56.0(± 8.7)° pre-op to 17.4(± 6.4)° post-op resulting in a 68%($\pm 12\%$) improvement.

Conclusion: This effective, innovative and novel posterior technique for the treatment of severe scoliosis requires fewer implants and a reduced number of fusion levels, while demonstrating deformity correction that is comparable to standard methods. Longer follow-up is required to determine if these results are sustainable. The early results of this multi-center study demonstrate deformity correction similar to traditional methods. However, less fusion is required presenting a potential for enhanced mobility.



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).

147. Does Minimally Invasive Posterior Instrumentation (PPI) Prevent Proximal Junctional Kyphosis (PJK) in Adult Spinal Deformity (ASD) Surgery? A Prospectively Acquired Propensity Matched Cohort Analysis

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USA

Summary: PJK remains a significant problem in adult deformity surgery. Soft tissue trauma likely plays a role in development of PJK. The use of MIS pedicle screws has been theorized to be protective. In this propensity matched cohort

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analysis the use of MIS pedicle screws was protective with PJK incidence of 0% versus 19.4% among open posterior surgery at one-year post op. cMIS was able to maintain sagittal alignment at 1 year and HYB able to correct the sagittal plane deformity.

Introduction: Proximal junctional kyphosis (PJK) is an unwanted complication of ASD surgery. Multiple theories exist why PJK occurs. One potential contributor is damage to the paraspinal musculature and intervertebral stabilizers frequently disrupted during exposure and screw placement. This study aims to investigate the effect of PPI versus Open screw placement on PJK development.

Methods: 280 pts in 2 prospective databases (MIS n=85; OPEN n=195) were retrospectively reviewed, divided in 2 separate approaches and propensity matched for pelvic incidence - lumbar lordosis (PI-LL) and change of LL. Inclusion criteria: age >45, Cobb >20°, min 1 yr Follow-Up. Groups defined as: 1) cMIS-lateral interbody fusion (LIF) with PPI (n= 31) and 2) Hybrid (HYB)- LIF followed by open posterior instrumentation (n=31). PJK was defined as Proximal junctional angle (PJA) >10° and change post op >10°.

Results: A mean of 4.1 levels were fused (range 2-6). The mean age was 64 years and mean BMI was 26.1. Mean follow-up was 27.5 months. There was no preop difference between groups for LL-PI or SVA. Both groups showed significant improvement in LL (cMIS: 33°-41°; HYB: 35°-44°; p<0.001) and PI-LL (cMIS: 19.7°-12.4°; HYB: 19.6°-7.4°) and significant difference in PT. SVA remained physiologic for cMIS (29-26mm) and improved in HYB (54-31 mm; p=0.024). The cMIS group had a smaller change in PJA (+1.3°) than HYB (+6°) (p=0.005). PJK developed in 19.4% of HYB patients and 0% in cMIS (p<0.01). One patient in the Hybrid group required vertebroplasty for PJK. Both groups saw significant improvement in ODI (cMIS 39 to 20.1; HYB 46.7 to 30; p<0.001).

Conclusion: The addition of PPI seems to have a protective effect on the development of PJK. The analysis controlled for preoperative sagittal alignment as well as for correction of PI-LL. HYB was effective in restoring sagittal global alignment and cMIS in maintaining it.

148. Muscular Volume and Fat Infiltration Parameters of the Spino-Pelvic Complex Correlate with HRQOL and Skeletal Malalignment in Adult Spinal Deformity

Bertrand Moal, MS; Nicolas Bronsard, MD, PhD; Jamie S. Terran, BS; Jose G. Raya; Themistocles S. Protopsaltis, MD; Jean-Marc Vital; Wafa Skalli, PhD; Frank J. Schwab, MD; Virginie Lafage, PhD
USA

Summary: Typically, only skeletal parameters are used to evaluate adult spinal deformity. Understanding the impact of the muscular system on deformity would greatly enhance diagnosis and treatment in this patient population. Based upon analysis of muscle volume and fat infiltration we have identified several muscle components found to relate to disability and radiographic deformity.

Introduction: Spinal pathologies are mostly analyzed only by skeletal parameters.

Understanding of the muscular system is limited but may aid in optimizing diagnosis and treatment of adult spinal deformity (ASD). The purpose of this study was to offer qualitative and quantitative analysis of trunk, pelvic and proximal lower extremity musculature in ASD patients

Methods: Consecutive female ASD patients (n=19, mean age 60) had MRI (3 T, Magnetom Verio, Siemens Healthcare): T1-weighted TSE sequence for three points Dixon method with imaging from proximal tibia up to T12 vertebra. 3D reconstruction permitted evaluation between muscle volume (MV), and contractile tissue volume (CTV) and contractile ratio (CTV/MV). Height/weight and full free-standing radiographs of the spine/pelvis were obtained, and questionnaires completed (ODI, SRS-23).

Results: No correlation was found between the MV total and age or BMI; CTV correlated with age (r=-0.670) and BMI (r=-0.467). CTV of Erector Spinae correlated only with the age (r=-0.516). Difference in MV and CTV distributions revealed that muscular degeneration impacted more spinal erector. On average the contractile ratio was 81%±8, with significantly smaller ratio for Spinal and Hip Erector (55%). Mismatch in the muscle contractility of hip flexors vs extensors correlated with ODI (r=0.489), SRS Pain (r=0.490). Increased Pelvic Tilt (PT) correlated with loss in MV of entire muscle system (r=0.46), decreased CTV in spinae erectae (r=0.54). SVA correlated with lower extremities contractile ratio, and fat infiltration in spinae erectae (r=0.501).

Conclusion: As a general rule, CTV was negatively correlated with age and BMI, but the large variability in fat infiltration reveals specificity of spinae erectae. The ratio in contractile components of hip flexors/extensor is tied to disability. Increased PT is associated with decrease in contractile component of spinae erectae, and decrease fat component spine flexors. Evaluation of the quality and proportion of the spino-pelvic muscular system may change the way we evaluate our ASD patients beyond skeletal radiographic parameters.

149. Clinical Results and Functional Outcome of Revision Surgery for Symptomatic Proximal Junctional Kyphosis in Adult Spinal Deformity

Haruki Funao, MD; Floreana Naef, MD; Khaled Kebaish, MD
USA

Summary: We reviewed the outcome of revision surgery for symptomatic proximal junctional kyphosis (PJK). The incidence of recurrence PJK (rePJK) was 30.4%. Statistically significant risk factors for rePJK were: larger initial proximal kyphotic angle (PKA), larger preoperative thoracic kyphosis (TK), larger preoperative SVA, greater TK and the amount of SVA correction. All SRS22 domains and ODI were significantly improved in both rePJK and non-rePJK groups. However, there were no significant differences in clinical outcomes between the two groups.

Introduction: The majority of patients with PJK are not symptomatic, however, some patients show progressive change and develop symptoms, and may require revision surgery. To date, the outcome of revision surgery for symptomatic PJK has

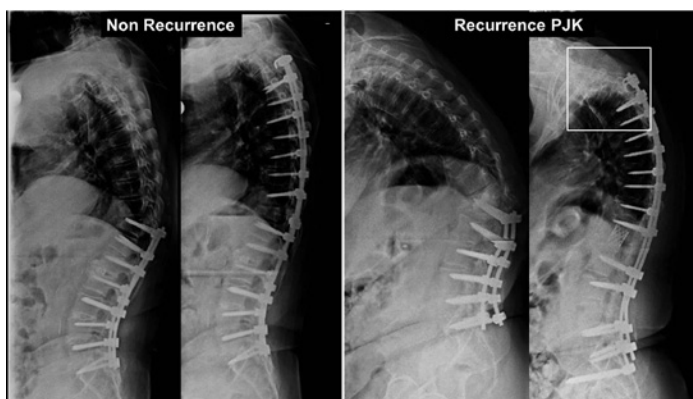
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not been well reported.

Methods: A retrospective review from a prospectively collected database was performed, and a total of 46 patients who underwent surgery for symptomatic PJK met study inclusion criteria. Radiographic/clinical assessment was conducted with an average 38.7 months follow-up. Statistical analyses were performed using Student t test and χ^2 test.

Results: Mean age at surgery was 62.4 years. 31 were females, 91.3% had multiple co-morbidities. Pedicle subtraction osteotomy was performed in 28, vertebral column resection in 8 patients. The incidence of rePJK was 30.4%. There were significant differences in (non-rePJK/rePJK group) : initial PKA (27.3/35.1°) ($p<0.05$), pre TK (37.9/54.2°), pre-post TK (8.1/17.9°), pre SVA (9.0/15.6cm), and pre-post SVA (5.6/11.6cm) ($p<0.01$). There were no significant differences in coronal major, lumbar lordosis, and pelvic incidence. Statistically significant risk factors for rePJK were: initial PKA ($>40^\circ$) ($p<0.05$), pre TK ($>60^\circ$), pre SVA (>10.0 cm), post TK decrease ($>15^\circ$) and SVA decrease (>5.0 cm) ($p<0.01$). There were no significant differences in age, sex, proximal construct, fusion to sacrum, BMI, and BMD. All SRS22 domains were significantly improved (pre/final, non-rePJK versus rePJK); activity (2.9/3.7 vs 2.7/3.9), pain (2.5/3.2 vs 2.4/3.2), self-image (2.5/3.2 vs 2.7/3.4), mental (2.5/3.5 vs 2.9/3.5), and satisfaction (2.6/3.8 vs 3.0/3.9) ($p<0.001$). ODI also showed a significant decrease (67.4/41.7 vs 67.0/42.2) ($p<0.001$). However, there were no significant differences in clinical outcomes between the two groups. 8 patients required reoperation; rePJK (3), screw back out (1), pseudoarthrosis (1), broken rod (1), residual deformity (1), sacral fracture (1). There were one transient neurologic deficit and one wound dehiscence.

Conclusion: The incidence of rePJK was 30.4%. Larger initial PKA, pre TK, and pre SVA, and greater TK and SVA decrease were considered risk factors for rePJK. There were no significant differences in clinical outcomes between rePJK and non-rePJK groups.



150. Clinical Results and Functional Outcome of Revision Surgery for Distal Junctional Kyphosis in Adult Spinal Deformity Patients

Haruki Funao, MD; Floreana Naef, MD; Khaled Kebaish, MD USA

Summary: We reviewed the outcome of surgical treatment for distal junctional kyphosis (DJK) in adult deformity surgery. We define a new anatomical spinopelvic parameter, named lumbo-coccygeal angle (LCoA). This can be an alternative measurement of the lumbo-sacral alignment. Corrective osteotomies were performed in all patients with significant improvement in lumbar lordosis, LCoA, and SVA at postoperative and final follow-up. All SRS 22 domains and ODI were significantly improved. However, patients who remained sagittally imbalanced showed worse outcome.

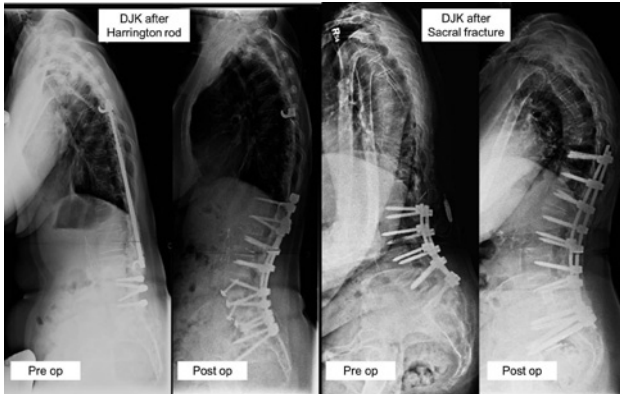
Introduction: DJK can occur as a complication of long spinal fusion. It may be associated with significant pain, deformity and may require surgical treatment. To our knowledge, there is only few reports on the outcome of surgical treatment for this problem.

Methods: A retrospective review from a prospectively collected database was performed. Inclusion criteria were: patient that developed DJK following long spinal fusion and had the following criteria; intractable pain at the lumbo-sacral area, sagittal imbalance (SVA >5.0 cm), and LCoA less than 10° . LCoA was defined as the angle between the inferior endplate of T12, and the perpendicular line connecting the posterior endplates of S4-S5. A total of 35 patients met study inclusion criteria. Radiographic/clinical assessment was conducted with an average 36.9 months follow-up. Statistical analysis was performed using Student t test.

Results: Mean age at surgery was 55.7 years (31 -76). 29 were females, 91.4% had multiple co-morbidities. Pedicle subtraction osteotomy was performed in 22 patients, vertebral column resection in 4 patients. 34 patients were fused to the pelvis. Mean radiographic changes were (pre/post/final); thoracic major (23.8/21.5/22.6°), lumbar major (29.6/21.2/22.0°), thoracic kyphosis (26.3/28.9/31.7°), lumbar lordosis (15.6/45.0/43.2°), LCoA (-18.2/14.2/12.1°), and SVA (17.3/3.8/4.8cm). There was significant improvement in lumbar lordosis, LCoA, and SVA at postoperative and final follow-up ($p<0.001$). All SRS 22 domains were significantly improved (pre/final); activity (2.9/3.8), pain (2.4/3.8), self-image (2.7/3.5), mental (2.7/3.6), and satisfaction (2.8/3.7) ($p<0.001$). ODI also showed a significant decrease (64.0/40.5) ($p<0.001$). However, patients who remained sagittally imbalanced (SVA >5.0 cm) had higher ODI (46.6versus38.5) ($p<0.05$), and tended to have lower SRS22 satisfaction (3.3versus3.8) ($p=0.06$). Reoperation was performed on 6 patients; PJK (2), pseudoarthrosis (2), junctional stenosis (1), neurologic deficit (1). There were two transient neurologic deficits and one deep infection.

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Conclusion: Revision surgery for DJK significantly improved both radiographic and clinical outcomes. However, patients who remained sagittally imbalanced had a significantly worse outcome.



151. Does Pelvic Fixation Decrease the Incidence of Pseudoarthrosis and Proximal Junctional Kyphosis (PJK) in Long Fusion Constructs? Long-Term Follow-Up of 139 Adult Patients

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USA

Summary: Compared to sacral fixation, pelvic fixation in long fusion constructs decreases the rate of revision surgery and PJK but increases risk of lumbar pseudoarthrosis and painful hardware.

Introduction: Adult scoliosis surgery is a complex procedure with high complication rates and need for revision surgery. Pseudoarthrosis, PJK, and painful hardware are possible complications after long fusion constructs. Distal fixation options include the sacrum or the pelvis. Prior studies demonstrate a high rate of pseudoarthrosis with fixation to sacrum. It is unclear if pelvic fixation confers any advantage in long fusion constructs.

Methods: 101 patients with long fusion constructs (min >5segments) to the pelvis and 38 patients with long fusion constructs to the sacrum were included in the study. The incidence of pseudoarthrosis, sagittal imbalance, painful hardware, and revision surgery were measured for the two groups.

Results: There were 101 patients with long fusion constructs to the pelvis. 66 of these patients (ave age 58 yrs) did not require revision surgery (ave length of construct 10.2 levels; ave f/u 3.6 yrs). 39 patients (ave age 54.8) required revision surgery (ave length 9.92, ave f/u 5 yrs). Average time to revision surgery was 2.16 years. Reasons for revision included pseudoarthrosis (18/39), PJK (8/39), and painful hardware (12/39). 11 of the 18 nonunion occurred in the upper lumbar spine (L1-4). There were 38 patients with long fusion constructs

to the sacrum. Of this group, 20 patients (ave age 58y) did not undergo revision surgery (ave length 8.9, ave f/u 5.9 yrs). 18 patients (ave age 58.9y) underwent revision surgery (ave length 10.3, ave f/u 7.3yrs). Average time to revision surgery was 3.62 yrs. Reasons for revision included pseudoarthrosis (6/18), PJK (7/18), painful hardware (4/18), and one fracture (1/18). In each group, length of construct, the presence of osteotomy (SPO or PSO) or use of interbody device at L4-5 and L5-S1 did not have a significant effect on the rate of complication or need for revision surgery.

Conclusion: In long fusion constructs, fixation to the pelvis had overall decreased rate of revision (38.6 vs 47%, p=0.31) compared to fixation to the sacrum. There was decreased risk of sagittal decompensation (20.5 vs 38.8%) with pelvic fixation. However, there was a higher rate of pseudoarthrosis (46 vs 33%) and painful hardware (30.7 vs 22%) necessitating revision surgery in the pelvic fixation group.

152. Extension of Spine Fusion to the Sacrum Following Long Fusions for Deformity Correction

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USA

Summary: Patients (pts) undergoing extension of long fusions to the sacrum were found to have significant improvements in Oswestry Disability Index (ODI) and Scoliosis Research Society (SRS) scores and sagittal alignment. However, mean sagittal alignment worsened from 1 to 5 yrs post-operative (PO) and only ODI and SRS appearance scores exceeded minimal clinically important difference (MCID) threshold values after 5 yrs.

Introduction: Long spine fusions ending in the lumbar spine may be complicated by distal degeneration requiring extension to the sacrum. The outcomes following such revision remain unknown.

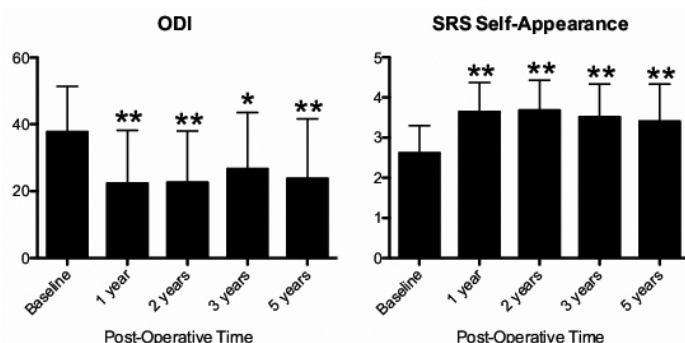
Methods: Pts who had extension of a long fusion (>5 levels) to the sacrum between 2002-2007 at a single institution were analyzed. ODI and SRS scores and/or radiographic parameters were assessed at baseline, 6 wks and 1, 2, 3, and/or 5 yrs PO. Complications were assessed at each clinical visit. We hypothesized that pts would have significant early improvement with some deterioration by 5 yrs PO.

Results: There were 74 pts included with a mean age of 49 yrs (range 19-76 yrs), mean clinical follow-up time of 4.4 yrs (range 2 mo-10 yrs), and 81% (n=60) with follow-up greater than 2 yrs. The mean time between the original fusion and subsequent extension to the sacrum was 22 yrs (range 6 mo-52 yrs). All had distal segment degeneration and 72% (n=53) had fixed sagittal imbalance. Sacropelvic fixation was used in all cases, interbody fusion in 85% (n=63), and an osteotomy in 41% (SPO: 20%, n=15; PSO: 14%, n=10; both: 7%, n=5). Sagittal alignment improved at all PO time points from baseline (mean 78mm), but worsened between 1 (mean 21mm) and 5 yrs (mean 42mm,

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p=0.02). Complications occurred in 53% (n=39), with the most common being temporary radiculopathy (15%, n=11), iliac screw prominence (12%, n=9), and nonunion (10%, n=7). Two-thirds of nonunions occurred above L5-S1. There were 17 reoperations in 15 patients (20%), the most common cause for which was nonunion (8%, n=6; additional 2%, n=1 considering surgery). Improvements (p<0.05) in ODI and all SRS domain scores were found at each time point. Scores between 1 and 5 yrs were similar, but after 5 yrs only the ODI and SRS appearance domain reached MCID thresholds (Figure 1). Mean outcomes at 5 yrs PO were similar in groups with complications (ODI: 25; SRS: 3.3) vs without (ODI: 22, p=0.8; SRS: 3.3, p=1.0) and with reoperation (ODI: 25; SRS: 3.3) vs without (ODI: 23, p=0.5; SRS: 3.4, p=0.4).

Conclusion: Extension of long fusions to the sacrum resulted in significant and sustained improvements in ODI and SRS scores and alignment compared to baseline, despite some deterioration in sagittal alignment observed by 5 yrs.



Extension of long fusions to the sacrum resulted in significant improvements in ODI and SRS self-appearance scores (*p<0.05, **p<0.05 and difference from baseline>MCID).

153. Improving Local and Regional Lordosis in Degenerative Scoliosis: Preliminary Findings on the Effect of an Expandable TLIF Cage

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Summary: Ninety-eight crescent shaped hydraulic expandable TLIF cages (FDA approved for TLIF) were used to improve segmental and regional lumbar lordosis in 45 patients with degenerative lumbar scoliosis. Cages were expanded up to 6mm beyond insertion height of the cage. Radiographic analysis showed improvement of 8.5mm in disc height, 8.3 degrees in segmental lordosis, and 22 degrees in regional lordosis. There were no cage-related complications, and early clinical results showed significant improvements in VAS and ODI compared to preop scores.

Introduction: Previous studies have shown expanding TLIF cages (EC) have the potential to improve both segmental and regional lordosis when compared to

static height cages in patients undergoing fusion for degenerative disease. This is the first report of EC effect on sagittal parameters in patients with degenerative lumbar scoliosis (DLS) undergoing arthrodesis, with early clinical and radiographic outcomes and complications.

Methods: 45 consecutive adults undergoing primary or revision spinal arthrodesis for DLS augmented with TLIF at average 1.8 levels using a new hydraulic EC at 4 centers. Age averaged 64 years(40-80years); Number of TLIF levels: one- 7, two- 23, three- 15. Posterior instrumented fusions averaged 6.6 levels(2-16 levels). Technique: EC were placed front and center in the disc space, expanded up to 6mm above insertion height to improve cage fit and fill within the disc. Cage expansion assisted in distracting the anterior interspace and acting as a fulcrum to increase segmental lordosis when combined with posterior compression instrumentation, with or without Smith-Petersen osteotomies. Backfill bonegraft was used in the disc space at all TLIF levels.

Results: All sagittal parameters improved(P<0.01). TLIF anterior disc height: Preop- 6.7mm(0-14), 1 year- 15.2mm(10-20). Segmental Lordosis(degrees): Pre-op- 4.9°, 1 year- 13.2°(4-30°). Regional lordosis(L1-S1): Preop- 27.8°(8-50°), 1 year- 49.8°(36-62°). Two patients remained in global imbalance>5mm. Early complications: neuro deficit-0, loss of cage expansion height - 0. Revision surgery was required in 2 for unrelated adjacent level fractures in the thoracolumbar spine in deformity patients. For 15 patients with more than 1 year follow-up, improvement was noted in VAS: pre- 6.1, 1 year- 2.9; ODI scores improved: preop- 47.5 (P<0.05), 1 year - 25.0(P<0.05).

Conclusion: This study demonstrates the ability to improve lumbar lordosis with a new, crescent shaped hydraulic cage in patients undergoing surgery for degenerative scoliosis. Early clinical outcomes are favorable in these patients and there have been no adverse cage related events in this study population.

154. Validation of the Fusion Risk Score: Predictor for the 90 Day Perioperative Complication Rate

Kedar Deogaonkar, MD, FRCS; Amir A. Mehbod, MD; Ensor E. Transfeldt, MD USA

Summary: In our institute, we have previously devised the 'Fusion Risk Score' from multivariate analysis of the patient co-morbidities and magnitude of thoracolumbar fusion surgery. The fusion risk score (patient score + procedure score) has been shown to be highly predictive of perioperative complications in the 90 days after surgery.

We then used this score for an independent cohort of 131 patients and validated that the score is highly predictive of perioperative complications.

Introduction: Thoracolumbar fusion surgery for degenerative conditions is on the rise due to numerous factors. The patients are often elderly with multiple comorbidities. The magnitude of surgery performed for the same condition can vary a lot depending on the surgeon's philosophy, amongst other factors. Patient reported outcome measures often give no indication of the patient or procedure factors which influence it.

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Methods: The fusion risk score was formulated after a review of data from 364 patients undergoing fusion surgery. We collected data to ascertain if the 'Fusion Risk Score' accurately predicts the morbidity in a new cohort of 131 patients from the year 2010.

Results: The fusion risk score provided a reliable way of classifying patients into low (score 1-3), medium (score 4-9) and high risk (score 10-20) groups. This risk stratification was highly predictive of the perioperative morbidity. The score correlated with rate of major complications, blood loss, surgical time and stay in ICU; along with other accepted criteria of perioperative morbidity.

Conclusion: Fusion risk score is easy to calculate.

It accurately predicts occurrence of perioperative complications.

It identifies the high risk group of patients with a greater than 50% chance of getting major complications.

It can be used as a tool to tailor the extent of surgery.

It can provide an indicator of the complexity of the procedure and hence has financial and resource implications.

155. Clinical Decision Making in Early Wound Drainage After Pediatric Spine Surgery

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USA

Summary: This study evaluated the incidence and characteristics of early wound drainage after posterior spine surgery in pediatric patients. Early drainage in idiopathic deformity (within 10 days) tended to be non-infected and delayed drainage (after 10 days) in especially neuromuscular patients proved to be mostly infected.

Introduction: Wound drainage in the early post-operative period may be a challenge. Our aim was to identify the factors suggestive of non-infected drainage to help clinical decision making.

Methods: Our spine surgery database was searched to identify the cases that presented with drainage from the surgical wound in the early post-operative period between January 2000 and October 2012.

Results: We identified 905 cases of index posterior instrumentation procedures between 2000 and 2012, with 2 months or more clinical follow-up. 42 patients (4.6%) were taken back to the OR for drainage in the early post-operative period (within 6 weeks). All patients were operated on by opening all layers, irrigation and debridement. Intraoperative cultures were sent in all cases. 29 patients proved to have non-infected drainage and did not require further treatment. In 13 patients infection was confirmed with intraoperative findings and cultures. These patients were treated with serial debridements and antibiotic course. In 3 cases implants had to be removed after multiple debridements. The group with non-infected drainage differed from the infection group in that the majority of the patients (24/29) had non-neuromuscular deformities whereas 77% of the infected group has neuromuscular etiology (10/13) ($p=0.0004$). At the index

procedure, in the non-infected group, 12 (41%) of the 29 patients had drains, in the infected group 7 (54%) patients had drains. Drain use did not have a significant effect on the outcome ($p=0.5$). Average day to revision was 9 days (range 5-30 days) for the non-infected group. 25 of the 29 patients presented in the first 10 days. In the infected group average day to revision was 19; ten of the 13 patients presented at the post-operative day 14 or later. Logistic regression analysis showed a significant association between increased likelihood of infection and increased time from the index procedure ($p=0.0085$, coefficient=0.2).

Conclusion: The findings suggest that early presenting drainage in pediatric idiopathic spine deformity is mostly not infected. Drainage, especially presenting after the second post-operative week in NM patients proved to be mostly infections. Subcutaneous drain use at the index surgery did not correlate with infection.

156. Neurologic Risks Associated with Treating Myelopathy due to Severe Spinal Deformity with Vertebral Column Resection

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USA

Summary: 16 patients presented with myelopathy due to severe spinal deformity and were treated with pVCR for both spinal cord decompression and deformity correction. 13 patients (82%) stabilized or improved while 3 (18%) experienced postop neurological worsening. Preop spinal cord tenting/compression predicted neurological improvement, but no factor predicted deterioration.

Introduction: Posterior vertebral column resection (pVCR) is a technique reserved for severe spinal deformities. Rarely, such deformities produce apical spinal cord compression or tenting that causes myelopathy. There are no reports of neuromonitoring (NM) reliability or postop neurological status (NS) in these high-risk patients undergoing pVCR for both neural decompression and deformity correction.

Methods: 16 pts (11 females/5 males) with mean age of 15 yrs \pm 10 presented with myelopathy due to severe spinal deformity and were treated with pVCR (6 primary/10 revision, median 2 level resection, range 1-3), by one surgeon from 2000-2012. All patients presented with myelopathy and 88% (14/16 pts) had overt weakness or sensory deficit. NM was used in all cases. Preop MRIs in 10 pts exhibited cord compression in 80% (n=8), T2 signal change in 60% (n=6), and a syrinx in 30% (n=3). NS obtained preop and <2 weeks postop were compared to stratify patients as: (1) improved, (2) unchanged, or (3) deteriorated.

Results: Mean correction of the major coronal Cobb was 56 \pm 22 $^{\circ}$ (range 0-108 $^{\circ}$, $p<0.01$), while major sagittal was improved by 52 \pm 34 $^{\circ}$ (range 6-92 $^{\circ}$, $p<0.01$). NM was unable to capture all modalities in 56% (9/16). There were 5 (31%) true positive, 1 (6%) false positive, and 1 false negative NM readings. NS improved postop in 7 pts (44%), was unchanged in 6 (38%), and worsened

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in 3 (18%). The 3 noted to have postop paraplegia (all 3 revisions, mean preop Cobb was 54°, mean sagittal Cobb was 108°). Preop cord compression was associated with neurological improvement after surgery ($p=0.042$). Preop T2 signal change ($p=0.5$), deformity correction ($p=0.7$), age ($p=0.3$), revision status ($p=0.32$), number of VCR levels ($p=0.23$), and NMDifficulty ($p=1$) were not associated with postop NS.

Conclusion: Patients with myelopathy due to severe spinal deformity are extremely challenging to treat and NMD data is often unobtainable or unreliable. Although 82% of patients were neurologically stabilized or improved postop, 18% awoke with paraplegia. Cord compression predicted neurological improvement after VCR though no factor predicted deterioration.

157. Perioperative Morbidity and Mortality in High Risk Pediatric Patients with Severe Restrictive Lung Disease Undergoing Posterior-Only Spine Deformity Surgery

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Summary: Of 66 pediatric patients with severe RLD who underwent PSF, 51.5% remained intubated an average 3 days, averaged 4.9 days in ICU and 13.7 days hospitalized. Nine patients (13.6%) experienced 16 respiratory complications including 2 tracheostomies, but there were no deaths. Patients were divided into groups (PFTs 31-40% predicted vs $\leq 30\%$ and surgery with thoracoplasty/VCR vs without). Surgery involving the chest wall increased hospitalization, while patients with PFTs $\leq 30\%$ predicted were more likely to remain intubated with increased ICU stay.

Introduction: Pediatric pts. with severe spinal deformity and restrictive lung disease (RLD) are considered high-risk for pulmonary morbidity and mortality following surgery. The purpose of this study was to evaluate the periop respiratory complications in pts. with severe RLD (PFTs $\leq 40\%$ predicted) undergoing a posterior spine fusion (PSF).

Methods: We evaluated the hospital course of 66 consecutive pediatric pts. with an ave. age of 13.6 yrs (range 6.5-20.4) at one institution who underwent a PSF and had preop PFTs (FVC, FEV1) $\leq 40\%$ predicted. Diagnoses were (23 (35%) idiopathic, 19 (29%) neuromuscular, 12 (18%) syndromic, and 12 (18%) congenital). The mean max. Cobb angle was 102° (range 70-180°), ave. preop FVC was 33% predicted and ave. preop FEV1 was 32.6% predicted. Pts. were divided into 2 groups: PFTs $\leq 30\%$ predicted ($n=23$) vs 31-40% predicted ($n=43$) and those with surgery involving the chest wall (thoracoplasty, VCR, $n=32$) vs not involving the chest wall ($n=34$).

Results: 51.5% (34/66) pts. remained intubated after surgery for an ave. of 3 days (range 0.5-14). The ave. ICU stay was 4.9 days (range 1-54), and hospital stay was 13.7 days (range 5-98). 9 pts. (13.6%) had 16 periop respiratory complications (7 pneumonias, 4 re-intubations, 3 chest tube insertions, and 2 tracheostomies) but there were no mortalities. Pts. whose surgery involved

the chest wall (thoracoplasty, VCR) had a longer hospital stay (17.2 vs 9.9 days, $p=0.038$) than pts. without chest wall surgery. However, there were no differences between those 2 groups regarding intubation after surgery (20 vs 14 pts., $p=0.09$), length of intubation (2.95 vs 2.82 days, $p=0.91$), ICU stay (5.1 vs 3.4 days, $p=0.17$), or respiratory complications (9 vs 7, $p=0.42$). Pts. with PFTs $\leq 30\%$ predicted were more likely to remain intubated after surgery (16/23 vs 18/43 pts., $p=0.04$) and spend more time in the ICU (7.4 vs 3.7 days, $p=0.05$) than pts. with PFTs 31-40% predicted.

Conclusion: Overall morbidity (13.6% complications) and mortality (0%) in high-risk pediatric pts. with PFTs $< 40\%$ predicted who underwent a PSF was surprisingly low; however, VCR pts. (inc. hospital stay) and pts. with PFTs $\leq 30\%$ predicted (inc. remaining intubated after surgery, and ICU stay) had higher morbidity.

158. Venous Thromboembolic Events in Spine Surgery Patients: Which Patients are High Risk?

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Summary: This study used a large national database to report on the epidemiology of venous thromboembolic events after spinal fusions, as well as to analyze the patient and procedure specific risk factors for post-operative VTEs. A novel VTE Risk Index that identifies patients at high risk of postoperative VTE was created based on this data.

Introduction: Postoperative venous thromboembolic events (VTEs), which include pulmonary embolisms (PEs) and deep venous thrombosis (DVTs), are important potentially preventable causes of death. Evidence is lacking regarding which patients are at highest risk of developing postoperative VTEs. This study aims to investigate the patient determined and procedure determined risk factors for VTE occurrence in patients undergoing spinal surgery.

Methods: Using the National Inpatient Sample (NIS) database from 2001 through 2010 patients undergoing spinal fusions and occurrence of symptomatic VTE were identified via corresponding ICD-9 procedure and diagnosis codes. Univariate analysis of patient and hospital demographics, comorbidities, and post-operative complications was used to compare the VTE and non-VTE groups. Independent risk factors for VTE were identified via multivariate logistic regression.

Results: A total of 755,082 spinal fusion procedures were identified. The NIS dataset contained 2,234 DVTs (0.30%) and 1,870 PEs (0.25%), for a total of 4,104 (0.54%) VTEs in 3,831 patients. Patients that had a VTE were on average older (58.98 years for VTE, 53.53 years for no VTE, $p<.01$), more often women than men (VTE incidence in women 0.60%, men 0.4%, $p<.01$), black (white patients .48%, black .78%, $p<.01$), insured with Medicare or Medicaid (.77% Medicare, .71% Medicaid, .38% private insurance, $p<.01$), and had a higher comorbidity burden (Charlson index 1.27 versus 0.37, $p<.01$). Post-operative VTE was associated with longer hospital stays (18.7 days versus 4.09). VTE

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increased the total hospital costs (\$207,182 versus \$68,029, $p < .01$). The results of the logistic regression models were used to construct a VTE Risk Index (table 1), a score of 4 or above qualifies a patient as high risk.

Conclusion: A number of comorbidities and procedure related factors were identified as independent risk factors for VTE. Based on the independent risk factors identified we constructed a VTE Risk Index for postoperative VTE. In conjunction with current guidelines this data can be used to guide clinical decision-making regarding VTE prophylaxis in patients undergoing spine surgery.

159. Wound Complications of VEPTTR Incisions

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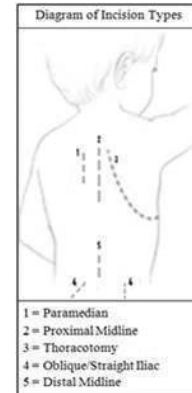
Summary: The overall incidence of infection in patients with >4 VEPTTR lengthening encompassing 9 sites in North America was 24% (25/103 patients). There was no difference in site of infection comparing the various incisions locations (proximal paramedian, proximal midline, thoracotomy, distal midline, and iliac). Presence of prior surgical incisions was not a risk factor for infection. Surgeons should utilize the most appropriate incision in relation to their patient's pathology when using VEPTTR while remaining vigilant for development of infection.

Introduction: VEPTTR surgery requires multiple incisions that are used repetitively. Our purpose was to compare the incidence of infection between the various incision types and determine if the infection risk increases in relation to previous incisions and/or increased number of times incisions are opened.

Methods: A prospective database (7 sites) and institutional database (2 sites), were queried to identify their 20 most recent VEPTTR patients with a minimum of 4 expansions for inclusion. A total of 103 patients were identified. Clinical and operative reports were retrospectively reviewed to determine incision sites, number, and infection complications.

Results: 25/103 patients (24%) developed an infection during treatment. Six had multiple infections (range 2-4), providing a total of 34 infection events. There was no difference in infection rate between participating institutions. Patients averaged 6.4 expansion procedures and 13 total incisions. The most common infecting organism was Staph aureus (59%), but 20% did not grow an organism. Infection rate at each incision site was not significantly different, ranging from 1-5%: paramedian (6 infections/23 patients with total 185 incisions, 3%), proximal midline (12/39; 224, 5%), thoracotomy (6/61; 455, 1%), iliac (5/37; 143, 4%), and distal midline (5/58; 148, 3%). Infection events occurred after an average of 3.0 incisions [95% CI: 2.2 -3.8]. There was a trend towards higher infection rate with increased number of times a particular incision was opened. There was no increased infection rate in patients with history of surgical incisions prior to VEPTTR (26%; 6/23) compared to those patients not having prior incisions (24%; 19/80). Magnitude of coronal plane deformity did not differ between infection and non-infection groups.

Conclusion: The overall incidence of infection in patients with >4 VEPTTR lengthening was 24% and did not differ across the various incision types. Presence of prior surgical incisions was not a risk factor for infection. Surgeons should utilize the most appropriate incision in relation to their patient's pathology when using VEPTTR while remaining vigilant for development of infection.



160. Role of Weekly Administered Teriparatide in Bony Union Enhancement After Posterior Lumbar Interbody Fusion for Osteoporosis-Associated Lumbar Degenerative Deformity: A Prospective, Randomized Multi-Center Study

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Summary: Weekly administration of teriparatide may promote bony fusion after PLIF and show favorable surgical outcome postoperatively.

Introduction: In accordance with increased population of advanced age, surgical indication for lumbar degenerative diseases such as lumbar degenerative deformity is also increased. Lumbar instrumented spinal fusion is widely used to stabilize to provide better physiological alignment. However, to achieve a solid fusion is sometimes difficult in the aged patients due to poorer bone quality and less bone available for harvest. A recent study showed that teriparatide administration significantly enhanced spinal fusion in rats (Spine 2012). Therefore, we examined radiological change and clinical scores for assessing the role of weekly teriparatide before and after PLIF.

Methods: This study comprised thirty patients from 3 university hospitals. The patients were female and older than 50 years, had a young adult mean score of <80% or had previous spinal compression or femoral fractures, and had lumbar degenerative deformity. The patients had a surgical indication of a single-level PLIF; however, multilevel surgeries were indicated for adequate decompression. Each case was submitted to the central office and randomly distributed into 2 groups: 1 in which teriparatide was subcutaneously administered after once a week after postoperative week 1 for 6 months, and the other in which no teriparatide was administered. Bony union was diagnosed using x-ray and 3D computed tomography scans at 2, 4, and 6 months postoperatively.

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Results: Compared with the non-teriparatide group, the teriparatide group scans commonly showed fusion with remodeling and presence of trabeculae or showed intact grafts that were incompletely remodeled and incorporated but did not show lucency. In addition, the teriparatide group showed favorable outcome evaluated by ODI and JOABPEQ postoperatively.

Conclusion: Previous study to determine accurate fusion rate of a PEEK cage in PLIF with three deminsional CT scan showed 90.0% segmental fusion rate at 12 months after surgery respectively. Thus accurate assessment of the complete fusion of local bone in PLIF was recommended at 12 months postoperatively (Spine J 2011). Thus, weekly teriparatide treatment may promote bony fusion after PLIF.

161. Re-Operation Rates in the Surgical Treatment of Metastatic Spinal Cord Compression

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United Kingdom

Summary: The re-operation rate was 11.5% in our patients treated surgically for MSCC over a 7 year period. The most common cause was infection [13/28 (46.4%)] that occurred within 2 weeks of the primary surgery. Failure of instrumentation occurred mostly at junctional levels at approximately 1 year.

Introduction: Emergency surgical treatment in MSCC has been shown to improve function and neurological outcome. Unplanned hospital readmissions can be costly and cause unnecessary harm. Our aim was to analyse the re-operation rate in MSCC from an academic tertiary spinal institute.

Methods: We reviewed all patients treated surgically from our comprehensive database. All data was collected retrospectively from October 2004-October 2009, then prospectively from October 2009-October 2011 (7 years). We reviewed all patient records held on the database, including patient demographics and re-operation rates.

Results: During the 7 year study period, there were 302 patients who underwent emergency surgery for MSCC. Of these, 243 patients were included who had complete information available. There were 28 re-operations performed (11.5%; mean age 60.2 years; 13 M, 15 F). The re-operation was performed in the same admission in the majority of patients (21), while 7 patients had their second procedure in subsequent hospitalisation. The re-operations were due to infection [13/28, (5.3%)], local recurrence [5/28, (2%)], failure of instrumentation [5/28, (2%)], haematoma evacuation [2/28, (0.8%)], re-fracture of other vertebral levels [2/28, (0.7%)], wrong level [1/28, (0.3%)]. Failure of instrumentation occurred mostly at junctional levels- cervicothoracic or thoracolumbar regions.

Conclusion: There was a modest re-operation rate (11.5%) in our patients treated surgically for MSCC over a 7 year period. Most of these were for infection [13/28 (46.4%)] and occurred within 2 weeks of the primary surgery whilst

failure of instrumentation occurred mostly at junctional levels (approximately 1 year stage). This study may help to assist with (informed) decision making for this vulnerable patient group.

162. Suitability of Stand-Alone ALIF as Replacement for Supplemental Posterior Fixation in Long Fusion Constructs

Jeremi M. Leasure, MSME; Morsi Khashan, MD; William Camisa, MSME; Hooman M. Melamed, MD; Sigurd H. Berven, MD
USA

Summary: Testing ALIF cages reduce strain on sacral screws comparably to bilateral iliac fixation by using a validated in-situ biomechanical model.

Introduction: Long fusions to the sacrum generate high stresses on the sacral screws that may lead to loosening or pseudarthrosis. Techniques to reduce strain on the sacral screws on the S1 screws are anterior column support with ALIF or TLIF and iliac fixation. However, stand-alone ALIF cages, may serve to reduce the need for pelvic fixation. We hypothesized that in long L1-S1 fusion, ALIF cages reduce strain on S1 screws comparably to bilateral iliac fixation.

Methods: 7 lumbo-pelvic human cadavers were used. Each was driven under a load-controlled pure moment up to 7.5 Nm in order to measure range of motion. Pedicle and iliac screws were deployed into each prior to biomechanical testing. S1 pedicle screws were instrumented with strain gauges used to measure pullout force during testing. Posterior fixation including bilateral L1-S1, bilateral L1-S1 with uni-lateral iliac screw, and bilateral L1-S1 with bilateral iliac screw was used. These constructs were tested with and without the presence of an ALIF cage at L5-S1.

Results: ALIF cages did not reduce L5-S1 ROM and iliac screws produced statistically significant decreases in ROM as compared to intact. Bilateral L1-S1 hardware reduced F/E ROM from an intact value of 6.7 +/- 4.2 deg to 3.1 +/- 1.3 deg. The addition of an ALIF cage resulted in 3.3 +/- 1.2 deg F/E ROM which is not statistically significantly different from w/o ALIF. Fixation with uni- and bi-lateral iliac screws decreased F/E ROM to 1.2 +/- 1.2 deg and 0.6 +/- 0.6 deg, respectively. L1-S1 posterior hardware did not decrease LB ROM compared to intact. ALIF cages during F/E significantly increased loads on the S1 screws compared to uni- and bi-lateral iliac constructs which tended to decrease loading. Only the addition of bi-lateral iliac screws lowered S1 loads compared to the L1-S1 construct.

Conclusion: The addition of an ALIF cage to bilateral L1-S1 fusions did not increase stability or reduce mechanical loading on S1 screws compared to iliac fixation. ALIF inclusion without iliac fixation may increase risk of S1 hardware purchase and does not stabilize the column. Alternatively, iliac fixation reduces S1 screw strain and increases construct stability; yet, clinical outcomes suggest this approach lacks anterior column support.

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163. The Effect of Sagittal Alignment on Standing Balance: Correlation with Sway Path Length and Sway Velocity

Sergio A. Mendoza-Lattes, MD; Monica Paliwal; Christopher Graves, MD, MS; Bethany Harpole, BS; Rachel C. Nash, BS
USA

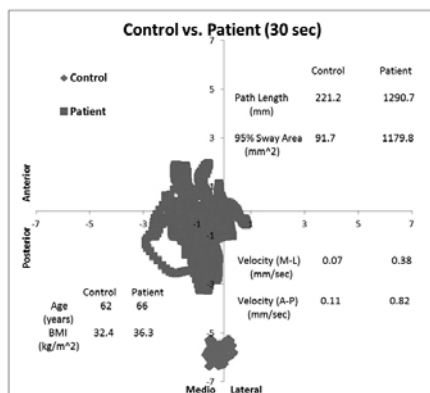
Summary: The center of gravity (COG) of 92 patients with scoliosis was measured. Scoliosis patients with SVA ≥ 10 cm had a significantly higher sway path length and sway velocity than those with SVA < 10 cm, reflecting increasing difficulty in standing balance.

Introduction: Sagittal imbalance correlates with impaired function and pain. The purpose of this study is to examine standing balance in patients with scoliosis and varying degrees of sagittal alignment.

Methods: Prospective case-control (Type II): 92 patients with spinal deformity (age=59 \pm 1; BMI= 28 \pm 7) were divided into 3 groups- I: SVA=0-4cm; II: SVA=5-9cm; III: SVA ≥ 10 cm; and compared with 23 non-scoliotic individuals "controls" (age=28 \pm 3; BMI=23 \pm 5). Subjects were asked to stand on a Wii BalanceBoard for 30s with their knees locked in extension, arms resting on the sides of the body. The COG was measured and the sway path length, velocity and 95% sway area were calculated (MATLAB); Turkey's HSD and Games-Howell multiple-comparison's tests; values expressed as mean and 95% CI.

Results: Group III patients had a significantly longer sway path length than groups II and I (65.6cm (47.2 to 84.1) versus 40.4 (34.3 to 46.4) and 35.4cm (30.3 to 40.6), p=0.001), as well as controls (figure 1). Similarly, group III had a significantly faster sway velocity (65.6cm/s (47.2 to 84.1) versus 40.4cm/s (34.3 to 46.4) and 35.4cm/s (30.3 to 40.6), p=0.001).

Conclusion: The sway path length and velocity is significantly increased in patients with sagittal imbalance (SVA ≥ 10 cm), reflecting increased difficulty in standing balance with spinal deformity.



164. Global Tilt: A New Sagittal Plane Parameter Combining Spinal Balance and Pelvic Compensatory Mechanisms

Ibrahim Obeid; Virginie Lafage, PhD; Ahmet Alanay; Jean M. Vital; Olivier Gille; Anouar Bourghli, MD
USA

Summary: We describe a new parameter; the global tilt angle (GT), the angle between the line drawn from the center of C7 to the center of sacral endplate and a line drawn from the center of sacral endplate to the center of the femoral head. Thirty-one consecutive pts with severe sagittal plane deformities. In both preop and postop x-rays, GT was highly correlated to LL gap and this correlation was more significant than the correlation of pelvic tilt and SVA with LL gap.

Introduction: Despite the close interaction between the spinal balance (SVA, C7 tilt, T1 tilt) and pelvic compensatory mechanisms (PI, PT, SS), no single parameter combines both. We describe a new parameter; the global tilt angle (GT), the angle between the line drawn from the center of C7 to the center of sacral endplate and a line drawn from the center of sacral endplate to the center of the femoral head (figure 1). From a geometrical point of view, GT equals the sum of the pelvic tilt and the spinal tilt angle, GT = PT + ST. The aim is to introduce the new parameter and analyze its correlation with lumbar lordosis gap (LL gap).

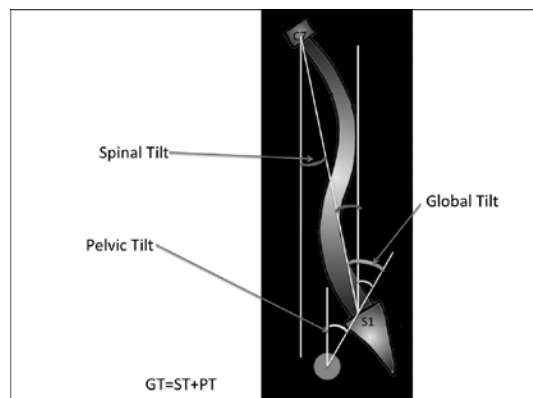
Methods: Thirty-one consecutive pts with severe sagittal plane deformities due to lumbar hypolordosis and operated by pedicle subtraction osteotomy were included. Etiologies were degenerative (n=12), posttraumatic (n=4) and iatrogenic (n=15). All patients had pre and post-operative EOS standing sagittal x-rays. Pelvic parameters (PT, PI, SS), sagittal balance parameters (SVA, T1 tilt), GT and lordosis gap ((PI+9)-Lumbar lordosis) were measured by using EOS software. Correlation (spearman rank order) analysis was pursued to determine correlation between radiographic parameters and LL Gap.

Results: (Table 1) In both preop and postop x-rays, GT was highly correlated to LL gap and this correlation was more significant than the correlation of pelvic tilt and SVA with LL gap. All patients had abnormal GT ($>25^\circ$) preoperatively while 3 patients had normal PT ($<20^\circ$) and 3 other patients had normal SVA (<4 mm). In postop x-rays, all patients with LL gap $>10^\circ$ were associated to a GT of $>20^\circ$ except for 2 and all patients with GT of $>20^\circ$ was correlated to a LL gap $>10^\circ$ except for 3.

Conclusion: GT provides more accurate information on sagittal imbalance compared to PT and SVA. This is explained by the fact that GT angle assess simultaneously the global spinal alignment and the compensatory pelvic

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parameters together. GT as a single parameter is a useful method to analyse the global spinopelvic alignment and obviates the need to use SVA and PT.



165. Revision Rate Following Thoracolumbar Fusion for Adult Deformity: Upper Versus Lower Thoracic UIV

Prokopis Annis, MD; Brandon Lawrence, MD; Michael D. Daubs, MD; Darrel S. Brodke, MD

USA

Summary: Revision rates for adult deformity surgery were assessed by location of the upper-instrumented vertebrae (UIV). Patients with the UIV in the upper thoracic spine (UT) had similar rates of revision as those with in the lower thoracic (LT) spine. UT revisions were due to non-unions while LT revisions were for proximal junctional failure.

Introduction: Complication rates are relatively high in adult deformity surgery. While nonunion appears to be the most common complication overall leading to revision surgery, early revisions may be required more often after proximal junctional failure (PJF). It has been suggested that the rate of PJF may vary based on the level of the upper-instrumented vertebrae (UIV). The purpose of this study was to review and compare early and late revision rates of fusions with UIV in the upper (UT) or lower thoracic (LT) spine.

Methods: We reviewed 110 consecutive patients, with mean age 61 years (19-82) and mean follow-up 39 months (24-103), treated operatively for deformity at a single institution. Early revision rates (return to the operative room within 12 months) and late revision rates (return by final follow up) were calculated. Patients were divided into 2 cohorts, those with fusion to the UT spine (T1-T5) and LT spine (T7-T12).

Results: At the final follow-up there was a trend for higher revision rate in the UT group (43%) as compared with the LT (26%) ($p=0.07$). There was no difference in the early revision rates between the two groups. Proximal junctional failure (PJF) for the LT (14%) ($p=0.03$) and nonunion for the UT (8%) ($p=0.01$) group were the most common causes of early revision surgery. Late revision rates for nonunion were significantly higher in the UT group ($p=0.003$).

Conclusion: Adult deformity surgery has a relatively high complication rate with

revisions commonly required due to PJF or nonunion. The complication profile varied based on the location of the UIV. While revision for PJF was significantly lower in those fused to the upper thoracic spine (0%), the nonunion rate require revision was significantly higher (36%) negating any perceived benefit of the longer fusion.

166. Short-Term Mortality and Morbidity after Surgical Treatment of Fixed Spinal Deformities. Two-Years Experience in 102 Adult Patients

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Denmark

Summary: In a one-center prospective study the short-term mortality after surgical treatment of fixed spinal deformities was 1.2 % and permanent motor deficit was seen in two patients. This confirms that posterior osteotomy carries an acceptable level of short-term mortality and morbidity in a high-volume center.

Introduction: During the last decade increasing evidence suggests that improved sagittal balance is of major importance to obtain improved health related quality of life in the surgical treatment of adult spinal deformities. In patients with fixed deformities, the two primary surgical techniques used are pedicle subtraction osteotomy (PSO) and vertebral column resection (VCR). Due to the surgical demands of these techniques, assessment of mortality and morbidity associated with these procedures is of relevance.

Methods: In a prospective cohort study, all complications in adult patients (> 17 years of age) undergoing posterior correction of fixed spinal deformities in the thoracolumbar region from February 1st 2010 through January 31st 2012 were included. Patients were excluded if they had undergone previous posterior instrumentation on more than five levels for a degenerative condition. Also, patients with previous malignant, infectious or traumatic conditions of the spine were excluded. All relevant information regarding surgical procedure and perioperative complications were registered, and the neurologic condition was assessed at the one-year follow-up. Intraoperative neuromonitoring was used in all cases. Survival status was obtained through the National Health Service. The study was approved by the National Data Protection Agency.

Results: A total of 102 patients were operated with a mean age of 61 at the time of surgery (range 19 - 86). 52 were men and 50 women. A median number of 10 levels were instrumented with pedicle screws (range 5 - 17). 81 % of the patients underwent PSO and 19% VCR. The 30-day mortality was 1.2% and the primary complication was dura lesion (16%). Two patients (2 %) had permanent neurological deficit corresponding to 1 ASIA motor grade deterioration and four patients (4 %) patients had persisting sensory deficits.

Conclusion: This prospective one-center study confirms recent national database reports suggesting that surgical treatment of fixed spinal deformities carries a relatively low risk of short-term mortality and severe neurological complications.

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167. Adult Spinal Deformity (ASD) Patients have Distinct Baseline Characteristics based on Idiopathic Versus Degenerative Scoliosis Types

Han Jo Kim, MD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Frank J. Schwab, MD; Virginia Lafage, PhD; Vedat Deviren, MD; Justin S. Smith, MD, PhD; Matthew E. Cunningham, MD, PhD; Shay Bess, MD; Richard Hostin, MD; Khaled Kebaish, MD; Christopher P. Ames, MD; International Spine Study Group USA

Summary: ASD pts are different based on having a diagnosis of idiopathic (IS) vs degenerative scoliosis (DS). Specifically, DS patients experience more back and leg pain which translated into worse baseline SRS and ODI scores compared to patients with IS.

Introduction: No studies have delineated the differences between patients with adult IS and DS. The purpose of this study was to compare those patients with either diagnosis with respect to demographics, curve magnitude, pain presentation, operative details and outcomes.

Methods: A prospective database of ASD pts was reviewed. Operative pts with a diagnosis of adult DS or IS were included. Revisions and pts with insufficient data were excluded. Age, BMI, Charlson Comorbidity Index (CCI), OR details, radiographic measurements, back and leg pain quantification via numeric rating scale (NRS), Oswestry Disability Index (ODI) and SRS Outcome Scores were collected.

Results: Of the 357 pts in the prospective operative database, 187 pts underwent primary surgery and 161 of them had sufficient data for inclusion into the study. There were 54 pts with a diagnosis of adult DS and 107 with Adult IS. The average age, BMI and CCI was larger in Group DS (Table 1).

No significant differences were noted in operative details (Table 1), except for a higher number of decompressions and three column osteotomies performed in DS. (79%vs46%; $p<0.01$, 25%vs7%; $p=0.02$) However, patients with IS had deformities of greater magnitude evidenced by a larger pre-op thoracic and thoracolumbar scoliosis (Table 1).

In addition, DS patients had significantly more back pain and leg pain compared to IS patients (Table 1). Although both groups improved with respect to the NRS back and leg pain scores, the amount of improvement seen with operative intervention was seen more in DS as well. With respect to SRS Outcomes, DS patients also demonstrated lower baseline SRS Activity, Pain and Appearance subscores and higher ODIs, however, these outcome measures equalized with surgery. (Table 1)

Conclusion: Adult IS and DS patients appear to be different patient subsets in the ASD population. Patients with Adult DS are older and have more back and leg pain at baseline compared to their IS counterparts. Both groups demonstrated good outcomes with operative intervention.

168. Long-Term Radiographic Outcomes of a Central Hook-Rod Construct for Osteotomy Closure: Minimum 5-Year Follow-Up

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Summary: Fifty-six cases of fixed sagittal imbalance were evaluated for the effectiveness of a central hook-rod construct utilized to close various spinal osteotomies. We found no fixation failure of the central hook-rod construct and no pseudarthrosis at the osteotomy site at a minimum 5-year follow-up and recommend this as a primary means of posterior osteotomy closure.

Introduction: All techniques used to close an osteotomy add premature stress on spinal fixation points and may lead to loosening and eventual fixation failure. Our purpose was to evaluate the long-term effectiveness of a central hook-rod construct for posterior closure of various spinal osteotomies.

Methods: 56 consecutive pts with fixed sagittal imbalance were treated with either multilevel Smith-Petersen osteotomies (SPOs, N=19), pedicle subtraction osteotomy (PSO, N=31) or vertebral column resection (VCR, N=6). All 56 pts had osteotomy closure utilizing a central compression hook-rod construct and were analyzed at min 5yr F/U. Compression hooks were inserted into the fusion mass above and below the osteotomy and centrally attached to a short rod then connected to pedicle screw-based rods via a crosslink. Diagnoses included 39 various types of scoliosis, 14 degenerative sagittal imbalance, 2 ankylosing spondylitis. There were 55 revisions and 1 primary. Radiographic and clinical analysis was performed to evaluate the efficacy and possible complications of this technique.

Results: Overall, lumbar lordosis increased an average of 31.7° (range $10-65^\circ$), local lordosis through the osteotomy site increased an average of 29.3° (range $11-57^\circ$). The C7 sagittal plumbline improved an average of 92mm (range 12-237mm). In all cases, osteotomy closures were performed without screw loosening or correction loss occurring intraoperatively. At min 5yr radiographic F/U, there were no hook-rod construct failures seen, but there were asymptomatic partial rod breakage in 3 (5.3%) pts in the pedicle screw-based rods, but NO symptomatic pseudarthrosis at the osteotomy site. However, 4 (7.1%) pts did develop pseudarthrosis below the construct. One patient underwent partial implant removal at 6 yrs postop due to prominence.

Conclusion: A central hook-rod construct is a safe, controlled and effective method for applying compressive forces to close posteriorly various types of osteotomies without fixation failure or pseudarthrosis at the osteotomy site noted at min 5yr F/U. It not only adds fixation strength to the overall construct but also avoids placement of undue stress on pedicle screws that can lead to screw loosening and potential fixation failure.

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169. Is There a Patient Profile that Characterizes a Patient as a Candidate for Minimally Invasive Surgery (MIS) to Treat Adult Spinal Deformity (ASD)?

Robert K. Eastlack, MD; Gregory M. Mundis, MD; Michael Y. Wang, MD; Praveen V. Mummaneni, MD; Juan S. Uribe, MD; David O. Okonkwo, MD, PhD; Behrooz A. Akbarnia, MD; Neel Anand, MD; Adam S. Kanter, MD; Paul Park, MD; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Richard G. Fessler, MD, PhD; Vedat Deviren, MD; International Spine Study Group
USA

Summary: Recent advances in technology have allowed patients to be treated for adult spinal deformity with minimally invasive techniques. Our analysis aimed to identify baseline patient characteristics of both open and MIS techniques. MIS patients were found to be older than OPEN, and they had significantly less sagittal and coronal deformity.

Introduction: Corrective surgery for adult spinal deformity (ASD) has been shown to result in improvement in radiographic parameters and clinical outcomes, and has been accomplished with traditional open (OPEN) and minimally invasive (MIS) techniques. The goal of this study was to evaluate the baseline characteristics of patients undergoing traditional open or minimally invasive surgery for ASD.

Methods: Retrospective review of two prospectively collected databases of adult spinal deformity patients, one of OPEN procedures and the other of MIS procedures. Inclusion criteria included age > 45yrs, Cobb angle minimum of 20° and minimum 1 year follow-up. Preoperative radiographic parameters were reviewed including, major coronal Cobb, sagittal vertical axis (SVA), lumbar lordosis (LL), pelvic incidence (PI). Preoperative disability was measured with Oswestry Disability Index (ODI), and numerical rating scale (NRS) values. Independent T-test and chi square analysis was used to compare groups.

Results: 164 patients, 118 OPEN patients and 46 MIS patients met inclusion criteria. OPEN patients were significantly younger than MIS (60.6y vs 64.05y, $p=0.022$). Both groups were over 80% F and similar BMIs. Preoperative Lumbar Cobb was significantly higher for OPEN (42.8°) than MIS (32.4°, $p=0.0001$). Preoperative SVA averaged 5.8cm for OPEN and 3.4cm for MIS ($p=0.030$). LL averaged 41.1° and 34.4° for OPEN and MIS respectively ($p=0.033$). PI-LL was 13.6 (OPEN) and 21.4 (MIS) ($p=0.014$). Preoperative ODI was similar between groups 41.4 in OPEN and 42.7 in MIS. NRS for back pain was 7.03 in the OPEN group and 6.38 in the MIS group preoperatively.

Conclusion: Patients suitable for MIS ASD surgery seem to follow a specific patient profile. They are younger, have less sagittal plane deformity and smaller lumbar Cobb. Patients with SVA <5 cm, and a moderate coronal deformity may be candidates for MIS approaches to ASD as long as the principles of deformity surgery are adhered to. Disability as measured by baseline ODI and VAS showed no difference between the groups.

170. Reoperation Rate after Surgery for Lumbar Herniated Intervertebral Disc Disease: Nationwide Cohort Study

Chi Heon Kim, MD, PhD; Chun Kee Chung, MD, PhD
Republic of Korea

Summary: A retrospective, population-based, cohort study using national health insurance data was performed. The reoperation rate after surgery for lumbar HIVD was 5.4% at 3 months, 7.4% at 1 year, and 13.4% at 5 years. Except for laminectomy, reoperation rates of the other lumbar surgeries were not different from that of open discectomy.

Introduction: HIVD is the most common cause of lumbar spinal surgery. Despite improved surgical techniques and instrumentation, reoperation cannot be avoided. Reoperation rates range from 6% to 24% in previous studies. A population-based study is less subject to bias; hence, a nation-wide longitudinal analysis was warranted. For that purpose, we performed Retrospective cohort study using national health insurance data to provide a longitudinal reoperation rate after surgery for lumbar herniated intervertebral disc disease (HIVD), and to compare reoperation rates among surgical methods.

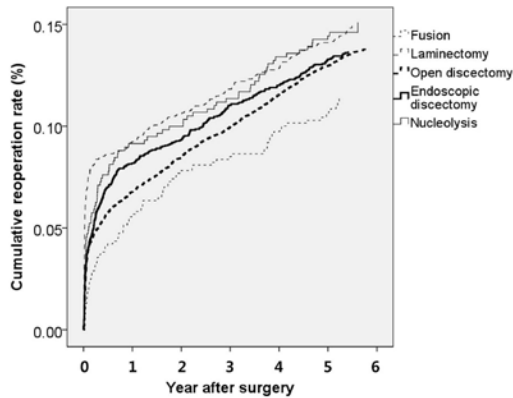
Methods: A national health insurance database was used to identify a cohort of patients who underwent first-surgery for HIVD in 2003 and 18,590 patients were selected. Individual patients were followed for at least 5 years through their encrypted unique resident registration number. The primary end-point was any type of second lumbar surgery. After adjusting for confounding factors, five surgical methods (fusion, laminectomy, open discectomy, endoscopic discectomy, and nucleolysis [including mechanical nucleus decompression]) were compared. Open discectomy was used as the reference method.

Results: Open discectomy was the most common procedure (68.9%) followed by endoscopic discectomy (16.1%), laminectomy (7.9%), fusion (3.9%), and nucleolysis (3.2%). The cumulative reoperation rate was 5.4% at 3 months, 7.4% at 1 year, 9% at 2 years, 10.5% at 3 years, 12.1% at 4 years, and 13.4% at 5 years. The reoperation rates were 18.6%, 14.7%, 13.8%, 12.4%, and 11.8% after laminectomy, nucleolysis, open discectomy, endoscopic discectomy, and fusion, respectively. Compared to open discectomy, the reoperation rate was higher after laminectomy at 3 months, while rates were similar among the other surgical methods.

Conclusion: The cumulative reoperation rate after 5 years was 13.4% and half of the reoperations occurred during the first postoperative year. With the exception of

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laminectomy, the reoperation rates of the other procedures were not different from that of open discectomy.



Adjusted cumulative reoperation rate among surgical methods during the entire follow-up period. The reoperation rate increased markedly during the first postoperative year. The adjusted reoperation rates were not statistically different over the entire follow-up period.

171. Bending the Cost Curve in Spinal Surgery

Melissa Esparza; Sigurd H. Berven, MD; Serena S. Hu, MD; Todd J. Lansford, MD USA

Summary: The purpose of this article is to introduce the concept of economic evaluation of new technologies as a factor to guide an evidence-based approach for their adoption.

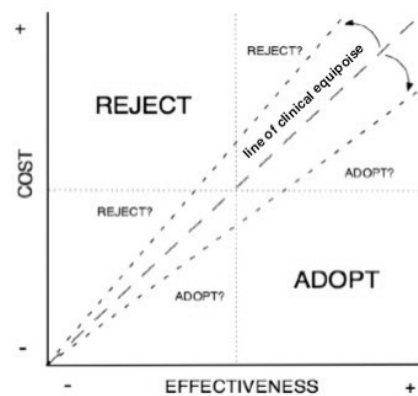
Introduction: The widespread use of new technologies is a primary driver of the increasing rates of spending in spinal care. Bending the cost curve in spinal surgery may be achieved through a value-based approach to the adoption of new technologies.

Methods: The literature was reviewed for cost-utility analysis studies of four technologies in spinal care: 1) circumferential fusion versus posterolateral fusion for severe, chronic low back pain; 2) total disc replacement (TDR) versus arthrodesis for single level cervical degenerative disc disease (DDD); 3) bone morphogenetic protein (BMP) versus autograft in posterolateral lumbar spinal fusions; and 4) percutaneous vertebroplasty (PVP) in osteoporotic vertebral compression fractures.

Results: Sustaining technologies are innovations that optimize value by improving outcomes or reducing cost over time. Cost-utility analyses show circumferential fusion and TDR to be cost-effective technologies. Circumferential fusion was dominant over a posterolateral approach with an incremental savings of US \$49,306 per QALY. TDR with ProDisc-C had a positive incremental cost-effectiveness over ACDF in cervical DDD. Conflicting evidence exists for the cost-effectiveness of BMP in posterolateral fusions and PVP for osteoporotic vertebral fractures. A Markov model using 2-year outcomes in patients over age

60 reported a cost of \$39,967 for rhBMP-2/ACS compared to \$42,286 for autograft due to reduction in complications and need for revision surgery. This incremental advantage was not apparent at five years. Short-term cost-effectiveness of PVP in osteoporotic vertebral fractures has been reported but studies showing no significant difference in clinical outcomes compared to a sham procedure suggest it is not a cost-effective technology.

Conclusion: The adoption of new technologies in spine surgery should be guided by evidence showing that the technology adds value to our health care system by significantly improving outcomes or decreasing costs.



Cost-effectiveness of new technologies: Interventions in the bottom right quadrant are value-adding. Those in the upper left are value-destroying. Adoption of technologies in the remaining areas is less clear - the line of clinical equipoise represents the amount a society is willing to pay for an incremental gain. 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).

172. Hemivertebra Resection Via Posterior Approach in Children Under Age of Five Years with More Than Five Years Follow-Up

Sinan Kahraman; Meric Enercan; Gurkan Gumussuyu, MD; Bekir Y. Uçar, MD; Cagatay Ozturk, MD; Azmi Hamzaoglu, MD Turkey

Summary: Hemivertebra resection via posterior approach and short segment transpedicular instrumentation is safe and effective in children under age of five years.

Introduction: In this retrospective study, we evaluated the radiological and clinical outcomes of patients under age of five years having posterior resection of hemivertebra and pedicle screw to correct and stabilize the deformity.

Methods: 15 patients between 2-5 years having posterior hemivertebrectomy and transpedicular fixation for congenital deformities who had more than 5 years F/U were reviewed. The surgical technique includes posterior resection of hemivertebra

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with upper and lower disc spaces followed by short segment instrumentation. Compression is applied on the convex side. After gaining sufficient correction, gap is filled with titanium mesh cage. After surgery, patients were immobilized in a hip spica cast for 6 months and in a brace for 6 months more. Radiological and clinical charts were evaluated in terms of correction in coronal and sagittal plane deformity, balance and complications.

Results: Mean follow-up was 6.7 years (range; 5 to 11). Average age of patients (5 male and 10 female) was 3.1 years (2-5). Fifteen patients had 18 hemivertebra levels. Two hemivertebrae were ipsilateral consequent (2 patients) and two were distant from each other in one patient. Ten levels were scoliotic deformities with 33 degrees (range: 23 - 47), 8 levels were kyphoscoliotic deformities [mean scoliosis 29.4 degrees (range: 21 - 41)], [kyphosis 30.3 degrees (7 - 56)]. In 3 patients, two-level hemivertebra were present. Nine hemivertebrae were located in thoracic spine (T3-T11), 3 in thoracolumbar spine (T12-L1) and 6 in lumbar spine (L2-L5). There is no statistical difference between early postoperative and last follow-up coronal and sagittal plane deformities. The coronal plane deformity improved to 3.8 degrees (88%) and was 4.6 degrees at final follow-up in scoliotic levels. The coronal and sagittal plane deformities were found 2.7 degrees (91%) and 2.8 degrees (91%) respectively in kyphoscoliotic levels. They were 3.5 degrees and 3.6 degrees at final follow-up. Pseudoarthrosis or implant failure was not detected.

Conclusion: Hemivertebra resection via posterior approach and short segment transpedicular instrumentation is safe and effective in children under age of five years with more than five years follow-up.

173. Safety and Efficacy of Osteotomy for Congenital Spinal Deformity Associated with Split Spinal Cord Malformation

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China

Summary: 18 female and 11 male patients formed the basis of the study. The mean follow-up period was 24 months. After exposure of the determined levels and placement of instruments, the osteotomy was done directly in all patients, the level of osteotomy was above the bony spur in the patients of type I; posterior fusion surgery was performed in all patients. The mean major coronal curves were corrected from an average of 66.5 o to 24.4 o with a correction rate of 63.3%. The complication was transient, including 2 patients of cerebrospinal fluid leakage and 4 cases broken of pedicle screw, and there was no neurological compromise. The neurological status of seven patients who had TCS was improved in 4 patients and unchanged in the other patients. The osteotomy for CSD associated with SSCM may provide a satisfactory option to effectively improve the spinal deformity without significant complications and without the necessity of the resection of bony spur in the Type I SSCM.

Introduction: The aim of this study is to retrospectively evaluate the safety and efficacy of osteotomy for 29 consecutive patients, who had progressive congenital spinal deformity (CSD) associated with split spinal cord malformation (SSCM).

Methods: 18 female and 11 male patients formed the basis of the study. The mean age was 13 years and the mean follow-up period was 24 months. There were type I SSCM in 4 patients, type II in 22 patients and composite type in 3. Seven patients had tethered cord syndrome (TCS) with progressive neurologic deteriorations preoperatively. Patients had one stage surgery, after exposure of the determined levels and placement of instruments, the osteotomy was done directly in all patients and was composed of hemivertebrae resection, pedicle subtraction osteotomy (PSO) and vertebral column resection (VCR) (the level of osteotomy was above the bony spur in the patients of type I); after the corrective stage of surgery, posterior fusion surgery was performed in all patients.

Results: The mean major coronal curves were corrected from an average of 66.5 o to 24.4 o with a correction rate of 63.3%. The complication was transient, including 2 patients of cerebrospinal fluid leakage and 4 cases broken of pedicle screw, and there was no neurological compromise. The neurological status of seven patients who had TCS was improved in 4 patients and unchanged in the other patients at latest follow-up. The average loss of correction at final follow-up was 3.5o for major curves.

Conclusion: The osteotomy for CSD associated with SSCM may provide a satisfactory option to effectively improve the spinal deformity without significant complications and without the necessity of the resection of bony spur in the Type I SSCM. Neurosurgical interventions aren't recommended to patients with SSCM. But it is an ongoing study and additional large multi-center studies are necessary to further assess the safety and efficacy.

174. Management of Thoracic Insufficiency Syndrome in Patients with Myelomeningocele Using Vertical Expandable Prosthetic Titanium Rib

Vishwas Patil, MD; William Koeck; Kent Reinker, MD; Davin Cordell, MD; Hope Trevino, AA; Megan K. Roth, PhD; James W. Simmons, DO, PhD; Robert M. Campbell, MD; Ajeya P. Joshi, MD

Summary: Patients with myelomeningocele were treated with Vertical Expandable Prosthetic Titanium Rib (VEPTR). Treatment outcomes were retrospectively reviewed. Patients displayed improvements in Cobb angle, pelvic obliquity, and space available for lung (SAL), and Assisted Ventilation Rate (AVR) remained stable in most cases. These results demonstrate the efficacy of VEPTR treatment in myelomeningocele.

Introduction: Treatment of spinal deformities in patients with myelomeningocele poses a challenging task due to the high complication rates. VEPTR is an effective treatment for patients with various spinal and thoracic deformities. Therefore, the objective of the current study was to analyze the medium term results of treatment of spinal and pelvic deformities in Myelomeningocele patients by VEPTR instrumentation.

Methods: A total of 22 myelomeningocele cases treated using VEPTR were retrospectively reviewed. Among them 14 patients met the inclusion criteria

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of at least 2 yr follow-up. Charts were reviewed for operative course, Assisted Ventilation Rate (AVR), and complications. Radiographs were measured for Cobb angle, SAL, pelvic obliquity, and thoracic and lumbar kyphosis/lordosis.

Results: Mean age at first implant was 5.3 years with 5.9 years follow-up. Cobb angle, usually measured from T1 to L3, was 74.9° pre-operatively and 47.9° at last follow-up ($p < 0.001$). In the subset of patients with pre-operative lumbar kyphosis, initial curve was 49.9° which improved to 26.8° ($p < 0.05$). Mean pelvic obliquity improved from 27.4° to 11.1° ($p < 0.001$). Mean SAL improved from 0.68 to 0.83 ($p < 0.01$). AVR remained stable or improved in all but one case. Complications included 4 superficial infections, 5 deep infections, 3 wound dehiscence, 2 device dislodgement and 9 asymptomatic device migrations. 1 patient died from respiratory failure unrelated to surgery.

Conclusion: VEPTR treatment is a useful technique for correction of pelvic, spinal and thoracic deformities in patients with Myelomeningocele without affecting the growth potential of the spine and thorax. Although complications were common from multiple surgeries, they were manageable.

175. What is the Anticipated U.S. Cost of Pedicle Screws Versus Luque Wire Instrumentation for Neuromuscular Scoliosis Surgery?

A. Noelle Larson, MD; Charles Gerald T. Ledonio, MD; David W. Polly, MD; Suken A. Shah, MD; Scott J. Luhmann, MD
USA

Summary: Our economic model for neuromuscular scoliosis fusion estimates that switching from a Luque wire to pedicle screw construct would increase cost by \$8,250-39,440 per patient (estimated \$8.8M to \$42.4M annual U.S. cost increase). Assuming decreased blood loss, length of stay, and pseudoarthrosis rate, pedicle screws become cost neutral only with a low density, low cost construct.

Introduction: Luque wire fixation is typically used for neuromuscular scoliosis surgery, but pedicle screws may have significant advantages. We developed an economic model to evaluate the cost of changing to a pedicle screw construct.

Methods: Descriptive analyses explored annual costs for inpatient stays associated with ICD-9-CM 737.39 (neuromuscular scoliosis) using discharge data from the 2009 KID-HCUP (AHRQ), a national all-payer pediatric database. Inpatient stays were assumed to represent T2-pelvis posterior fusion with no anterior procedures. We evaluated the relative cost of high and low density pedicle screw fixation (2.0 versus 1.0 screws per level fused) and Luque wire instrumentation.

An all-pedicle screw construct was assumed to shorten the length of stay (3 days/\$3600), decrease transfusion rates (3 units/\$3000), and eliminate revision for pseudoarthrosis (1.0-6.5% with Luque wires to 0% with pedicle screws).

A sensitivity analysis was performed by varying cost per screw (\$600-\$1200) and rate of pseudoarthrosis in the Luque wire cohort (1.0-6.5%). Cost of revision surgery averted was calculated in order to determine under what parameters

would a pedicle screw construct become cost neutral.

Results: Total annual costs for 1,079 hospital stays for neuromuscular scoliosis was \$65.6M (\$61,620 per patient).

Substituting a low density screw pattern for Luque wires would result in an additional \$8250 to \$20,240 in implant cost. However, an anticipated 11-70 pseudoarthrosis revision surgeries would be avoided annually (Table). Assuming a low density screw construct, low screw cost, and high pseudoarthrosis rate, the model becomes cost neutral if revision surgery for pseudoarthrosis costs greater than \$25,575 per patient. For a high density screw construct, high screw cost, and a high Luque wire pseudoarthrosis rate, the model only becomes cost neutral if revision surgery cost > \$1.3M per patient.

Conclusion: Assuming decreased LOS, pseudoarthrosis, and transfusion rates, switching from Luque wires to a low density/low cost pedicle screw construct may prove cost effective.

High density pedicle screw constructs sold at market rates would need to have significant treatment advantages in order to offset such an increase in payer cost.

176. Single Stage Internal Distraction for the Correction of Pelvic Obliquity

Jahangir Asghar, MD; Amer F. Samdani, MD; Harry L. Shufflebarger, MD; Burt Yaszay, MD; Paul D. Sponseller, MD
USA

Summary: Our study finds the use of single stage temporary internal distraction provides improved pelvic obliquity correction and coronal Cobb correction over traditional techniques.

Introduction: Traditional corrective maneuvers, typically, utilize a variation of cantilevering techniques for correction of pelvic obliquity. In 2006, Buchowski et al. described the use of internal distraction for the correction of rigid spinal deformities with good results. The purpose of this study is to compare the pelvic obliquity correction obtained utilizing temporary internal distraction versus traditional corrective techniques in patients with CP.

Methods: An IRB approved multi-institutional retrospective analysis was performed comparing radiographic outcomes with internal distraction (ID) versus other techniques (OT). A consecutive series of patients from January 2008 to December 2011 were reviewed ($n=19$). The minimum follow-up was 24 months (range-26-42 months). The OT data set was matched using pre-operative pelvic obliquity ($\pm 3^\circ$) and coronal Cobb ($\pm 10^\circ$) data set obtained from a multi-institutional database for cerebral palsy. A comparative analysis between the two groups was performed.

Results: A total of 38 patients were evaluated (ID-19, OT-19). The data sets were statistically similar ($p > 0.05$) for age, coronal Cobb and GMFCS scores. The mean pelvic obliquity for the ID group was 28.1° and the OT group 29.1°. In ID group, All 19 cases consisted of Iliac screw fixation. In the OT, there were 4 unit rods. The mean correction of pelvic obliquity was significantly higher in ID group (ID-75.1% vs OT-66.4%, $p=0.032$). The mean coronal Cobb correction was also

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significantly greater in the ID group (ID 74.2 vs 66.5%, $p=0.019$). There were 2 deep infections in both groups. One proximal hardware prominence in OT group. Neither group had significant neuro-monitoring changes. However, 4 patients in ID group and 3 in OT group had absent SSEP, MEPs, or both throughout case. There were no significant differences in EBL and operative times were observed.

Conclusion: In our matched cohort, the use of single stage internal distraction exhibited statistically greater pelvic obliquity correction and coronal Cobb correction compared with traditional techniques. No significant neuro-monitoring changes were observed, as has been reported in the literature with the use of internal distraction.

177. Hybrid Fixation with Sublaminar Polyester Bands in the Treatment of Neuromuscular Scoliosis: A Comparative Analysis

Michael C. Albert, MD; Brett LaFleur, MD

USA

Summary: The polyester band technique using a hybrid construct in the treatment of neuromuscular scoliosis (NMS) provides another tool for the spinal deformity surgeon. This technique is a superior sublaminar implant with low risk of neural damage and infection, along with easier and safer removal than wires. It is superb in correction of NMS and kyphosis and is an excellent choice in osteoporotic bone, achieving equivalent corrections to all pedicle screw constructs, and avoiding the potential complications associated with transpedicular fixation.

Introduction: Despite its advantages, Luque wiring was associated with implant failure and neurologic complications, particularly in patients with neuromuscular disorders. Pedicle screw constructs are the most widely utilized method of fixation. High rates of implant malposition have been reported. The adequacy of fixation in osteoporotic bone has been called into question by several studies. We report use of polyester bands as an alternative fixation method in the treatment of NMS

Methods: A retrospective review was conducted of 115 pediatric spinal deformity cases between 2008 and 2010 at a single center performed by a single surgeon. Intraoperative and postoperative complications were recorded. Radiographs were reviewed preoperatively, postoperatively, and at the latest follow-up visit. A literature review identified studies of patients with NMS treated with either isolated sublaminar fixation techniques or all-pedicle screw constructs. Pooled data from the two reference groups were then used in a comparative analysis with the present study.

Results: 29 patients underwent hybrid fixation with a combination pedicle screw and sublaminar band construct. Minimum follow-up was two years. Postoperative correction of coronal balance was 69%. Sagittal balance was corrected to within 2cm of the C7 plumbline in 97% of patients. The loss of coronal and sagittal correction at latest follow was 0% and 2% respectively. Two intraoperative clamp failures out of 398 implants (0.5%). There were two major (7%) and seven minor (24%) complications in eight patients (27% overall). A literature review identified 12 articles that met our inclusion criteria (7 sublaminar and 5

all-pedicle). There were 150 complications in 397 patients (38%) treated with sublaminar wires, cables or hooks. Average coronal correction was 49%. All pedicle screw fixation papers showed 71% coronal correction with a complication rate of 29%. Implant failure in the sublaminar group and pedicle groups occurred in 8% and 3% of cases respectively.

Conclusion: The polyester band technique appears to be safer than previously described sublaminar fixation methods, achieves corrections equivalent to all pedicle screw constructs, and avoids the potential complications associated with transpedicular fixation.

178. Biomechanical Analysis of the Proximal Adjacent Segment after Scoliosis Correction: Do Hooks Ease the Transition?

Melodie F. Metzger, PhD; Samuel T. Robinson, BS; Doniel Drazin, MD; Mark T. Svet; Rick B. Delamarter, MD; Frank L. Acosta, MD

USA

Summary: This in vitro cadaveric study analyzes the effect of posterior segmental construct stiffness on the stability of the proximal adjacent un-instrumented spine in a multilevel thoracic fusion. Results suggest a less rigid proximal fixation, such as hooks, reduces instability at the superior un-instrumented spine potentially reducing the rate of Proximal Junctional Kyphosis (PJK).

Introduction: The placement of hooks at the top of an all pedicle construct may reduce the rate of PJK by decreasing soft tissue disruption and construct rigidity at the segment adjacent to the proximal un-instrumented spine. The following biomechanical study analyzes biomechanical changes between placing bilateral hooks, bilateral pedicle screws, or a hybrid hook/screw construct at the top of a transpedicular thoracic fusion.

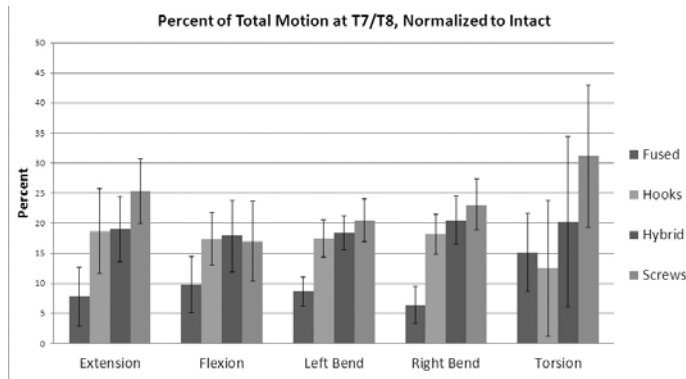
Methods: Human cadaveric thoracic spines (T7-T12) were nondestructively tested in flexion/extension, axial rotation, and lateral bending. Specimens were re-tested after bilateral transpedicular instrumentation from T9-T11 and again after "topping off" T8-T9 with the following: (1) bilateral pedicle screws, (2) bilateral supralaminar hooks, and (3) hybrid unilateral screw/hook construct. Intersegmental range of motion (ROM) was recorded with a motion analysis system and intervertebral disc pressure was recorded at the proximal adjacent segment (T7/T8).

Results: Total thoracic ROM was significantly reduced from the intact condition following T9-T11 instrumentation ($p<0.05$) and was further reduced in all but extension when the fusion was extended to T8-T9 with screws, hooks and the hybrid construct. Bi-lateral pedicle screws yielded the most instability at the supra-adjacent un-instrumented segment, represented by an increase in the percent of total ROM at T7/T8, significantly in torsion and extension ($p<0.05$), Figure 1. Intervertebral disc pressure at T7/T8 was reduced in extension with the addition of bilateral hooks ($p<0.05$) and increased in flexion with all three top off constructs. There was no change in disc pressure between intact, 2-level fusion, and any of the 3-level constructs during lateral bending and axial rotation.

Conclusion: Surgical treatment of scoliosis typically calls for a posterior approach

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using all pedicle screws. Data generated in this biomechanical study suggest placing hooks at the top of an all pedicle screw construct may reduce the risk of PJK by easing the transition to the non-instrumented spine.



179. Posterior Three Column Spinal Osteotomies for Severe Pediatric Deformities: Comparison Between Revision and Primaries

Stephen J. Lewis, MD; James G. Jarvis, MD; Marc R. Lipkus, BS; David E. Lebel, MD, PhD; Ilyas Aleem, MD
Canada

Summary: A retrospective review of 16 primary and 23 revision three column posterior spinal osteotomies performed for severe pediatric patients. The total correction was 81.5° (45.4° coronal and 36.1° sagittal) in the primary group compared to 54.1° (28.3° coronal and 25.7° sagittal) in the revision group ($p=0.02$). Excellent deformity correction can be achieved in previously fused spinal deformities with results similar to those seen in primary deformities. Significant complications were seen in both groups.

Introduction: We reviewed a series of pediatric cases undergoing three column posterior revision spinal reconstructions for persistent deformities and compared them to a group of patients undergoing similar procedure as their primary reconstruction.

Methods: A retrospective chart and radiographic review was performed on a consecutive series of 39 thoracic level three column osteotomies. Curve patterns were subdivided into patients with mixed sagittal and coronal deformities and those with primary sagittal plane deformities. Statistical evaluation of the data was performed.

Results: There were 16 primary (10 mixed, 6 sagittal) and 23 (19 mixed, 4 sagittal) revision osteotomies. For mixed deformities, the mean total Cobb in the primary group was 209.7° (mean 97.8° coronal and 111.9° sagittal) compared to 174.3° (mean 88.5° coronal and 85.8° sagittal) in the revision group ($p=0.07$). The total correction was 81.5° (45.4° coronal and 36.1° sagittal) in the primary group compared to 54.1° (28.3° coronal and 25.7° sagittal) in the revision group ($p=0.02$). Mean non-autologous blood transfusion was less in

the primary group (383.0 vs 1099.8 mL, $p=0.008$). There was no significant differences in mean age (15.3 vs 14.2 years), OR time (440.7 vs 382.3), cell saver (187.9 versus 191.7), length of stay (12.6 vs 10.7 days), levels instrumented (11.8 vs 12.0). Major complications included one early reintubation in each group, three pseudarthrosis (2 primary, 1 revision), 2 deep infections (primary), 4 transient neurological deficits in primary group and 2 in the revision group, one peri-operative death in a syndromic child (primary). There was one permanent paralysis in a primary syndromic patient following revision surgery for pseudarthrosis of her index surgery.

Conclusion: Excellent correction can be achieved with posterior three column osteotomies in both primary and revision cases. Greater correction was seen in the primary group, as correction was restricted to the region of the osteotomy in the previously fused patients. Major complication rates were similar in both groups. We feel revision osteotomies carry similar risks to primary osteotomies in severe pediatric spinal deformities.

180. The Efficacy and Complications of Posterior Surgical Correction with Transpedicular Instrumentation of Congenital Kyphosis: More Than 2 Years Follow-Up.

Zhang Jianguo, MD
China

Summary: Most of the congenital scoliosis lead to a malignant natural history. And surgical treatment of congenital kyphosis is a more challenging procedure for surgeons. Until now there were few reports on posterior surgical correction of congenital kyphosis.

Introduction: This is a retrospective study to evaluate the efficacy and complications of posterior surgical correction with transpedicular instrumentation of congenital kyphosis.

Methods: 27 patients average aged 13.3(4-31) years with congenital kyphosis were treated by posterior surgical correction with transpedicular instrumentation. The mean follow-up is 51.9(24-127) months. There were 13 cases of failure of vertebral body formation, 8 cases of failure of segmentation and 6 cases of mixed failure of formation and segmentation. 6 patients has intraspinal anomalies. Osteotomy was performed on 24 patients, including 9 cases of vertebral column resection, 6 cases of pedicle subtraction osteotomy, 3 cases of hemivertebra resection, 6 cases of Ponte osteotomy. 3 cases underwent posterior fusion in situ. Radiographs, operative reports and patient charts were reviewed to record the correction and complications.

Results: The mean operation time was 4.6 (2-8) hours. The averaged blood loss was 809(100-2800) ml. The segmental kyphosis was 64.9° before surgery, 22.2° post surgery and 23.9° at the latest the follow-up. And the sagittal trunk translation (difference to normal alignment) was improved from 69.5mm to 33.5mm. Complications included 2 rod breakage due to pseudarthrosis, 1 proximal junctional kyphosis, 1 incomplete spinal cord injury and 1 transient root injuries.

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Conclusion: Posterior surgical correction with transpedicular instrumentation is a safe and effective procedure for congenital kyphosis. Pseudarthrosis and implant failures occurred more in patients with posterior fusion in situ. As most of these deformities are severe and rigid, techniques of osteotomies including VCR, PSO and hemivertebra resection could provide satisfied correction. However, the surgeons should pay enough attention to the complications of these aggressive procedures.

181. Long-Term Outcome of Laminectomy for Cervical Ossification of the Posterior Longitudinal Ligament

Chun Kee Chung, MD, PhD; Soo Eon Lee, MD; Tae-Ahn Jahng, MD, PhD; Hyun-Jib Kim

Republic of Korea

Summary: We assessed the long-term outcome of laminectomy for cervical OPLL, in terms of the changes in the cervical curvature and in the neurological status. In conclusion, the OPLL itself may serve as a support for the spinal column.

Introduction: Although laminectomy is an effective surgical technique for the treatment of multilevel cervical stenotic lesions, postoperative kyphosis and neurological deterioration have been frequently reported after laminectomy. However, our clinical impression from the long-term follow-up of patients who had undergone laminectomy does not support that postoperative kyphosis is common in patients with OPLL.

Methods: The authors retrospectively reviewed medical records and radiologic images with patients who underwent cervical laminectomy between 1999 and 2009. The preoperative and the last follow-up status, with the JOA score and recovery rate were assessed. The cervical global angle and ROM were measured preoperatively and at the last follow-up. The cervical curvature was classified into three types: lordosis, straight, and kyphosis.

Results: The total number of patients available for reviewing medical records and performing telephone interviews was 34. There were 28 males and 6 females, whose mean age at the time of surgery was 57.8 years. The mean follow-up period was 57.5 months. The JOA score at the last follow-up was significantly improved to 14.3 ($p < 0.001$) with a recovery rate of 56.3%. The JOA score at each postoperative follow-up increased until 6 years postoperatively, and thereafter, it gradually decreased. The preoperative global angle was -11.3° and the latest global angle was -8.4° . The preoperative ROM was 33.9° and the latest one was 27.4° . There was no statistical significance in the change of cervical curvature and ROM. Preoperatively, 29 of the 34 patients had lordotic cervical curvature, and 5 patients had straight curvature. At last follow-up, 24 patients had lordotic curvature, 3 patients changed from lordosis to kyphosis and 7 patients had straight curvature.

Conclusion: The long-term outcome of laminectomy for cervical OPLL is satisfactory, in terms of the clinical and radiologic aspects. The risk of postlaminectomy kyphosis was not high, raising the possibility that the OPLL itself may serve as a support for the spinal column.

182. Proximal Junctional Kyphosis (PJK) is a Common Feature in Scheuermann's Kyphosis Treated with Pedicle Screw Instrumentation

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USA

Summary: Pedicle screw instrumentation (PSI) with segmental osteotomies has recently gained popularity over anterior and posterior approach for Scheuermann's kyphosis correction. There is a lack of data on the incidence proximal junctional kyphosis (PJK) in patients treated with all pedicle screw instrumentation. This study reports 74% incidence of PJK in Scheuermann's kyphosis.

Introduction: An increasing popularity and growing comfort of the surgeons over segmental PSI and segmental osteotomies has resulted in advocating posterior only approach. However, an increase incidence of PJK has been reported in adolescent idiopathic scoliosis (AIS) patients treated with pedicle screws. In this study we report the incidence of PJK in Scheuermann's Kyphosis patients treated with all pedicle screws.

Methods: Nineteen patients with diagnosis of Scheuermann's kyphosis who underwent posterior spinal fusion (PSF) between 2005 and 2012 were enrolled in the study. Patients were evaluated for kyphosis, lordosis, sagittal balance, proximal junctional kyphosis ($PJK > 10^\circ$), and segmental osteotomies. Pre-operative (VO), immediate post-operative (V1) and most recent follow-up (V2) X-rays were reviewed. Patient charts were reviewed for intra operative maneuvers.

Results: The data in this study is non-normally distributed, hence, medians and Inter Quartile range (IQR) have been reported. The median pre-operative kyphosis was 71° (IQR $70-79^\circ$), sagittal balance was -27.3 mm (IQR $-50.4, 10.4$ mm), and lordosis was 76° (IQR $70-84^\circ$). At V1 median kyphosis corrections was 50° (IQR $44, 56^\circ$), which was significant ($p < 0.001$) and at V1 lordosis was 62° (IQR $59, 67^\circ$), which was significant $p < 0.001$. At V2 no significant change in kyphosis, lordosis and sagittal balance was seen. At V1 12 (63%) patients had PJK and 14 (74%) patients had PJK at V2. This change in PJK from V1 to V2 was statistically significant ($p = 0.001$). Median levels fused were T3, which had no correlation on kyphosis, sagittal balance, lordosis or PJK. Most commonly fused levels were T3-L3. Neither the upper nor the lower instrumented vertebra (UIV & LIV) had any effect on maintenance of correction. Ponte/Smith Peterson osteotomies, high strength rods, maneuvers had no significant effect on correction and maintenance.

Conclusion: Lonner et. Al. (Supplemental data) reported 32.1 % risk of PJK in Scheuermann's kyphosis treated with hooks, hybrids and screws. Our study showed a very high incidence (74%) of PJK in Scheuermann's kyphosis treated with PSI suggesting, considering hook instrumentation at UIV, instead of all PSI.

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183. Prediction of Sagittal Balance in Patients with Osteoporosis Using Spinopelvic Parameters

Jung Sub Lee, MD, PhD; Jong Ki Shin; Tae Sik Goh
Republic of Korea

Summary: This study shows significant relationships between sagittal spinopelvic parameters in osteoporosis patients. In particular, osteoporotic patients and normal controls were found to differ significantly in terms of sagittal spinopelvic parameters. Furthermore, significant correlations were found between sagittal parameters in osteoporotic patients, and low FNBM and high pelvic incidence were found to be important predictors of sagittal balance in osteoporotic patients.

Introduction: Little data is available on the relationships between sagittal balance and spinopelvic parameters in osteoporosis. We analyzed sagittal spinopelvic parameters in osteoporotic patients.

Methods: In this prospective study, the patient and control groups comprised 124 osteoporotic patients and 40 controls. Average age were 72.4 ± 6.8 in the osteoporosis group and 42.7 ± 12.5 in the control group, which were significant different ($P < 0.001$). Osteoporotic patients were allocated to two groups by sagittal vertical axis, namely, a sagittal balance group ($n=56$) and a sagittal imbalance group ($n=68$). All 164 study subjects underwent whole spine lateral radiography, which included hip joints. The radiographic parameters investigated were sacral slope, pelvic tilt, pelvic incidence, thoracic kyphosis, lumbar lordosis, and sagittal vertical axis. Statistical analysis was performed to identify significant differences between the two groups.

Results: Osteoporotic patients and controls were found to be significantly different in terms of sagittal vertical axis, sacral slope, pelvic tilt, lumbar lordosis, and thoracic kyphosis. However, no significant difference was observed between patients and controls in terms of pelvic incidence ($P > 0.05$). Significant differences were found between the balance and imbalance groups in terms of age, lumbar spine bone mineral density (LSBMD), femoral neck BMD (FNBM), visual analogue scale (VAS) score, sacral slope, and pelvic incidence. Correlation analysis revealed significant relationships between sagittal parameters and osteoporosis. Stepwise logistic regression analysis revealed that FNBM and pelvic incidence contributed significantly to sagittal balance.

Conclusion: Sagittal spinopelvic parameters were found to be significantly different in patients and normal controls. Significant relationships were found between sagittal spinopelvic parameters in osteoporotic patients. In particular, low

FNBM and high pelvic incidence were significant parameters in determination of sagittal balance in osteoporotic patients.



184. The Change of Aortic Length after Closing-Opening Wedge Osteotomy for Ankylosing Spondylitis Patients with Thoracolumbar Kyphosis: A Computed Tomography Study

Jun Jiang; Mingliang Ji, PhD; Bangping Qian; Qiu Yong, MD; Wang Bin; Yu Yang; Zhu Ze-zhang, Xu Sun, MD, PhD
China

Summary: This is the first study focusing on the change of aortic length in ankylosing spondylitis (AS) patients with thoracolumbar kyphosis following closing-opening wedge osteotomy (COWO). The result of this study showed that the correction of kyphosis by COWO could lengthen the aorta.

Introduction: The COWO procedure could lead to the elongation of the aorta. Until now, no studies specifically focusing on the relationship between COWO and the change of aortic length had been reported. The purpose of this study was to investigate the change of aortic length in AS patients with thoracolumbar kyphosis following COWO.

Methods: A total of 21 AS patients with a mean age of 38.9 years undergoing COWO for the correction of thoracolumbar kyphosis were retrospectively reviewed.

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Radiographical measurements included global kyphosis (GK), thoracic kyphosis (TK), lumbar lordosis (LL), angle of fusion levels (AFL), local kyphosis (LK) and anterior height of the osteotomized vertebra (AHOV). Both preoperative and postoperative sagittal 2D-reconstruction CT images of the spine were used to measure aortic length (the length between the superior endplate of the upper instrumented vertebra and the inferior endplate of L4).

Results: There was an average 2.2 cm increase of aortic length postoperatively. Significant differences were observed in terms of the improvements of GK, LK, AFL, LL and anterior height of the osteotomized vertebra ($P < 0.01$). The alteration of aortic length showed significant correlations with the changes of GK ($r = 0.525$, $P = 0.015$), LK ($r = 0.654$, $P = 0.001$), AFL ($r = 0.634$, $P = 0.002$), and LL ($r = 0.538$, $P = 0.012$).

Conclusion: The aorta lengthening after COWO was quantitatively confirmed by this study. With the correction of kyphosis, the aorta would be lengthened. Spine surgeons should be aware of the potential risk for the development of aortic injury in AS patients undergoing COWO for thoracolumbar kyphosis.

were increased after surgery, although there were no statistical significance in the changes of FVC, FEV1, FEV1/FVC or FVC%. Age was significantly negative related with the change of FVC after surgery. Thoracic volume did not show any significant relation with kyphosis deformity or other pulmonary function parameters. After surgery, thoracic volume had no significant changes.

Conclusion: The major pulmonary dysfunction caused by kyphosis was restrictive impairment. Age was significantly negative related with the change of FVC after surgery. After posterior correction surgery, thoracic volume of patients did not change significantly.

185. The Impact of Posterior Corrective Surgery on Pulmonary Function and Thoracic Volume in Kyphosis Patients

*Zhongqiang Chen, MD; Yan Zeng, MD; Zhaoqing Guo, MD; Desi Ma, MD
China*

Summary: The objective of this study is to compare pulmonary function and thoracic volume changes before and after posterior surgical corrective in kyphosis.

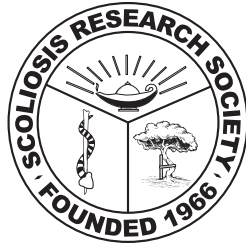
Introduction: The corrective surgery for kyphosis become prevalent in the recent years. Whereas, few document focuses on the respiratory function of this type of patients. We made a study of pulmonary function and thoracic volume of our kyphosis patients.

Methods: Thirty-four Kyphosis patients underwent posterior corrective surgery were included as the group for observing pulmonary function changes with measuring forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), forced expiratory volume in 1 second ratio (FEV1/FVC) and forced expiratory volume ratio (FVC%) before and after surgery. Kyphosis angle changes before and after surgery were also measured. The patients were divided into different group according to the degree of kyphosis angle, the apex of kyphosis, the follow-up time, the degree of kyphosis angle correction rate, and the segment extension of fixation. Nineteen patients were included as the group for measuring thoracic volumes with CT scanning before and after surgery. Thoracic volumes were then calculated by integration method.

Results: Before surgery, 6 patients were defined as mild and 8 patients were defined as moderate pulmonary dysfunctions, respectively. All of the pulmonary dysfunctions were restrictive impairment. After surgery, 5 patients who had mild pulmonary dysfunction and one patient who had moderate pulmonary dysfunction before surgery turned to be normal. Three patients with moderate pulmonary dysfunction before surgery improved to mild pulmonary dysfunction after surgery. Among the 34 patients, the FVC of 16 patients and the FEV1 of 13 patients

E-Poster Index





The Scoliosis Research Society gratefully acknowledges the following companies for their support of the Hands-On Workshops:

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E-Poster Index

This index includes all accepted E-Posters whose authors confirmed participation prior to publication. If provided by the author, E-Posters are available for viewing at the computer kiosks in the Exhibit Hall and on the CD-ROM provided with your registration materials.

E-Posters may be viewed as specialized kiosks, in the Exhibit Hall, as well as on the CD-ROM included with your registration Materials, supported, in part, by a grant from K2M.

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Early Onset Scoliosis	280-286
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Lumbar Degenerative	297-307
Miscellaneous	308-323
Neuromuscular Deformity	324-329
Spondylolisthesis	330
Trauma	331-332
Tumors	333-335

201. Outcomes in Surgery for Adolescent Idiopathic Scoliosis: Drivers of Satisfaction and Durability of Results

Ian G. Dorward, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Brian J. Neuman, MD; Kevin R. O'Neill, MD, MS; Terrence F. Holekamp, MD, PhD; Azeem Ahmad, BA, BS; Christine Baldus, RN, MHS
USA

Summary: We analyzed the SRS scores and radiographs of 186 patients undergoing surgery for adolescent idiopathic scoliosis (AIS) from 2003-2009 at a single institution. At 2 yr and 5 yr f/u, appearance correlated most strongly with satisfaction. Radiographic variables showed only weak negative correlations with satisfaction. SRS-30 scores did not decline in any domain between 2 and 5 yr follow-up (f/u).

202. Spinal Deformity Progression after Modern Segmental Instrumentation and Fusion: Is this Crankshaft?

Vidyadhar Upasani, Michael Glotzbecker, MD; Daniel J. Hedequist, MD; Michael T. Hresko, MD; Lawrence Karlin, M.D.; John B. Emans, MD
USA

Summary: Although modern posterior segmental instrumentation provides three-column fixation, deformity progression can occur in immature patients with remaining growth potential.

203. Factors Associated With the Use of BMP During Pediatric Spinal Fusion Surgery: An Analysis of 4817 Children

Amit Jain, MD; Khaled Kebaish, MD; Paul D. Sponseller, MD
USA

Summary: Our goal was to investigate the trends in use of recombinant human bone morphogenetic protein (BMP) during pediatric spinal fusion surgery. From 2003 through 2009, the use of BMP during pediatric spinal fusion increased significantly from 2.7 to 9.3%. Factors associated with increased BMP use include: older age, diagnoses of congenital scoliosis, thoracolumbar fractures and spondylolisthesis, private insurance status, non-teaching hospital status, large bed capacity, and hospital location in the Western and Southern United States.

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204. Symptomatic Operative Adolescent Idiopathic Scoliosis Patients: Can Their Increased Perception of Deformity be Changed?

Anna M. McClung, BSN, RN; Daniel J. Sucato, MD, MS

USA

Summary: Comparison of SRS-30 outcomes between symptomatic and non-symptomatic operative AIS patients shows an increased effect of deformity across all domains in the symptomatic patients. Postoperatively symptomatic patients scores improved significantly and were comparable to non-symptomatic peers.

205. How Does Pedicle Screw Distribution Impact Curve Correction in Lenke 1 Curves?

Franck Le Naveaux; Carl-Éric Aubin, PhD, PEng; A. Noelle Larson, MD; David W. Polly, MD; Yaser M. Baghdadi, MD; Hubert Labelle, MD; Minimize Implants Maximize Outcomes Study Group

Canada

Summary: Regional pedicle screw density (screws per level fused) in 279 surgically instrumented Lenke 1 cases varied along the spine and between the concave and convex sides, with the lowest density in the intermediate convexity regions. Only screw density at the apical concavity was associated with curve correction. Regions for possible screw drop out may exist in the periapical convexity, but such option requires to be further biomechanically validated.

206. Is There a Better Derotation Manoeuvre in Posterior Correction of Thoracic Adolescent Idiopathic Scoliosis?

Mario Di Silvestre, MD; Francesco Lalli; Francesco VomMaro; Massimo Balsano, MD; Konstantinos Martikos, MD

Italy

Summary: Retrospective review of 62 consecutive patients affected by AIS (Lenke type 1 or 2) treated by posterior fusion with pedicle screw-only instrumentation. Three groups identified: Pre-Rod (direct derotation procedure done before inserting rods), Single-Rod (derotation done after concave rod insertion) Double-Rod (after both rods). The Pre-Rods insertion cases showed a significantly better final correction of apical vertebral rotation (61.9% vs 55.8% and 50.1%) and a greater final correction of main thoracic curve.

207. Does Size Matter? Comparison of 6.35 mm vs. 5.5 mm Diameter Rods for Posterior Spinal Fusion in Adolescent Idiopathic Scoliosis

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

USA

Summary: In a large dataset (n=956) of AIS patients, BMI and coronal/sagittal pre-op curves were higher in patients undergoing PSF using 6.35 mm vs. 5.5 mm diameter rods ($p=0.02$). Choice of rod diameter was surgeon specific with 91% of 6.35 patients from 3/13 sites ($p<0.001$). However, in a matched cohort, there was no difference in curve correction, maintenance of correction, sagittal/coronal radiographic measurements, SRS scores, or complication rates for 6.35 mm vs. 5.5 mm diameter rods in PSF for AIS at 2 years post-op.

208. Parent Perception of Appearance Influences Patient Expectations of Outcomes in the Treatment of AIS

Adriana De La Rocha, MS; Daniel J. Sucato, MD, MS; Anna M. McClung, BSN, RN; David Podeszwa, MD

USA

Summary: In the treatment of AIS with a PSF, patients' and parents' perception of appearance and expectations for deformity correction varied significantly, with parents' rating the physical deformity and appearance worse than the patients rated themselves. Pts continue to want greater expectations for deformity correction after surgery which may be the result of their parents' negative perception of their deformity. Addressing these differences pre-operatively may improve overall pt and parent satisfaction.

209. Sagittal Alignment Two Years After Selective and Nonselective Thoracic Fusion for Lenke 1C Adolescent Idiopathic Scoliosis

Paul C. Celestre, MD; Leah Y. Carreon, MD, MSc; Lawrence G. Lenke, MD; Daniel J. Sucato, MD, MS; Steven D. Glassman, MD

USA

Summary: Compared to nonselective fusion, selective thoracic fusion for Lenke 1C adolescent idiopathic scoliosis may predispose patients to increased thoracolumbar kyphosis. While it is unlikely that the risk of a small increase in thoracolumbar kyphosis will outweigh the well accepted advantages of leaving the lumbar spine unfused, this study highlights the need to study AIS patients throughout the aging process.

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211. Cervical Spine Alignment After Lumbar Pedicle Subtraction Osteotomy(PSO) for Sagittal Imbalance

Ibrahim Obeid; Anouar Bourghli, MD; Jean M. Vital; Olivier Gille; Vincent Pointillart, MD, PhD; Virginie Lafage, PhD

France

Summary: Cervical spine alignment varies significantly after lumbar pedicle subtraction osteotomy for major sagittal spine deformities. Distal cervical spine lordosis and C7 slope decrease significantly; proximal cervical spine lordosis and occipito C2 angle increase slightly after correction.

Global position of the head toward C7 evaluated by the external auditory meatus tilt seems to be very close to the vertical axis and still unchanged.

212. Identification of Risk Factors Predicting Treatment Failure and Complications in Adult Scoliosis Surgery

Heiko Koller, MD; Oliver Meier, MD; Juliane Zenner, MD; Michael Mayer, MD; Wolfgang Hitzl, PhD, MSc

Germany

Summary: Analysis of correction and failures in a consecutive series of >400 adult scoliosis (AS) patients identified significant risk factors. Multiple stepwise regression analyses revealed that non-union was elevated in patients with smaller postop LL ($p=.02$), greater postop SVA ($p<.001$) and increased BMI ($p<.001$). Curve correction was improved by higher screw density ($p<.05$ for TC: $r=-0.6$ and LC: $r=-0.7$) and outcome by avoidance of revision surgery and better curve correction in coronal and sagittal plane ($p<.05$, COMI, ODI, SF36-PCS: $r=-0.41$ to $r=-0.66$).

213. Lumbosacral Junctional Failures in Long Spinal Fusion for Adult Spinal Deformity: Where to Stop, L5, S1 or Pelvis?

Tatsuya Yasuda; Tomohiko Hasegawa; Yu Yamato; Sho Kobayashi, PhD; Daisuke Togawa; Hideyuki Arima; Yukihiro Matsuyama, MD

Japan

Summary: We investigated the lumbosacral junctional complications in long spinal fusion for adult spinal deformity. It was a high complication rate in case the distal fusion end was L5 or S1. It was good outcome in case the iliac screw was used as distal end. We recommend iliac screw as lower end of long spinal fusion in adult deformity surgery.

214. The Impact of the Change of Pelvic Obliquity on the Coronal Alignment of the Spine After Total Hip Arthroplasty

Yuichiro Abe, MD, PhD; Shigenobu Sato, MD

Japan

Summary: The patterns of compensation in lumbar or lumbosacral spine in coronal plane after leg lengthening THA were classified as regards to pelvic obliquity and Cobb angle. 89.2% of all 195 patients showed acceptable compensation in lumbar spine, 21 patients developed coronal imbalance and 2 patient developed painful scoliosis. THA therefore considered to safe as regards to spinal balance in coronal plane. However we keep in mind that patients with preoperative rigid scoliosis could have a risk for progress spinal imbalance.

216. Does Curve Magnitude/Deformity Correction Correlate with Pulmonary Function After Adult Deformity Surgery?

Ronald A. Lehman, MD; Daniel G. Kang, MD; Lawrence G. Lenke, MD; Jeremy J. Stallbaumer, MD; Brenda A. Sides, MA

USA

Summary: We evaluated the relationship of pre-op curve magnitude and deformity correction with pulmonary function in 76 adult patients following spinal deformity surgery. Pre-op main thoracic (MT) curve magnitude correlated negatively with pre-op pulmonary function, and MT deformity correction correlated negatively with %pred PFTs. This suggests that a greater MT deformity correction may result in significantly less decline in pulmonary function than smaller curve corrections. Sagittal curve magnitude and deformity correction as well as pulmonary function did not demonstrate a significant relationship.

218. Interbody Fusion and Adult Deformity: Are the Benefits Worth the Risks?

Michael S. Chang, MD; Yu-Hui Chang, PhD; Jan Revella, RN; Dennis Crandall, MD

USA

Summary: 127 patients undergoing adult scoliosis correction with 2 year f/u were examined. 35 patients received anterior-posterior surgery with interbody cages. 48 patients underwent posterior spinal fusion with multiple TLIFs to assist in deformity correction. 44 patients underwent posterior spinal fusion alone. All groups had similar and substantial improvement in clinical and radiographic outcome measures. PSF alone had lower complication rates and better sagittal balance compared with either interbody-assisted correction group.

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219. Anterior Shift of the Lumbar Plexus Within the Surgical Corridor in Scoliotic Spines: Considerations During the Transpoas Approach to the Lumbar Spine

Ashish Patel, MD; Srinivas Kolla, MD; Jason Oh; Qais Naziri, MD; Carl B. Paulino, MD; Dante M. Leven, DO
USA

Summary: The transpoas approach to the lumbar spine has been increasing in popularity. Indications for this procedure have expanded to include patients with spinal deformities. Evaluation of lumbar anatomy demonstrates that with increasing rotation there is a significant anterior shift in the lumbar plexus on the side of the curve concavity as compared to the contra-lateral side. Special attention should be taken when positioning the spinal deformity patient during the transpoas approach to the lumbar spine.

220. Does Gait Posture Well Reflect Walking Ability After Corrective Surgery for Adult Spinal Deformity?

Hideyuki Arima; Yu Yamato; Daisuke Togawa; Tomohiko Hasegawa; Sho Kobayashi, PhD; Tatsuya Yasuda; Yukihiko Matsuyama, MD
Japan

Summary: We investigated spinal sagittal balance on gait and walking ability of patients who underwent corrective surgery for their adult spinal deformity. Postoperative gait posture was improved when the spinal deformity was well corrected. However, postoperative walking ability was not significantly improved in patients who was elder patients or had mental disorders, even if they could restore a suitable sagittal balance by corrective surgery.

221. Validation of a Simple Computerized Tool for Measuring Pelvic Parameters

Chun Kee Chung, MD, PhD; Seil Sohn, MD; Sungjoon Lee; Chi Heon Kim, MD, PhD
Republic of Korea

Summary: The computerized measurement of pelvic parameters with a novel tool in PACS may be a more reliable and efficacious approach than manual measurement.

222. Correlation Between Sagittal Alignment and Adjacent Fracture After Percutaneous Vertebroplasty or Kyphoplasty

Ki-Chan An; Dae-Hyun Park; Hyung Seok Lee
Republic of Korea

Summary: The purpose of this study is to analyze the relationship between sagittal alignment and adjacent vertebral fracture (AVF) after percutaneous vertebroplasty (VP) or kyphoplasty (KP)

223. Correction of Sagittal Imbalance in Adult Deformity Patients with Smith-Petersen Osteotomy Combined with Transforaminal Interbody Fusion (SPO+TLIF)

Farbod Khaki; Robert A. Hart, MD
USA

Summary: We evaluated adult spinal deformity patients undergoing surgical treatment including SPO+TLIF for sagittal imbalance at minimum 2-year follow-up. Focal correction averaged 14.3° per level of SPO+TLIF at 2-year follow-up. Total increase in lumbar lordosis (LL) averaged 18.4° at 2-year follow-up. SPO+TLIF can effectively increase focal lordosis and total LL.

224. Factors Predictive of Proximal Failure After Thoracolumbar Instrumented Fusion

Jayme R. Hiratzka, MD; Paolo Punsalan, MD; Natalie L. Zusman, BS; Alexander C. Ching, MD; Jung U. Yoo, MD
USA

Summary: Proximal junctional failure is a complex entity complicating adult deformity surgery for which clear risk factors have not been established. This study of 79 patients undergoing thoracolumbar fusion for adult deformity attempts to identify risk factors for proximal failure. We have identified several possible risk factors, particularly increased pre- and post-op main thoracic kyphosis, which may increase risk for the development of early proximal junctional failure.

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227. Biomechanical Effects of Dynamic Stabilization or Transverse Process Hooks Cephalad to Long Posterior Instrumentation to Prevent Proximal Junctional Kyphosis: Range of Motion Analysis

Ivan Cheng, MD; Joseph Pirolo, MD; Soumya Yandamuri; Manasa Gudipally, MS; Mir Hussain; Mark Moldavsky, MS; Noelle Klocke, MS; Brandon Bucklen, PhD
USA

Summary: Soft stabilization adjacent to long rigid fusion may be considered in order to buffer the drastic mechanical contrast caused by fixed instrumented levels adjacent to free mobile levels. The purpose of this study is to determine if spine motion is affected by the addition of soft stabilization elements or hooks at the cephalad end. Instrumentation increased adjacent motion especially two-levels above the instrumented levels. These effects decreased with increasing levels of soft stabilization.

228. Motor and Neural Deficit Following Lateral Transpsoas Access

Luiz Pimenta, MD, PhD; Elder Camacho; Luis Marchi, MSc; Rodrigo A. Amaral; Thiago Coutinho
Brazil

Summary: This work evaluated motor and neural deficits after transpsoas approach. We've found high rates of immediate transient postoperative thigh symptoms. Numbness was widely found in early postop period, as hip flexion weakness. EMG use is still imperative in transpsoas access and larger casuistic studies are required to complete understanding.

229. Moderate to Almost Perfect Inter- and Intrarater Agreement in Assessment of Adult Spinal Deformity Using the SRS-Schwab Classification

Dennis Hallager Nielsen, MD; Lars V. Hansen; Jonas Walbom; Martin Gehrchen, MD, PhD; Benny Dahl, MD, PhD, DMSci
DenMark

Summary: The SRS-Schwab classification has been suggested for the classification of adult spinal deformities (ASD). Additional knowledge about the rater agreement is necessary to properly assess its clinical feasibility. Inter- and intrarater agreement was analyzed using Fleiss' Kappa statistics on a consecutive series of 67 adult cases. Kappa-values corresponding to moderate to almost perfect agreement were obtained, supporting the future use of the SRS-Schwab classification.

230. Addressing the Challenges with Surgical Correction of Adult Scoliosis: Identification of Parameters Predicting Coronal LIV-Balance, Curve Correction and Risk Factors for ASD

Heiko Koller, MD; Oliver Meier, MD; Juliane Zenner, MD; Michael Mayer, MD; Wolfgang Hitzl, PhD, MSc
Germany

Summary: To improve surgical planning and outcomes in adult scoliosis (AS), the study targeted the prediction of curve correction, postop LIV-balance in terms of LIV-take-off (LIV-TO), risk factors for ASD and treatment failure. Using prediction models, LIV-balance was predicted at best by preop LIV-TO and LIV-take-off on bending/traction-films (bLIV-TO, differences on bending- vs traction-films were not significant ($13.5^\circ/13^\circ, p < 0.5$)). ASD was shown to influence outcomes. Parameters of sagittal balance rather than coronal predicted ASD. Grading of preop adjacent disc degeneration (PfirsMann/MRI) did not improve prediction of ASD.

231. Impact of Pelvic Incidence/Lumbar Lordosis Mismatch in the Surgical Treatment for Adult Spinal Deformity

Satoshi Inami; Hiroshi Taneichi, MD; Takashi Namikawa, MD, PhD; Daisaku Takeuchi; Chizuo Iwai; Yo Shiba, MD; Yutaka Nohara, MD
Japan

Summary: Aim was to determine key factor leading to sagittal vertical axis (SVA) < 50 mm, in surgical treatment for adult spinal deformity (ASD). Spino-pelvic parameters were compared between SVA <50 and SVA 50 groups, on post-op radiographs of 49 ASD patients. Only pelvic incidence/lumbar lordosis mismatch (PI-LL) was significantly different, and SVA <50 group had smaller PI-LL (8.4° vs. 16.5°). This result implicate that enough LL which reflects PI is necessary to obtain stable sagittal balance.

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232. Lateralization and Outward Tilt of Uppermost Instrumented Vertebra Tend to Cause Proximal Adjacent Diseases in Short Fusion of Degenerative Lumbar Scoliosis

Kyoichi Hasegawa, MD, PhD; Masanori Fujiya, MD; Ken Nakashita, MD

Japan

Summary: In short fusion for degenerative lumbar scoliosis (DLS), the UIV should not be shifted laterally or tilted outward for reduction of proximal adjacent diseases which in this study significantly tended to occur in DLS fusion with the shift or tilt of UIV observed in 45 subjects with 42 months follow up.

233. Are Clinical Outcomes Favorable Following of Posterior Vertebral Column Resection (PVCR) for Severe Adult Spinal Deformity?

Woo-Kie Min, MD, PhD; Lawrence G. Lenke, MD; Michael P. Kelly, MD; Han Jo Kim, MD; Yutaka Nakamura, MD, PhD; Dong-Ho Lee, MD, PhD; Moon Soo Park, PhD;

Brenda A. Sides, MA

Republic of Korea

Summary: 31 PVCRs with minimum 2-year follow-up were reviewed in the treatment of severe adult spinal deformity. Patients had overall favorable radiographic and clinical outcomes with only one (2.3%) major neurologic deficit, despite high risks of complications in these very challenging patients.

234. Anterior & Posterior Fusion Versus Posterior only Fusion for Adult Degenerative Lumbar Scoliosis

Kyu-Jung Cho, MD; Young-Tae Kim; Se-Il Suk, MD; Jin-Hyok Kim

Republic of Korea

Summary: Thirty-one patients who underwent long fusion from thoracolumbar junction to L5 or S1 were enrolled with a minimum 2-yr follow up. Seventeen patients had posterior instrumentation with posterior lumbar interbody fusion (AP group). Fourteen patients had only posterior instrumentation (post group). Anterior and posterior fusion was better to restore lumbar lordosis in adult degenerative lumbar scoliosis even though it took more operative time than posterior only surgery. The proximal junctional problem was less occurred in the AP group.

235. Quantifying the Role of Baseline HRQOL and Readmissions on the Cost-Effectiveness of Surgical Treatment for Adult Spinal Deformity (ASD)

Ian McCarthy, PhD; Michael F. O'Brien, MD; Christopher P. Ames, MD; Thomas J. Errico; Han Jo Kim, MD; Gregory M. Mundis, MD; Frank J. Schwab, MD; Eric Klineberg, MD; Christopher I. Shaffrey, MD; Munish C. Gupta, MD; David W. Polly, MD; Richard Hostin, MD; International Spine Study Group

USA

Summary: Little is known regarding the determining factors of the incremental cost-effectiveness ratio (ICER) of surgical versus non-surgical treatment for ASD. Using regression-based methods, this analysis calculates the incremental improvement in QALYs due to surgical treatment, and quantifies the effect of baseline HRQOL and readmissions on the resulting ICER. Projected through 10-year follow-up, cost-effectiveness of surgical treatment improved over time and was most cost-effective for patients with poorer baseline HRQOL who were never readmitted to the hospital (ICER=\$139,893).

236. Intraoperative Neuromonitoring (IONM) on Patients Undergoing Posterior Spinal Deformity Correction Surgery (PSDCS): Portland Experience

Ilker Yaylali, MD, PhD; Batuhan Baserdem; Jung U. Yoo, MD; Alexander C. Ching, MD; Robert A. Hart, MD

USA

Summary: The purpose of this study was to observe the effects of Intraoperative Neuromonitoring (IONM) on patients undergoing Posterior Spinal Deformity Correction Surgery (PSDCS).

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237. Poor Psychosocial Profile Reported by SF 36, SRS 22r and DRAM does not Predict Outcome Following Adult Spinal Deformity Surgery

Jamie S. Terran, BS; Frank J. Schwab, MD; Gregory M. Mundis, MD; Eric Klineberg, MD; Jacob M. Buchowski, MD, MS; Robert A. Hart, MD; Richard Hostin, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Virginie Lafage, PhD; Shay Bess, MD; Douglas C. Burton, MD; International Spine Study Group
USA

Summary: Patients present to surgeons with varying psychological state and predisposition. Surgeons may be concerned about offering surgical intervention to patients with psychological distress. We found adult spinal deformity (ASD) patients with poor preoperative psychological state, based upon mental health SF questions, to have equal opportunity to gain minimally clinical important difference (MCID) compared to those with a better preoperative psychological state. ASD patients should not be excluded from surgical intervention based upon preoperative psychological HRQOL.

239. Higher Volume Hospitals and Surgeons Perform Increased Rates of Complex Adult Spine Deformity Surgeries

Justin C. Paul, MD, PhD; Baron S. Lonner; Vadim Goz, BA; Jeffrey H. Weinreb, BS; Raj Karia, MPH; Courtney Toombs, BS; Thomas J. Errico
USA

Summary: High complication rates have been shown in adult spinal deformity surgery (ASDS), especially in complex and revision cases. Using relevant in-hospital patient records from the National Inpatient Sample, we found that these cases are performed at higher rates at higher volume hospitals and with higher volume surgeons.

241. Effect of Occipitocervical Angle on the Swallowing Difficulty: Videofluorographic Swallowing Study

Jae Taek Hong, MD, PhD; Il Sup Kim; Ho Jin Lee
Republic of Korea

Summary: The finding of this preliminary VFSS demonstrated dysphagia is significantly related with OC2 angle and kyphotic OC2 angle is significantly correlated with incidence of aspiration and bolus retention on VFSS. These data support the finding that the OC2 angle has considerable impact on dysphagia after O-C fusion and C01 angle is more significantly related to dysphagia than C12 angle.

242. Cervical Microendoscopic Foraminotomy/Discectomy: Clinical Outcomes, Complications, and the Necessity for Subsequent Fusions In a Multicenter Study

Raqeeb Haque, MD; Sheeraz Qureshi; Branko Skovrlj, MD; Yakov Gologorsky; Cort D. Lawton, BS; Yousef M. Ahmed, BS; Richard G. Fessler, MD, PhD
USA

Summary: Cervical microendoscopic foraminotomy/discectomy (CMEF/D) can result in good patient outcomes with low rate of subsequent fusion at the index or adjacent level

243. A Comparison of Implants Used in Open-Door Laminoplasty: Structural Rib Allografts Versus Metallic Mini-Plates

Ehsan Tabaraee, MD; Praveen V. Mummaneni, MD; Beejal Y. Amin, MD; Christopher P. Ames, MD; Shane Burch, MD; Vedat Deviren, MD; Sigurd H. Berven, MD; Serena S. Hu, MD; Dean Chou, MD; Bobby Tay, MD
USA

Summary: This study attempts evaluate clinical differences in patients undergoing open-door laminoplasty with either rib allograft struts or metallic mini-plates. Both groups showed improvements in pain and function, but there was no difference between groups. The mini-plate group had a shorter operative time and required less immobilization while the allograft group had lower average costs.

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244. Treatment with Plated Laminoplasty Decreases the Range of Motion but Improves Neck Pain and Clinical Outcomes in Patients with Cervical Stenosis

Takahito Fujimori, MD, PhD; Hai Le; John Ziewacz, MD, MPH; Dean Chou, MD; Ehsan Tabaraee, MD; Bobby Tay, MD; Darryl Lau; Praveen V. Mummaneni, MD
Japan

Summary: We evaluated clinical and radiographic results following laminoplasty using mini-plates (without bone graft) for patients with cervical stenosis. Neurological outcomes and neck pain were significantly improved after laminoplasty. However, laminoplasty did decrease the range of motion of the cervical spine.

245. Estimating EQ-5D Values from the Neck Disability Index and Numeric Rating Scales for Neck and Arm Pain

Leah Y. Carreon, MD, MSc; Kelly R. Bratcher, RN, CCRP; Nandita Das, PhD; Jacob B. Nienhuis, MD; Steven D. Glassman, MD
USA

Summary: Previous studies showed a robust relationship between cervical spine specific measures and the Short Form-6D. In this study of 3,732 patients seen in clinic for cervical spine complaints, a similar relationship was not seen between the Neck Disability Index (NDI), neck and arm pain scores and the EuroQOL-5D. Thus, the EuroQOL-5D cannot be accurately estimated from the NDI, neck and arm pain scores

246. Estimating EQ-5D Values from the Oswestry Disability Index and Numeric Rating Scales for Back and Leg Pain

Leah Y. Carreon, MD, MSc; Kelly R. Bratcher, RN, CCRP; Jacob B. Nienhuis, MD; Nandita Das, PhD; Steven D. Glassman, MD
USA

Summary: Previous studies showed a robust relationship between low back specific measures and the Short Form-6D. In this study of 14,544 patients seen in clinic for low back complaints, a similar relationship was not seen between the Oswestry Disability Index (ODI), back and leg pain scores and the EuroQOL-5D. Thus, the EuroQOL-5D cannot be accurately estimated from the ODI, back and leg pain scores.

247. Postoperative Sacral Fracture After Instrumented Lumbosacral Fusion

Seiichi Odate, MD; Jitsuhiko Shikata, MD, PhD; Hiroaki Kimura, MD, PhD; Tsunemitsu Soeda, MD, PhD
Japan

Summary: Cases involving lumbosacral fusion for postmenopausal women with a high PI are risk factor of postoperative sacral fracture. Surgeons should plan to achieve large increases in LL to restore not only spinopelvic harmony but also to avoid postoperative sacral fracture. For such patients, because it is difficult to consistently achieve a sufficiently large LL, we recommend prophylactic iliosacral fixation to protect the sacrum.

248. The Influence of Proximal Anchors on the Risk of Proximal Junctional Fracture in the Osteoporotic Spine: Biomechanical Comparison Between Pedicle Screws and Transverse Process Hooks

Jean-Marc Mac-Thiong, MD, PhD; Annie Levasseur; Stefan Parent, MD, PhD; Yvan Petit, PhD
Canada

Summary: This study consists in a biomechanical comparison of the risk of proximal junctional fracture (PJF) after multilevel spinal instrumentation using pedicle screws or transverse process hooks on the top of a pedicle screw construct. Based on the testing of 24 segments of 4 vertebrae from 6 human cadaveric spines, the current study failed to observe a significant benefit of using either transverse process hooks or pedicle screws on top of multilevel pedicle screw construct to decrease the risk of PJF.

249. Analysis of Complications and Related Risk Factors of Posterior Vertebral Column Resection for Severe and Rigid Spinal Deformities

Zhang Jianguo, MD
China

Summary: Posterior vertebral column resection(PVCR) is a effective but high technically demanding procedure because of relative higher rate of complications.

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250. Antibiotic Impregnated Cement Embedding Technique for Spinal Instrument Infections

So Kato, MD; Takahiro Hozumi; Kiyofumi Yamakawa; Takahiro Goto; Taiji Kondo

Japan

Summary: The antibiotic impregnated cement embedding technique was performed for 13 consecutive patients with postoperative infection after spinal instrumentation surgery. After the meticulous open debridement, the whole metallic implants were embedded using polymethylmethacrylate mixed with antibiotics. Nine patients were cured by one debridement procedure with the cement embedding technique and following systemic antibiotic treatment. It is an easy to perform and effective method for the treatment of spinal instrument infections.

251. Risk and Predisposing Factors in Surgical Site Infections After Pediatric Spinal Deformity Surgery: Density Case-Control Assessment

Jesse Allert, MD; Sina Pourtaheri, MD; Freeman Miller, MD; Kirk W. Dabney, MD; Laurens Holmes, PhD, DrPH; Suken A. Shah, MD; Susan Dubowy, BS

USA

Summary: In this large, single center cohort of pediatric patients undergoing complicated spinal deformity surgery, the Surgical Site Infection (SSI) rate was 3%. The SSI patients were compared to a random sampling of non SSI deformity patients (control) and risk factors were identified. These risk factors include: increased weight, severe spasticity, wound problems and prolonged surgical time. SSI patients had more intra-operative complications, longer ICU stays.

252. Complications in Patients with Down Syndrome Undergoing Cervical Spine Surgery Using Modern Instrumentation Techniques, Long Term Follow-up

Kris Siemionow, MD; Mark Hansdorfer; Steven M. Mardjetko, MD, FAAP

USA

Summary: Pulmonary events are the most common perioperative complication in patients with Down Syndrome undergoing cervical spine surgery. Modern instrumentation techniques are associated with lower pseudoarthrosis rates and decreased loss of reduction when compared to historical controls.

253. Pleural Effusion After Posterior Correction and Fusion Surgery Using Pedicle Screw Construct for Scoliosis

Masahiro Ozaki; Kota Watanabe; Naobumi Hosogane, MD; Yoshiaki Toyama; Morio Matsumoto, MD

Japan

Summary: 103 patients with thoracic scoliosis who underwent posterior correction surgery using PS were evaluated for the occurrence of postoperative abnormal findings on chest CT. 51.5% of the patients had abnormal findings in chest. However, pedicle perforation was not significantly associated with the occurrence of the abnormal findings. Since the occurrence was positively correlated with the magnitude of scoliosis and correction, the morphological change in the thoracic cage may be one of the causes of postoperative pleural effusion in chest.

254. Safety of Surgical Treatment for Scoliotic Patients with Surgically Corrected Congenital Cardiac Malformations: A Retrospective Case Control Study

Jinqian Liang; Jianxiong Shen; Zheng Li

China

Summary: This retrospective case-control study was undertaken to investigate the postoperative complications in unselected scoliotic patients with surgically corrected congenital cardiac malformations and to identify whether spinal fusion is safe in this population.

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255. Using the Scoliosis Research Society 2011 M&M Data Base to Determine Significant Difference in Case Volume and Membership Status to Occurrence of Complications

Paul A. Broadstone, MD; Douglas C. Burton, MD; Michael J. Goytan, MD; Justin S. Smith, MD, PhD; Theodore J. Choma, MD; Amer F. Samdani, MD; Yongjung J. Kim, MD; Robert F. Heary, MD; Howard M. Place, MD; Jonathan E. Fuller, MD; Karl E. Rathjen, MD; John R. Dimar, MD

USA

Summary: Summary: Based on the 2011 SRS M&M reporting system, the rate of three complications was collected from Active and Candidate members. In comparing the complication rates, there was a significant difference between Active and Candidate members and between those Active members doing <200 cases/year for the complication of neurologic deficit only

256. Perioperative Complications and Mortality After Spinal Fusions: Analysis of Trends and Risk Factors

Vadim Goz, BA; Jeffrey H. Weinreb, BS; Virginia Lafage, PhD; Thomas J. Errico

USA

Summary: This study uses a national database to analyze trends in complications and mortality after spinal fusions. The study also identifies independent predictors of postoperative complications.

257. Analysis of Unplanned Hospital Readmissions Following Pediatric Spinal Fusion Surgery

Amit Jain, MD; Jared M. Wohlgemut, BSc; Paul D. Sponseller, MD

USA

Summary: The aim of our study was to investigate the incidence and causes of unplanned readmissions after pediatric spinal fusion surgery, and to analyze factors associated with readmission. We found that the rate of 90-day unplanned readmission after pediatric spinal fusion surgery exceeds 7%, with wound healing complications predominating. Patient diagnosis, number of levels fused and intraoperative blood loss are independent predictors of readmission. These factors may be of consideration in the postoperative management of children receiving spinal fusion.

258. Deep Venous Thromboembolism Following Pediatric Spinal Surgery

Natasha O'Malley; George H. Thompson, MD; Jochen P. Son-Hing; Christina Hardesty, MD; Connie Poe-Kochert, BSN

USA

Summary: We performed a 20 year retrospective review from our Pediatric Orthopaedic Spine database to evaluate the incidence of deep venous thromboembolism (DVT) in those who had spine surgery, including growing rods and VEPTRs. There was a 0.3% incidence among 1264 patients, corresponding to a 0.19% incidence in 2062 procedures. DVT is a rare occurrence in children undergoing spine surgery, and thus, thromboembolic prophylaxis is not indicated.

259. In the World of Pay-for-Performance, How Do We Evaluate Baseline Risk? An Innovative Risk Assessment Tool for Spine Surgery

Nathan L. Hartin, MD; Kedar Deogaonkar, MD, FRCS; Siddharth B. Joglekar; Amir A. Mehbod, MD; Ensor E. Transfeldt, MD

USA

Summary: The Fusion Risk Score is introduced to objectively assess baseline risk of spine surgery preoperatively. The score is the sum of two components - one arises from risks unique to the individual patient (Patient Score) and the other from the planned surgery (Procedure Score). With knowledge of the Patient Score, the surgeon may plan intervention (Procedure Score) that appropriately controls risk.

E-Poster Index

260. Should Cerebral Palsy Patients Undergo Scoliosis Deformity Correction in the Winter Months?

Burt Yaszay, MD; Paul D. Sponseller, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Firoz Miyajji, MD, FRCSC; Jahangir Asghar, MD; Peter O. Newton, MD; Harms Study Group
USA

Summary: Due to their comorbidities, scoliosis surgery in CP patients is typically associated with greater complications. This may influence some surgeons to perform these surgeries outside the winter months to reduce respiratory risk. Our study suggests that CP scoliosis surgery can safely be performed during the winter. While one-third of our polled surgeons subjectively attempt to avoid winter surgery in patients with frequent respiratory hospitalization, this does not appear to be consistently applied.

261. Complication Rates are Reduced for Revision Adult Spine Deformity Surgery Among High Volume Hospitals and Surgeons

Justin C. Paul, MD, PhD; Baron S. Lonner, Vadim Goz, BA; Jeffrey H. Weinreb, BS; Raj Karia, MPH; Courtney Toombs, BS; Thomas J. Errico
USA

Summary: Previous studies have shown improved outcomes associated with higher volume surgeons and hospitals, but this relationship has not been shown in revision adult spinal deformity surgery, an intervention with a high complication rate. Using relevant in-hospital patient records from the National Inpatient Sample, we found an improvement in major complications among higher volume hospitals and surgeons for complex revision cases of adult spine deformity.

262. Incidence and Mortality of Surgical Site Infections After Lumbar Spine Surgery

Matthew Oglesby, BA; Miguel A. Pelton, BS; Alpesh A. Patel, MD; Steven J. Fineberg, MD; Kern Singh, MD
USA

Summary: A national database was utilized to identify the incidence, risk factors, and hospital outcomes for surgical site infections after lumbar spine surgery.

263. Outcomes and Complications of Anterior and Posterior Cervical Fusion with Bone Morphogenic Protein

Steven J. Fineberg, MD; Matthew Oglesby, BA; Miguel A. Pelton, BS; Alpesh A. Patel, MD; Kern Singh, MD
USA

Summary: The Nationwide Inpatient Sample database was analyzed in order to characterize the outcomes of BMP utilization in anterior and posterior cervical fusions using parameters of incidence, demographics, hospital outcomes, risk factors, and mortality.

264. Revision Surgery for Proximal Junctional Failure (PJF) with Neurological Injury After Spinal Deformity Surgery

Mario Di Silvestre, MD; Francesco Lollì; Konstantinos Martikos, MD; Francesco Vommaro; Andrea Baioni; Elena Maredi, MD; Tiziana Greggi,
Italy

Summary: Retrospective review of 6 patients (5 women and 1 man), surgically treated for a proximal junctional failure (PJF) with neurological lesion after spinal deformity surgery. Neurological symptoms appeared acutely or subacutely (first 2 months after surgery) in 4 cases, later in 2. There were: 1 paraplegia, 4 severe paraparesis, 1 cervical radiculopathy with deficit. Revision surgery was performed in all cases (instrumentation extension + osteotomies). There was complete neurological recovery in 3 patients, partial in 2, no recovery in 1.

266. The Utility of Cultures in the Treatment of Osteomyelitis of the Spine

Sina Pourtaheji, MD; Arash Emami, MD; Mark J. Ruoff, MD; Eiman Shafa, MD; Kimona Issa, MD; Tyler Stewart, BS; Kumar Sinha, MD; Ki S. Hwang, MD
USA

Summary: Obtaining blood or tissue cultures prior to administration of antibiotics has been the standard of care in the treatment of osteomyelitis of the spine. In this retrospective study on vertebral osteomyelitis, the clearance rate of osteomyelitis was similar in the positive culture group and the group with continually negative cultures. In the culture negative group, an ESR > 48 on initial presentation was associated with clearance of the infection.

E-Poster Index

267. The Effect of Multimodality Intraoperative Monitoring in Vertebral Column Resection Surgery: Evaluation of Consecutive 33 Severe Thoracic Deformity Cases

Yang Junlin, PhD; Huang Zifang, PhD; Deng Yaolong

China

Summary: To evaluate the effect of multimodality intraoperative monitoring in reducing the incidence of iatrogenic neurological deficit in severe thoracic deformity with thoracic vertebral column resection. The monitoring outcomes were concluded and analyzed in various surgery procedures.

268. Use of the Scolioscreen to Support the iPhone when Measuring the Angle of Trunk Inclination in Scoliosis. Comparison with the iPhone Alone and with the Scoliometer

Chanel Fortier-Tougas; Hubert Labelle, MD; Stefan Parent, MD, PhD; Mark Driscoll, BEng, PhD; Jean-Marc Mac-Thiong, MD, PhD

Canada

Summary: This study evaluates the reliability of using the Scolioscreen to support the iPhone when measuring the angle of trunk inclination (ATI) in scoliosis. The Scolioscreen-iPhone provides a reliability similar to that obtained using the Scoliometer, as opposed to the iPhone used alone. The use of the Scolioscreen also improves the consistency with the measurements taken from the Scoliometer. The benefits of the Scolioscreen were observed for clinicians as well as for parents in this study.

269. Is In-Vivo Manual Palpation for Thoracic Pedicle Screw Instrumentation Reliable?

Ross R. Moquin, MD; Blair Calancie, PhD; Miriam Donohue, PhD

USA

Summary: This is the first study to assess in vivo accuracy of manual palpation of thoracic pedicle screw tracks. 526 pedicle track/screw placements were compared. Ball point tipped probe palpation of pedicle breaches has an error rate of 89.8% while 100% reliable in verifying the absence of a breach. The accuracy of manual palpation for detecting breaches was disturbingly low. These findings are consistent with cadaveric studies and point to the need for alternative methods to assess pedicle integrity during surgery.

270. An Innovative Ultrasound Method to Measure Coronal Curvature and Vertebral Rotation in Adolescent Idiopathic Scoliosis (AIS): A Pilot Study

Edmond H. Lou, PhD; Wei Chen; Lawrence H. Le, PhD; Douglas Hedden, MD; Marc J. Moreau, MD; Jim K. Mahood, MD; Douglas L. Hill, MBA

Canada

Summary: Coronal curvature and vertebral rotation seen in AIS can be measured from radiographs, however, there is a growing concern with exposing AIS patients with too much radiation. An ultrasound method was developed. A trial on 4 AIS subjects who consisted of 4 curves and 14 vertebral rotations was performed and the results demonstrated high repeatability and reliability measurements. The mean absolute difference of the coronal measurement between the radiographs and ultrasound was $0.8^{\circ} \pm 0.5^{\circ}$, and the vertebral rotation between 2 measures was $0.7^{\circ} \pm 0.7^{\circ}$.

271. Intraoperative Aorta Movement, Relative to the Spine, Before and After Correction in Posterior Surgery for Scoliosis: Assessment Using O-Arm Computed Tomography Imaging

Tsutomu Akazawa, MD; Toshiaki Kotani; Tsuyoshi Sakuma, MD, PhD; Shohei Minami

Japan

Summary: The purpose of this study was to evaluate intraoperative aortic movement, relative to the spine, before and after spinal correction in posterior surgery for scoliosis. The 113 vertebrae were analyzed by multiplanar reconstruction, using O-arm computed tomography data. The intraoperative aorta position, relative to the spine, changes after correction in patients undergoing posterior surgery for scoliosis. Surgeons should be aware of this intraoperative aortic movement during the correction procedure.

E-Poster Index

272. Aortic Pedicle Screw Impingement: Diagnostic Accuracy of Prone and Supine CT

Terry D. Amaral, MD; Darlene Jean-Pierre, MD; Beverly Thornhill, MD; Preethi M. Kulkarni, MD; Abhijit Pawar, MD; Adam L. Wollowick, MD; Vishal Sarwahi, MD
USA

Summary: Pedicle screw (PS) misplacements are asymptomatic and frequently undetected. An aortic PS impingement can be fatal. A CT scan done in both supine and prone position can better delineate the position of the aorta to the screw.

274. Postoperative Mechanical Lumbar Radiculopathy Caused by Pedicle Screws with Intraoperative Normal t-EMG Thresholds. The Value of Probe Stimulation at the Pedicular Mid-Track

Vicente García, MD; Jesús J F. Burgos, PhD; Teresa Del Olmo; Carlos Barrios, MD, PhD; Eduardo Hevia, MD; Luis Miguel Antón-Rodríguez, PhD; Gema De Blas, MD,
PhD

Spain

Summary: A series of 8 cases with postoperative lumbar radiculopathy after surgical correction of spinal deformity using pedicle screws was analyzed. Postoperative CT scans showed 10 screws with malposition and were removed. All 8 cases had no neurophysiologic alterations after screw stimulation at the time of surgery. After removal of the screws, stimulation of the probe within the track showed very low thresholds at mid pedicular track. The authors recommend probe stimulation at the track when placing lumbar pedicle screws.

275. Reliability of Sagittal Pelvic Parameters' Measurement Using the New SRS Computerized Tool. The Effect of Lumbosacral Instrumentation and Measurement Experience

Ferran Pellise, MD; Alba Vila-Casademunt; Emre Acaroglu, MD; Francisco J. S. Pérez-Gruoso, MD; Mar Perez Martin-Buitrago; Tunay Sanli, MA; Sule Yakici; Ana García de Frutos; Antonia Matamalas; José Miguel Sánchez Márquez, MD; Ibrahim Obeid; Juan Bago, MD; Ahmet Alanay; European Spine Study Group

Spain

Summary: The accuracy of Sagittal Pelvic Parameters' (SPP) measurement in instrumented spines and the reliability of the new SRS computerized tool (SurgiMap) in SPP assessment are still unknown.

Thirteen observers evaluated twice 63 radiographs (31 with lumbosacral instrumentation). Measurement of SPP by Surgimap equaled or improved (ICC >0.85) previously reported data. Lumbosacral instrumentation reduced significantly inter-observer reliability of Pelvic Tilt ($p=0.006$) (ICC 0.92; SEM 2.2degrees) and Sacral Slope ($p=0.007$) (ICC 0.77; SEM 4.4degrees). Inexperienced observers measured SPP reliably following a short tutorial.

276. New Diagnostic Criteria for Pott's Disease

Sina Pourtaheri, MD; Mark J. Ruoff, MD; Tyler Stewart, BS; Kimona Issa, MD; Arash Emami, MD; Eiman Shafa, MD; Kumar Sinha, MD; Ki S. Hwang, MD
USA

Summary: Delays in the diagnosis of vertebral tuberculosis (VTB) is well reported. Identifying new diagnostic criteria for vertebral osteomyelitis is crucial to prevent delays in diagnosis. Previous studies lack a control group. In this study, Pott's disease had significant delays in diagnosis and was resilient to the treatment regimens. The delay in diagnosis converted these cases to chronic osteomyelitis. A notable finding was that the TB patients presented with significantly lower CRP levels on their initial ER visit.

277. Differences in 3D Upright Slot-Scanner Versus Supine CT in AIS Patients

Diana A. Glaser, PhD; Josh Doan, MEng; Fredrick G. Reighard, MPH; Peter O. Newton, MD; Lawrence G. Lenke, MD
USA

Summary: A mathematical algorithm was used to compare shape and curve differences between supine CT and weight bearing upright EOS models of large curve AIS patients.

E-Poster Index

278. Intervertebral Disc Local Biochemistry and Mechanics are Correlated with Quantitative T2* MRI Mapping

David W. Polly, MD; Arin M. Ellingson; Tina Nagel, MS; Jutta Ellermann, MD, PhD; David J. Nuckley, PhD

USA

Summary: T2* MR imaging, effective in cartilage research, was used in the present study to assess intervertebral disc health across the degenerative spectrum. Intervertebral disc proteoglycan content, residual stress, and excised strain were correlated with T2* relaxation coefficients in a site-specific fashion revealing great promise for this MRI technique in assessing early disc degeneration.

279. Outcomes Following Cervical Disc Arthroplasty: A Retrospective Review

Ronald A. Lehman, MD; John P. Cody; Robert W. Tracey, MD; Daniel G. Kang, MD; Adam J. Bevevino, MD; Michael Rosner, MD

USA

Summary: Cervical disc arthroplasty (CDA) has been established as a safe alternative to anterior fusion. The purpose of this study was to evaluate the outcomes of patients treated with CDA at a single institution. In the largest, non-sponsored study of its kind, we found that pre-operative symptoms were relieved in 95% of patients with a low complication rate. CDA continues to be a safe and reasonable alternative to discectomy and fusion.

280. Failure of Short Fusion Procedures in Deformed Growing Spine

Arvind Jayaswal, MS(Orth); Pankaj Kandwal, MS(POrth); Upendra Bidre, MS; Ankur Goswami, MS (Orth); Abrar Ahmad, MS(Orth)

India

Summary: Short fusion procedure is a treatment modality for deformity in skeletally immature patients. While fusing short in this population increases risk of progression of deformity, long fusions render these kids short in height with poor pulmonary functions. We encountered rate of revision to be as high as 30% in these patients.

282. A Comprehensive Evaluation of the Utility of Routine Post-Operative Radiographs Following Pediatric Scoliosis Surgery

David Shau; Jesse E. Bible, MD; Stephen P. Gadowski, BA; Richard Samade, PhD; Sheyan Armaghani; Clinton J. Devin, MD; Gregory Mencio, MD

USA

Summary: The purpose of this study is to comprehensively evaluate the utility of obtaining routine post-operative radiographs in pediatric scoliosis patients.

283. The Classification for Early Onset Scoliosis (C-EOS) Predicts Timing of VEPTR Anchor Failure

Michael G. Vitale, MD, MPH; Hiroko Matsumoto, MA; Howard Y. Park, BA; Daren J. McCalla, BS; David P. Roye, MD; Wajdi W. Kanj, MD; Randal R. Betz, MD; Patrick J. Cahill, MD; Michael Glotzbecker, MD; Scott J. Luhmann, MD; Sumeet Garg, MD; Jeffrey R. Sawyer, MD; John T. Smith, MD; John M. Flynn, MD

USA

Summary: The Classification for Early Onset Scoliosis (C-EOS) is a consensus-based classification developed by pediatric spine surgeons with expertise in the treatment of EOS. This study aims to examine the predictive ability of the C-EOS with respect to time to anchor failure in surgically treated EOS patients who experienced this complication. The results show that the C-EOS is able to discriminate risk of rapid failure between classes of the C-EOS, and more significantly, may guide decision making for pediatric spine surgeons.

284. "EOS-Imaging" System is Available for Early Onset Scoliosis Patients and Can Reduce Their Ionizing Radiation Exposure

Burt Yaszay, MD; Nima Kabirian, MD; Gregory M. Mundis, MD; Jeff Pawelek; Carrie E. Bartley, MA; Behrooz A. Akbarnia, MD

USA

Summary: The novel EOS-imaging system can significantly reduce emitted ionizing radiation in early onset scoliosis patients as young as 3 years old.

E-Poster Index

285. Proximal Hooks in Growing Rod Systems: Can They Prevent Proximal Junctional Failures?

Tiziana Greggi; Francesco Lolli; Elena Maredi, MD; Francesco Vommaro; Konstantinos Martikos, MD; Andrea Baioni; Mario Di Silvestre, MD

Italy

Summary: Retrospective review of 21 patients, affected by early onset scoliosis and surgically treated with growing rod using as proximal anchors pedicle screws in 7 patients, hooks in 14. At a mean follow up of 40 months, proximal anchors mobilization occurred in 6 patients (28.6%), 5 in case of pedicle screws (71.4%), 1 in case of hooks (7.1%), always requiring revision surgery. Those results showed that hooks used as proximal anchors seem to have a protective role versus proximal junctional failures.

286. Alveolar Morphometry in a Rabbit Model of Early Onset Scoliosis

Aidin Masoudi, MD; John C. Olson, MS; Michael Glotzbecker, MD; Brian D. Snyder, MD, PhD

USA

Summary: The goal of this study was to use a rabbit model of severe early onset scoliosis (EOS) created by tethering ribs unilaterally or bilaterally to evaluate the effect of the resulting thoracic hypoplasia on pulmonary microstructure. At maturity, rabbits with thoracic hypoplasia had reduced overall pulmonary mass. Preliminary alveolar morphometry suggest rabbits with unilateral tethered hemithorax have simplified alveoli, decreased parenchymal connectivity and decreased surface area.

287. Correlation Between Clinical Outcome and Spinopelvic Parameters in Ankylosing Spondylitis

Jung Sub Lee, MD, PhD; Jong Ki Shin; Tae Sik Goh

Republic of Korea

Summary: This study shows significant relationships between sagittal spinopelvic parameters in AS patients. Furthermore, AS patients and normal controls were found to be significantly different in terms of sagittal spinopelvic parameters. In addition, correlation analysis revealed significant relationships between parameters and clinical outcomes. Sagittal vertical axis, sacral slope and lumbar lordosis were found to be significant parameters in prediction of clinical outcomes in AS patient.

288. Pedicle Subtraction Osteotomy for Severe Proximal Thoracic Junctional Kyphosis

Stephen J. Lewis, MD; Majdi A. Hashem

Canada

Summary: The charts and radiographs were reviewed of five patients treated with a PSO for severe kyphotic deformities proximal to their constructs. A central rod using centrally placed laminar hooks was used to close the osteotomy in all cases, then removed once the two lateral rods were placed in 4 of 5 cases. The mean pre-op kyphotic angle was 61.2° (50-81°) and improved to 20.6° (11-32°) p=0.0005. The mean thoracic kyphosis T2-T12 improved from 74.8° (60-95°) to 49.4° (31-77°) p=0.04. The correction was maintained at final follow-up. No new neurological deficits occurred. Extension of the fusion into the cervical spine was not required in our ambulatory patients. A proximal thoracic PSO is an effective means of achieving large corrections for severe junctional kyphosis.

290. Mean 34 Years Follow-up of Severe Angular Kyphosis from Tuberculosis of the Spine: Bad Prognosis for Paraparesis of Late Disease

Yat-Wa Wong, MBBS, FRCS(Ed), FHKCOS, FHKAM(Orth); Kenneth M. Cheung, MBBS(UK), FRCS(England), FHKCOS, FHKAM(Orth); Dino Samartzis, DSc, PhD(C), MSc; Keith D. Luk, MD

China

China

Summary: Pott's paraparesis may occur many years after disease onset. Twenty-four patients having a mean 34 years follow-up and an average kyphotic angle of 113 degrees were reviewed. Twenty-two cases acquired TB spine at or below 5 years of age. Sixteen patients developed late onset Pott's Paraparesis 8 to 49 years after disease onset. Neurological recovery was poor after the onset of paraparesis. Prevention of severe kyphosis and solid bony union may decrease the chance of neurological deterioration.

291. Posterior Only Surgical Correction of ScheuerMann Kyphosis - Is Bilateral All-level Pedicular Screw Fixation Required?

Eyal Behrbalk, MD; Ofir Uri; Bronek M. Boszczyk, DM; Oliver Stokes, MBBS, MSc, FRCS, (Tr&Orth)

United Kingdom

Summary: This study compares outcome following surgical correction of SK using high-density [HD] PS fixation versus low-density [LD] PS fixation.

E-Poster Index

292. Reliability of PJK Measurements for Early Onset Scoliosis

Ron El-Hawary, MD, MSc, FRCSC; Luke Gauthier, MD; Jacob Matz; Ammar Al Khudairy, MBChB, MRCSI, MCh; Carla V. Rioux; John A. Heflin, MD

Canada

Summary: The development of PJK following distraction-based surgery may lead to implant failure and changes in upper instrumented vertebrae. PJK is not clearly defined in the literature. Our purpose was to use three recently used definitions to report the rates of PJK for a group of children treated with growth-friendly surgery and to define the variability associated with these measurements. Different definitions for PJK resulted in different rates of PJK (3%-33%), and demonstrated moderate inter and intra-rater agreement at best.

293. Reliability and Validity of Simplified Chinese Version of Scoliosis Research Society-22 (SRS-22) Patient Questionnaire in the Evaluation of Kyphosis After Corrective Surgery

Yan Zeng, MD; Zhongqiang Chen, MD; Qiang Qi, MD; Yiqing Zhang, MD; Kirkham B. Wood, MD

China

Summary: The objective of this study is to evaluate the reliability and validity of an adapted simplified Chinese version of the Scoliosis Research Society-22 (SRS-22) questionnaire in kyphosis patients.

294. The Use of Posterior Vertebral Column Resection in the Management of Severe Posttuberculous Kyphosis: A Retrospective Study and Literature Review

Hongqi Zhang, MD; Jinsong Li, MD

China

Summary: Many literatures reported on a VCR approach for severe kyphotic deformities, as well as for fixed kyphoscoliotic decompensation, but there were rarely clinical series documenting this posterior-only VCR technique in the treatment of the severe posttuberculous spinal kyphosis without any neurological deficit. The purpose of the present study was to evaluate the safety and efficacy of such a procedure in treating patients suffered Pott's disease in healed stage.

295. Incidence of Junctional Kyphosis After Posterior Vertebral Column Resection (PVCR) for Severe Rigid Kyphosis due to Osteoporotic Vertebral Fractures

Tomohiko Hasegawa; Yu Yamato; Daisuke Togawa; Sho Kobayashi, PhD; Tatsuya Yasuda; Hideyuki Arima; Yukihiko Matsuyama, MD

Japan

Summary: We investigated the incidence of junctional kyphosis and global sagittal spinal alignment after vertebral column resection for 21 patients who had severe rigid kyphosis due to osteoporotic vertebral fractures. Average age was 66y.o. New vertebral fractures occurred in 7 patients. Proximal junctional kyphosis (PJK) occurred in 3 patients and distal junctional kyphosis (DJK) occurred in 7. Oswestry disability index (ODI) of DJK group was higher than PJK group. We have to re-consider the distal end in osteoporotic kyphosis patients.

296. V-Y Vertebral Body Osteotomy for the Treatment of Fixed Flexion Deformity of the Spine

Hossein Mehdian, MD, MS(Orth) FRCS(Ed); Sherief Elsayed, FRCS(Tr&Orth); Georgios Arealis, PhD; Nasir A. Quraishi, FRCS; Ranganathan Arun, FRCS(Tr&Orth), DM, MRCS

United Kingdom

Summary: We describe a new V-Y osteotomy for the correction of flexion deformities of the lumbar spine. The technique incorporates features of both open and closing osteotomies in a single vertebra. A total of 10 patients were treated with a mean correction of kyphotic deformity of 80°. The mean correction at the osteotomy site was 44° and represents a significant aid to reducing deformity. This method is an effective alternative to other established osteotomy techniques.

E-Poster Index

297. Nerve Injury After Lateral Lumbar Interbody Fusion: A Review Of 919 Treated Levels with Identification of Risk Factors

Marios G. Lykissas, MD, PhD; Alexander Aichmair, MD; Alex P. Hughes, MD; Andrew A. Sama, MD; Darren R. Lebl, MD; Fadi Taher, MD; Jerry Y. Du, BS; Frank P. Cammisa, MD; Federico P. Girardi, MD
USA

Summary: Although immediately after surgery LLIF is associated with increased prevalence of neurological deficits our results support that the majority of these deficits are transient. The level of fusion appears to be a risk factor for lumbar plexus injury.

298. Nerve Injury and Recovery After Lateral Lumbar Interbody Fusion With and Without Bone Morphogenetic Protein-2 Augmentation: A Cohort Controlled Study

Marios G. Lykissas, MD, PhD; Alexander Aichmair, MD; Alex P. Hughes, MD; Andrew A. Sama, MD; Darren R. Lebl, MD; Fadi Taher, MD; Frank P. Cammisa, MD; Federico P. Girardi, MD
USA

Summary: This is the first study to implicate rhBMP-2 as a potential risk factor for neural deficits and pain after LLIF. Our results provide evidence of an increase rate of postoperative neurologic deficits and anterior thigh/groin pain after LLIF using rhBMP-2 compared with closely matched controls without rhBMP-2 exposure.

300. Neurological Deficits Following Lateral Lumbar Interbody Fusion - A Six Year Trend Analysis of a Single Institution

Alexander Aichmair, MD; Marios G. Lykissas, MD, PhD; Federico P. Girardi, MD; Andrew A. Sama, MD; Darren R. Lebl, MD; Fadi Taher, MD; Frank P. Cammisa, MD; Alex P. Hughes, MD
USA

Summary: We evaluated the proportional trend over time of neurological deficits after lateral lumbar interbody fusion (LLIF) between 2006-2012 at single institution. There is a decreasing proportional trend over time for both sensory deficits and anterior thigh pain, supporting the evidence of a learning curve in LLIF.

301. Minimum Two Years Results of a Clinical Pilot Study Utilizing a Pedicle Lengthening Osteotomy for the Treatment of Lumbar Spinal Stenosis

Sergey Mlyavkyh, MD; Christopher K. Kepler, MD, MBA; D. Greg Anderson, MD
USA

Summary: Symptomatic lumbar stenosis often affects older individuals and may cause substantial disability. Current surgical treatments are effective but have certain limitations in this patient population.

302. Effect of Comorbidities and Psychosocial Conditions on Clinical Outcomes after Lumbar Spinal Fusion

Nandita Das, PhD; Steven D. Glassman, MD; Mladen Djurasovic, MD; Kelly R. Bratcher, RN, CCRP; Jacob B. Nienhuis, MEd; Leah Y. Carreon, MD, MSc
USA

Summary: Although the presence of psychosocial comorbidities may influence treatment success or failure; in this study of 1347 patients who underwent lumbar fusion, medical and psychosocial comorbidities did not dominate the effect of lumbar fusion on HRQOLs. This further validates the use of these measures as an assessment tool to determine treatment effects in patients undergoing lumbar fusion surgery for degenerative spine conditions.

303. Epidemiological Trends in Interspinous Process Spacers, Pedicle-Based Dynamic Stabilization, and Facet Replacement Devices Between 2007-2009

Matthew Oglesby, BA; Steven J. Fineberg, MD; Alpesh A. Patel, MD; Miguel A. Pelton, BS; Kern Singh, MD
USA

Summary: The Nationwide Inpatient Sample database was analyzed in order to characterize trends in the utilization of interspinous process spacers, pedicle-based dynamic stabilization, and facet replacement devices in terms of incidence, demographics, hospital outcomes, and mortality.

E-Poster Index

304. Interspinous Spacers: Predictive Factors for Implant Failure and Proposal of a Scoring-System for Better Patient Selection

Alexander Tuschel, MD, MSc, MBA; Lukas Panzenboeck; Sandra Stenicka; Michael Ogon

Austria

Summary: We performed a subgroup-analysis of best and worst outcomes after interspinous spacer implantation regarding preoperative predictive factors for outcome. Younger age, higher disc height and a better segmental ROM were the best predictors for good outcome. A scoring system that incorporates several preoperative parameters was developed to help improve patient selection for the implantation of interspinous spacers.

305. Minimally Invasive Versus Open Posterior Interbody Lumbar Fusion: A Propensity-Matched Analysis of Quality Measures

Scott L. Parker, MD; Jason Lerner; Chris M. Kozma, PhD; Terra Slaton, MS; Matthew J. McGirt, MD

USA

Summary: In this retrospective multi-hospital database study evaluating quality measures following spinal fusion, MIS procedures were associated with the same incidence of 90-day hospital readmission, thromboembolic events, and mortality as observed with open procedures. Patients in the MIS cohort were significantly less likely to have received a blood transfusion, had shorter length of stay, were more likely to be discharged home, and were assigned to lower-severity DRGs — factors which may provide clinical and economic benefits from multiple perspectives.

306. Epidemiological Trends in Lumbar Spine Surgery between 2002-2009

Steven J. Fineberg, MD; Matthew Oglesby, BA; Alpesh A. Patel, MD; Miguel A. Pelton, BS; Kern Singh, MD

USA

Summary: A national database was analyzed to characterize epidemiological trends in lumbar spine surgery in the United States from 2002-2009. National trends in patient demographics, co-morbidities, hospitalizations, costs, and mortality were assessed.

307. Cost Analysis of Single Level Lumbar Fusions

Daniel A. Beckerman; Sigurd H. Berven, MD; Melissa Esparza; Serena S. Hu, MD

USA

Summary: The purpose of this paper is to analyze the determinants of direct costs of an episode of care for single level lumbar fusions and to identify potential areas for cost reduction.

308. The Compensatory Relationship of Upper and Subaxial Cervical Motion in the Presence of Cervical Spondylosis

Tetsuo Hayashi, MD; Michael D. Daubs, MD; Akinobu Suzuki, MD, PhD; Trevor P. Scott, MD; Kevin Phan; Bayan Aghdasi, BA; Monchai Ruangchainikom, MD; Xueyu Hu, MD; Christopher Lee, MD; Jeffrey C. Wang, MD

USA

Summary: 446 patients were evaluated with kinetic MRI to determine the effect of loss of motion in the subaxial spine on the the upper cervical spine. Decreased subaxial cervical spinal motion is associated with intervertebral disc degeneration. This decrease in mobility at the subaxial cervical spine is compensated for by an increase in angular mobility of the upper cervical spine at the occipital-atlantoaxial complex, especially at Oc-C1.

309. Complications in Spinal Surgery: A Comparison of Patient and Surgeon Reporting Systems

Mohammed N. Yasin, FRCSEd (Tr&Orth); Irfan Siddique, MBChB, FRCS(Orth); Rajat Verma, MSc, FRCS, FRCS(Orth); Saeed Mohammad, MBChB(Glas), FRCS(Glas), FRCS(Tr&Orth)

United Kingdom

Summary: Differences exits between patient and surgeon reporting of complications, We compared the two mechanisms to the true rate for 921 spinal patients. Results show patients over-report all negative outcomes and surgeons under-report. However, improved pre-operative counselling may reduce patient reporting and surgeon reporting remains the best tool for auditing purposes.

E-Poster Index

310. Thirty day Mortality Rate (30-MR) in the Surgical Treatment of Patients with Metastatic Spinal Cord Compression (MSCC)

Nasir A. Quraishi, FRCS; Sakthivel Rajan Rajaram Manoharan; Georgios Arealis, PhD; Kimberley L. Edwards, PhD; Hossein Mehdian, MD, MS(Orth) FRCS(Ed); Bronek M. Boszczyk, DM
United Kingdom

Summary: Our 30 day mortality rate following emergency surgery for MSCC was 12%. Of the 243 patients with MSCC 29 patients died, most within the first 3 weeks. Older patients with a lower revised Tokuhashi score and lung primaries were the poorest survivors.

311. Modified Posterior Vertebral Column Resection For The Treatment Of Vertebral Infections In Elderly Patients

Cagatay Ozturk, MD; Wael Al-Kasem; Sinan Kahraman; Meric Enercan; Bekir Y. Uçar, MD; Azmi Hamzaoglu, MD
Turkey

Summary: This study showed that radical debridement and anterior support can be provided by modified posterior vertebral column resection in elderly.

312. Optimization of Spine Deformity Surgery Training: A National Survey of Residency and Spine Fellowship Program Directors

Alan H. Daniels, MD; J. M. DePasse, MD; Stephen T. Magill, PhD; Staci A. Fischer, MD; Christopher P. Ames, MD; Robert A. Hart, MD
USA

Summary: This study examined the opinions of residency and spine fellowship program directors regarding current spine deformity surgery training in the United States. Orthopaedic and neurosurgical residents perform few adult spinal deformity cases during residency. A large majority of respondents felt that both orthopedic and neurosurgical trainees should complete an advanced fellowship if they desire to perform spine deformity surgery in practice.

313. Epidemiological Trends in the Use of Bone Morphogenic Protein in Spinal Fusions from 2002-2009

Steven J. Fineberg, MD; Matthew Oglesby, BA; Miguel A. Pelton, BS; Alpesh A. Patel, MD; Kern Singh, MD
USA

Summary: The Nationwide Inpatient Sample database was analyzed in order to characterize the epidemiological trends of BMP utilization in spine surgery using parameters of incidence, demographics, hospital outcomes, risk factors, and mortality.

314. Evaluation of Occipito-Cervical and Atlanto-Axial Motion in an In Vivo Model

Michael D. Daubs, MD; Tetsuo Hayashi, MD; Bayan Aghdasi, BA; Scott R. Montgomery, MD; Hirokazu Inoue, MD, PhD; Haijun Tian; Trevor P. Scott, MD; Kevin Phan; Jeffrey C. Wang, MD
USA

Summary: This was an in vivo study evaluating upper cervical motion at the occipito-cervical (O-C1) and atlanto-axial (C1-C2) segments using kinetic MRI. 344 patients with neck pain were included in the study. Angular motion was measured at these two segments when going from flexion to extension, and their contribution to overall motion was also calculated. We found that the upper cervical spine accounts for 31.3% of overall cervical motion in flexion-extension; O-C1 accounts for 15.1%.

316. Posterior Laminectomy and Fusion Versus Laminoplasty: Regional and Demographic Variability in Treatment and Cost

Michael D. Daubs, MD; Scott R. Montgomery, MD; Bayan Aghdasi, BA; Haijun Tian; Jeffrey C. Wang, MD
USA

Summary: A PearlDiver search was conducted with the purpose of identifying patients (2458) who had undergone a posterior cervical laminectomy and fusion (PLF) or cervical laminoplasty (LP) between 2004-2009 in order to evaluate and compare trends in utilization, cost, and demographics. Results revealed that PLFs cost twice as much as LPs, and that both were more commonly performed on males and in the South. Hospital charges were highest in the Northeast.

E-Poster Index

318. The Predictive Value of the Spinal Instability Neoplastic Score (SINS) System for Adverse Events of Pathologic Fracture and Spinal Cord Compression in Patients with Single Spinal Metastasis

Hyoungmin Kim, MD; Choon-Ki Lee, MD; Jin S. Yeom, MD, PhD; Jae Hyup Lee, MD, PhD; Suk-Joong Lee, MD; Bong-Soon Chang, MD, PhD
Republic of Korea

Summary: The Spinal Instability Neoplastic Score (SINS) system was applied to the retrospective cohort of patients with single spinal metastasis who were followed up at least 2 years or until death. Among the components of the SINS system, the mechanical pain, location, and alignment showed significant correlation with the event of pathologic fracture, and with the event of spinal cord compression, mechanical pain and posterior involvement were related.

319. The Current State of Evidence Regarding Pediatric Spondylolysis: A Report from the SRS Evidence Based Medicine Committee

Charles H. Crawford, MD; Charles Gerald T. Ledonio, MD; Shay Bess, MD; Jacob M. Buchowski, MD, MS; Douglas C. Burton, MD; Serena S. Hu, MD; Baron S. Lonner; David W. Polly, MD; Justin S. Smith, MD, PhD; James O. Sanders, MD
USA

Summary: A structured literature review was performed by the SRS Evidence Based Medicine Committee to answer clinically relevant questions regarding pediatric spondylolysis. The evidence was stronger for the clinical questions of etiology, prevalence, natural history and diagnostic methods. The evidence was weaker for clinical questions regarding treatment (both non-operative and operative). This review will provide a foundation for future research and will help guide current clinical decisions with a summary of the best available evidence.

320. Blood Loss Reduced During Surgical Correction of AIS with an Ultrasonic Bone Scalpel

Carrie E. Bartley, MA; Tracey Bastrom, MA; Peter O. Newton, MD
USA

Summary: Using an ultrasonic bone scalpel to perform facetectomies and Ponte osteotomies when surgically treating AIS resulted in significantly less EBL than cuts made with standard osteotomes and rongeurs.

321. Use of Bipolar Sealer Device Reduces Blood Loss and Transfusions in Posterior Spinal Fusion for Neuromuscular Scoliosis

Christina Hardesty, MD; Zachary L. Gordon, MD; Jochen P. Son-Hing, MD, FRCSC; Connie Poe-Kochert, BSN; George H. Thompson, MD
USA

Summary: Use of a bipolar sealer device significantly reduces intraoperative blood loss and transfusion requirements in posterior spinal surgery for neuromuscular scoliosis.

322. Outcomes of Cervical Spine Surgery in Teaching and Non-Teaching Hospitals

Steven J. Fineberg, MD; Matthew Oglesby, BA; Miguel A. Pelton, BS; Alpesh A. Patel, MD; Kern Singh, MD
USA

Summary: The Nationwide Inpatient Sample database was analyzed in order to characterize the differences existing between teaching and non-teaching hospitals following cervical spine surgery. Differences were identified using parameters of incidence, demographics, complications, risk factors, and mortality.

323. Rationale, Design and Early Trial Performance of AOSpine North America Multi-Center Double Blind Randomized Controlled Trial of Safety and Efficacy of Riluzole in CSM (CSM - Protect Trial)

Branko Kopjar; Michael G. Fehlings, MD, PhD
Canada

Summary: The purpose of this study is to evaluate efficacy and safety of sodium-glutamate antagonist riluzole in improving neurological outcomes in patients with cervical spondylotic myelopathy undergoing surgical treatment.

E-Poster Index

325. Treatment of Spina Bifida with Spinal Fusion Surgery: Demographics, Complications and Mortality

Amit Jain, MD; Emmanuel N. Menga, MD; Hamid Hassanzadeh, MD; Surbhi Jain, MBBS; Addisu Mesfin, MD

USA

Summary: The aim of this study was to report the national trends in use of spinal fusion surgery in this group, and to analyze patient and hospitalization characteristics, and complications and mortality. We found that from 2000 through 2010, 13,316 spinal fusion surgeries were performed in patients with spina bifida in the United States; 47% were performed in children. The overall complication rate was 10.7% and mortality rate was 0.3%.

326. While Inconvenient, Baclofen Pumps Do Not Complicate Scoliosis Surgery in CP Patients

Burt Yaszay, MD; James D. Bomar, MPH; Paul D. Sponseller, MD; Suken A. Shah, MD; Jahangir Asghar, MD; Amer F. Samdani, MD; Tracey Bastrom, MA; Peter O.

Newton, MD; Harms Study Group

USA

Summary: It can be inconvenient for a surgeon to perform scoliosis surgery in a patient with a previously placed baclofen pump and catheter. The concern is whether this inconvenience translates into a more complex surgery that has greater risks for a wound complication. This study suggests that the prior placement of a baclofen pump does not increase operative time or the risk of wound complications.

327. Persistent Thoracic Spine Growth with Luque “Trolley” Technique for Kyphectomy in Patients with Myelomeningocele

Mark C. Lee, MD; Paul C. Baldwin, MD; Christopher Mileto; Jeffrey D. Thomson, MD

USA

Summary: A retrospective comparison of myelomeningocele patients undergoing kyphectomy demonstrated that patients instrumented posteriorly with Luque “trolley” (LT) technique had persistent thoracic spine growth, potentially benefiting the patient’s pulmonary function in the long term.

328. Risk Factors Associated with Progression of Chiari I Malformation Related Scoliosis After Decompression

Steven W. Hwang, MD; Amer F. Samdani, MD; Marie Roguski, MD; Patrick A. Sugrue, MD; Noriaki Kawakami, MD, DMSc; Peter Sturm, MD; Randal R. Betz, MD; Ron El-Hawary, MD, MSc, FRCSC; Joshua M. Pahys, MD; Patrick J. Cahill, MD

USA

Summary: Patients with Chiari I Malformation related scoliosis often undergo a suboccipital decompression to attempt and halt curve progression. We retrospectively reviewed a multicenter series to identify differences between patients that progressed requiring spinal fusion after a suboccipital decompression. The group requiring surgery presented at a later age, was more skeletally mature, presented with larger primary Cobb angles, more commonly had a right thoracic curve, and had a greater average rate of curve progression.

329. Variations in Perioperative Care of Children with Cerebral Palsy Undergoing Surgery for Scoliosis: A Multi-Center Comparison of the Drivers of Cost and Outcome

Brian Scannell, MD; Peter O. Newton, MD; Burt Yaszay, MD; Suken A. Shah, MD; Paul D. Sponseller, MD; Firoz Miyanji, MD, FRCSC; Mark F. Abel, MD; Harry L. Shufflebarger, MD; Harms Study Group

USA

Summary: An analysis of a multicenter prospective study of scoliosis in children with cerebral palsy was undertaken to identify variations in perioperative care between institutions. Significant variation exists especially as related to blood loss, operative time, hospital stay, ICU stay, and days of intubation. Efforts are needed to identify best practices for reducing the cost and improving the quality of care.

E-Poster Index

330. Single-Level Instrumented Posterolateral Fusion Versus Posterior Lumbar Interbody Fusion for Unstable Lumbar Spondylolisthesis

Shugo Kuraishi; Jun Takahashi, MD; Hiroki Hirabayashi; Keijiro Mukaiyama; Masayuki Shimizu; Hiroyuki Kato, MD, PhD; Toshimasa Futatsugi; Yutaka Tateiwa
Japan

Summary: JOA scores of the PLF group before surgery and at final follow-up were 12.3 ± 4.8 and 24.1 ± 3.7 , respectively; those of the PLIF group were 14.7 ± 4.8 and 24.2 ± 7.8 , respectively. Correction of slip estimated from postoperative slip angle, translation, and maintenance of intervertebral disc height was better in the PLIF group; however, there was no significant difference in lumbar lordotic angle and slip angle and translation angle upon maximum flexion and extension bending.

331. Usefulness of an Early MRI-Based Classification System for Predicting Vertebral Collapse and Pseudoarthrosis After Osteoporotic Vertebral Fractures

Tsukasa Kanchiku; Toshihiko Taguchi, MD, PhD; Yasuaki Imajo; Hidenori Suzuki, MD, PhD; Yuichiro Yoshida
Japan

Summary: We evaluated an MRI classification for early osteoporotic vertebral fractures in 129 vertebrae of 109 patients who underwent conservative treatment. By categorizing fractures into types on the basis of a combination of T1WI and T2WI classifications, we were able to differentiate types that demonstrated high pseudoarthrosis conversion rates. Therefore, we believe that the radiological prognosis of pseudoarthrosis and vertebral collapse progression can be predicted to a certain extent on the basis of MRI performed at the early stage of injury.

332. Risk Factors of Loss of Correction After Long Pedicle Screw Fixation in Unstable Thoracolumbar Burst Fracture

Kyu-Jung Cho, MD; Young-Tae Kim
Republic of Korea

Summary: Despite applying long segmental fixation in unstable thoracolumbar burst fracture, progression of kyphotic deformity and loosening of screws were found. Ten of 32 patients showed loss of correction. Sagittal index was 8.24 ± 16.38 in the LOC group and 1.32 ± 3.16 in the control group. ($p < 0.001$) The risk factors were identified old age and osteoporosis. The comminution of vertebral body and the amount of fracture displacement in load sharing classification were not associated with the LOC.

333. The Use of Intra-Operative Blood Salvage Autotransfusion (IBSA) in Metastatic Spine Tumour Surgery (MSTS): What Is the Current Evidence in Oncological Surgeries? A Systematic Review of the Literature

Naresh S. Kumar, FRCS(Ed), FRCS(Orth), DM; Yongsheng Chen, MBBS, MRCS; Aye Sandar Zaw, MBBS, MPH; Victor K. Lee, MBBS; Hee-Kit Wong
Singapore

Summary: Metastatic spine tumour surgery is associated with significant blood loss, which is presently replenished by allogeneic blood transfusion. Intra-operative blood salvage autotransfusion (IBSA) can be a viable alternative but it is contraindicated in tumour surgery due to risk of tumour dissemination. There is emerging evidence of successful application of IBSA and leucocyte depletion filter (LDF) in removing tumour cells in blood salvaged during various oncological surgeries. Research on the use of IBSA-LDF in MSTS is urgently needed.

334. Eliminating Tumour Cells from the Salvaged Blood in Metastatic Spine Tumour Surgery Using Cell Saver and Leucocyte Depletion Filter: Dispelling an Old Myth

Naresh S. Kumar, FRCS(Ed), FRCS(Orth), DM; Yongsheng Chen, MBBS, MRCS; Aye Sandar Zaw, MBBS, MPH; Richie Soong, PhD; Hee-Kit Wong
Singapore

Summary: Surgical management of spinal metastasis is often associated with significant blood loss, which is presently replenished by allogeneic blood transfusion (ABT). Using cell saver can reduce ABT requirements but it is contraindicated in tumour surgery due to risk of tumour dissemination. Our study found that cell saver in combination with leucocyte depletion filter could remove tumour cells from blood salvaged during metastatic spine tumour surgery and this result is consistent with results from previous similar studies in other oncological specialities.

E-Poster Index

335. Optimal Schedule of Preoperative Embolization for Spinal Metastasis

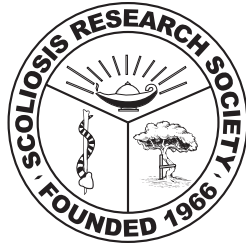
So Kato, MD; Takahiro Hozumi; Kiyofumi Yamakawa; Takahiro Goto; Taiji Kondo

Japan

Summary: Intraoperative blood loss was compared according to the time lapse between preoperative embolization and surgery for hypervascular spinal metastasis. Among those with complete embolization, 20 surgeries were performed on the same day and 41 surgeries were delayed up to 2 days later. The median blood loss were smaller in the same day group (345 mL vs. 590 mL, $p = 0.047$). Effectiveness of embolization can be reduced with delay and surgery should be performed on the same day if possible.

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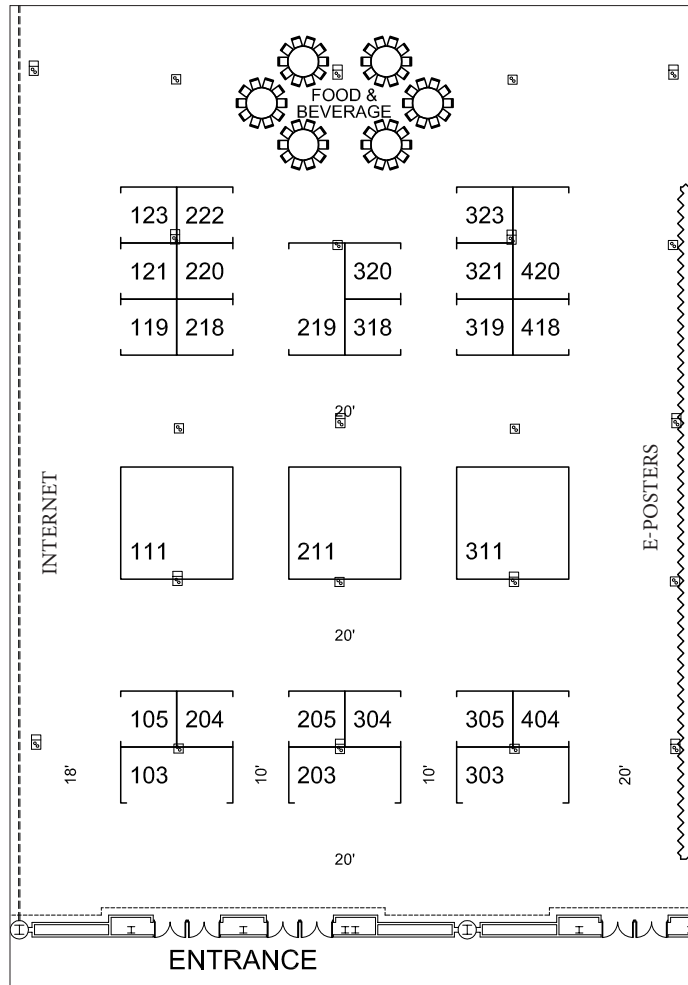
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SpineCraft is a privately-held, US medical device company founded in 2004 by a group of medical professionals and spine executives. The company creates intelligent solutions by listening to surgeons. Surgeon input remains central to the way we approach improving existing products or work on new ideas: from our Medical Advisory Board to the individual surgeons who work with us on product development. We hear and see, first-hand, the concerns and obstacles surgeons encounter. This approach results in more practical devices that provide intraoperative efficiency for surgeons, cost-effectiveness for the hospitals and healthcare system, and superior outcomes for patients.

SpineCraft is large enough to be able to provide the most advanced spine technology while meeting growing surgeon demand, yet small enough not to be hampered by inflated design and manufacturing processes that often prolong new product development at bigger companies. SpineCraft's main focus has been deformity correction and complex spine instrumentation.

Exhibit Descriptions

SPINEGUARD, INC.

1388 Sutter Street
Suite 510
San Francisco, CA 94109
Tel 415-512-2500
Fax 415-512-8004
www.spineguard.com

PediGuard is the world's first and only handheld device capable of alerting surgeons to potential pedicular or vertebral breaches. Real-time feedback is provided to surgeons via audio and visual signals. The PediGuard technology is available in 3 different tips; Classic PediGuard, Curved PediGuard and the Cannulated PediGuard. The primary objective of SpineGuard is to establish PediGuardR as the standard of care for safer pedicle screw placement to the benefit of patients, surgeons and health care providers. PediGuard has assisted orthopedic spine surgeons and neurosurgeons in the placement of over 100,000 screws worldwide. The company has offices in San Francisco and Paris. For further information, visit www.spineguard.com.

STRKYER

Stryker Spine, 2 Pearl Court
Allendale, NJ, 07401
Tel 1-866-45SPINE (457-7463)
www.stryker.com

Stryker is one of the world's leading medical technology companies and is dedicated to helping healthcare professionals perform their jobs more efficiently while enhancing patient care. The Company offers a diverse array of innovative medical technologies including reconstructive implants, medical and surgical equipment, and neurotechnology and spine products to help people lead more active and more satisfying lives. For more information about Stryker, please visit www.stryker.com.

ZIMMER SPINE

7375 Bush Lake Road
Minneapolis MN 55439
Tel 952-830-5600
www.zimmerspine.com

Zimmer Spine develops, produces and markets high quality spine products and services that repair, replace and regenerate spine health. Zimmer Spine works directly with surgeons to share best practices, facilitate surgeon-to-surgeon training and to provide continuous access to relevant information, all to improve patient outcomes. With continual technological advancement, Zimmer constructs highly competitive fusion and non-fusion spine systems, instrumentation systems, cervical plates, allograft bone filler and *Trabecular Metal*TM Technologies. Our products and procedures are designed to exceed doctor and patient expectations. Through the hands of skilled surgeons, Zimmer strives to enhance patient quality of life by alleviating pain and restoring mobility.

ZYGA

5600 Rowland Road, Suite 200
Minnetonka, MN 55343
Tel 855-455-1061
www.zyga.com

Zyga Technology is dedicated to the research, development and commercialization of solutions that provide empirical clinical and economic value in the treatment of under-served conditions of the spine. Zyga markets the SImmetry[®] Sacroiliac Joint Fusion System, the only minimally invasive system designed to provide a true arthrodesis of the SI Joint, including joint decortication and bone graft delivery.

Hands-on Workshops (HOW)

HOW SCHEDULE		
Wednesday, July 10, 2013		
15:00-17:00		
Biomet		
K2M		
Medtronic		
Thursday, July 11, 2013		
7:00-7:40	12:00-13:00	15:30-16:30
Medtronic	Biomet	Baxano Surgical
	Globus Medical	DePuy Synthes Spine
	K2M	K2M
	NuVasive	Stryker
Friday, July 12, 2013		
7:00-7:40	12:00-13:00	15:30-16:30
Medtronic	DePuy Synthes Spine	DePuy Synthes Spine
	K2M	
	Orthofix	
	OrthoPediatrics	

Wednesday, July 10, 15:00-17:00

BIOMET

Room: East 16

Translation™ Screw Technology, Multiple Platforms for Optimal Screw Placement

Presenters: Chris Shaffrey, MD; Sigurd Berven, MD; Justin Smith, MD

Biomet Spine introduces the next generation of its Translation™ Screw Technology, now available for use in Minimally Invasive and Open Thoracolumbar procedures. The Translation™ Screw Technology allows the screw head to translate 3mm medial-lateral relative to the screw shaft, allowing for less rod manipulation and easier rod introduction, as well as minimizes stress on the bone-to-screw interface*. *Data on file

HOW Descriptions

K2M

Room: East 19

MIS in Adult Deformity: Can It Work?

Presenters: John Kostuik, MD; Thomas Errico, MD; William Fred Hess, MD; Khaled Kebaish, MD; Mr Robert Lee

“Do technological advances overcome the challenges of MIS for Surgical Treatment of Adult Degenerative Lumbar Deformity? ”

1. Lumbar Lordosis Realignment
2. Short Segment Fixation:
 1. What can and can't be corrected
 2. What will and will not be improved
3. Demystifying the Evidence
 1. MIS vs Open
 2. Transient vs Long Term Complications
4. Technology matters: Safety Considerations

MEDTRONIC

Room: East 18

Implant Selection in the Complex Spine

Presenters: Charles G. Fisher, Marcel F. Dvorak, MD, FRCS, Lawrence G. Lenke, MD

Multi-axial, fixed angle, or sagittal adjusting screws? Titanium, stainless, or cobalt chrome rods? What about pedicle screw material? Is sagittal balance a consideration for patient outcome? With so many implant options from which to choose in today's world of complex spine, how do you decide which implants to best match the challenges in each of your cases? This workshop reviews pedicle screw types, material options, and biomechanical consideration in different procedures. Featuring CD HORIZON® SOLERA® Spinal System, this workshop includes didactic presentations and case reviews on screw selection and placement within deformity constructs

Thursday, July 11, 7:00-7:40

MEDTRONIC

Room: East 18

FacetLift: A New Treatment Option for Foraminal Stenosis Utilizing Facet Distraction

Presenters: Vincent Traynelis, MD

Please join us to learn a new technique that utilizes an allograft spacer and a set of facet joint prep instruments to treat posterior cervical foraminal stenosis through indirect decompression, and increases the stability of a posterior cervical fusion.

Thursday, July 11, 12:00-13:00

BIOMET

Room: East 16

DeRoduction, an Innovative Approach for Deformity Correction

Presenters: Michael Vitale, MD

Utilizing the DeRoduction™ Technique, Biomet Spine optimizes frontal, sagittal and axial plane deformity correction by decoupling the sequence of Derotation and Rod Reduction.

HOW Descriptions

GLOBAL MEDICAL

Room- East 17

Direct Visualization for MIS Lateral Lumbar Interbody Fusion

Presenters: Choll Kim, MD, PhD, San Diego Spine Institute, San Diego, CA; Joseph O'Brien, MD, MPH, George Washington University, Washington D.C.

This workshop will feature presentations and videos on the technique of direct visualization for the MIS LLIF approach. The Direct Look™ technique is a mini-open approach to the retroperitoneal space emphasizing complete visualization of the psoas muscle and identification of the corridor's neural structures. The goal of this approach is to improve surgical outcomes by decreasing postoperative leg pain, weakness, and sensory loss. The presentations will include case studies and outcome measurements. The workshop will also provide time for questions and hands on practice with the Direct Look™ instruments.

K2M

Room: East 19

Addressing Sagittal Plane Deformities in Adolescents and Young Adults

Presenters: Mr. Stuart Tucker; Laurel Blakemore, MD

- Challenges and Complications in Management of Sagittal Realignment
- Surgical Treatment of AIS and Scheuermann's Kyphosis: Impact of MESA Rail Technology
- Surgical Technique Demo: MESA Rail

NUVASIVE

Room: East 18

Anterior Column Realignment: MAS Techniques to Restore Sagittal Balance

Presenters: Behrooz Akbarnia, MD; Virginie Lafage, MD; Luiz Pimenta, MD; Juan Uribe, MD

Learning objectives:

Discuss sagittal and pelvic parameters and the overall importance of global spinal balance.

Demonstrate the benefits of XLIF ACR (Anterior Column Realignment) in conjunction with Precept vs. traditional open procedures when correcting sagittal balance.

Thursday, July 11, 15:30-16:30

BAXANO SURGICAL

Room: East 17

An Effective Surgical Alternative

Presenter: TBD

Presentation will highlight the AxiaLIF® Plus System, which offers a presacral approach to L5-S1 lumbar fusion, utilizing an expandable implant while enabling preservation of the annulus and paraspinal soft tissue structures. The presentation will be supported with two interactive demos that highlight the biomechanical advantages of AxiaLIF® Plus as compared to other interbody devices. The first demo will highlight the AxiaLIF® Plus screw strain benefits via a computerized strain gauge demo. The second demo will highlight subsidence resistance of the AxiaLIF® Plus System via a mechanical press system.

DEPUY SYNTHES

Room: East 18

Expanding the Limits of MIS: Complex Correction Techniques

Presenters: TBD

This session is designed for surgeons experienced with MIS procedures who want to learn new MIS techniques and advance their expertise in this area. This session will include a discussion on techniques for deformity correction through percutaneous fixation and an overview of the lateral approach to interbody fusion with the DePuy Spine MIS Lateral Platform.

HOW Descriptions

K2M

Room: East 19

Adolescent Idiopathic Scoliosis: Getting the Right Contour

Presenters: Mr David Marks; Mr John Ferguson; Martin Gehrchen, MD, PhD; Benny Dahl, MD

1. Contouring Considerations and Technique
2. Net Sagittal Realignment Strategies: Rigidity Selection and Low Profile
3. Surgical Technique Demo: MESA Rail

STRYKER

Room: East 16

Direct Vertebral Rotation for Adolescent Idiopathic Scoliosis Featuring XIA® 3, Suk® DVR, Ilios Revision Systems

Presenters: Professor Se Il Suk, MD, Seoul, Korea

This workshop will offer participants an opportunity to evaluate new corrective derotation techniques for the treatment of deformity. Participants will also assess the applications of deformity implants and how they impact the decision-making process.

Friday, July 12, 7:00-7:40

MEDTRONIC

Room: East 18

Oblique Lateral Interbody Fusion for L2-L5 (OLIF25TM) with Cortical Bone Screw Fixation.

Presenters: John Liu, MD

OLIF25TM represents a novel approach to lateral lumbar fusion. It is a psoas preserving approach to the lumbar spine that remains anterior to the neural elements that comprise the lumbar plexus. It also allows for easier access to the L4-L5 disc space in patients with a high iliac crest. Cortical bone fixation can be achieved through a minimally invasive approach that preserves muscle and neurovascular elements.

Friday, July 12, 12:00-13:00

DEPUY SYNTHES

Room: East 18

Advanced Techniques in Treating AIS

Presenters: TBD

This workshop is designed for surgeons who want to learn about advanced techniques in treating AIS from an expert panel. This case based session will include an overview of the latest available technology and techniques for treating complex deformity in the adolescent population.

K2M

Room: East 19

Adult Sagittal Plane Deformity Correction: Considerations and Pre-Op Planning

Presenters: Oheneba Boachie-Adjei, MD; Frank Schwab, MD; Han Jo Kim, MD; Luke Zebala, MD

1. Sagittal realignment: what are the principals; what happens when you ignore them?
2. Rigidity Selection and Early Results with MESA Rail
3. Osteotomy Pre-Op Planning: Surgical Mapping Demo

HOW Descriptions

ORTHOFIX SPINE

Room: East 17

The Power of Modularity

Presenter: Rajiv Sethi, MD

Our hands-on workshop will highlight the clinical advantages of utilizing a modular pedicle screw system and how that can provide greater interoperative options for posterior approaches to spinal deformity correction. The session will feature a robust interactive case study review using audience participation software followed by a hands-on demonstration.

ORTHOPEDIATRICS

Room: East 16

Response Spine System: Treating Pediatric Scoliosis

Presenters: George Thompson, MD; Michael Albert MD

Friday, July 12, 15:30-16:30

DEPUY SYNTHES

Room: East 18

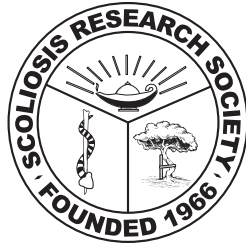
Correction Techniques in Adult Deformity

Presenters: TBD

This hands-on-workshop is designed for surgeons experienced with open deformity procedures who want to learn new techniques for instrumented deformity correction utilizing the Favored Angle Screw. The session will include a technique discussion with case examples as well as hands-on demonstration.

Author Index





Instant video archives will be available to all meeting delegates on the SRS website (<http://www.srs.org/meetings/>) 4-6 weeks after the meeting.

New this year!

All session rooms, both main ballrooms and break-out rooms, are being recording. If you were unable to attend a concurrent session, don't forget to watch it on the website!

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PRESENTATION KEY

1-185 = Paper/ Podium Presentations (Including Two-Minute Point) 200-335 = E-Posters RT= Roundtable Sessions ICL= Instructional Course Lectures
DB= Debate Series CS= Complication Series

About SRS

Founded in 1966, the Scoliosis Research Society is an organization of medical professionals and researchers dedicated to improving care for patients with spinal deformities. Over the years, it has grown from a group of 35 orthopaedic surgeons to an international organization of more than 1,200 health care professionals.

MISSION STATEMENT

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

MEMBERSHIP

SRS is open to orthopaedic surgeons, neurosurgeons, researchers and allied health professionals who have a practice that focuses on spinal deformity.

Active Fellowship (membership) requires the applicant to have fulfilled a five-year Candidate Fellowship and have a practice that is 20% or more in spinal deformity. Only Active Fellows may vote and hold elected offices within the Society.

Candidate Fellowship (membership) is open to all orthopaedic surgeons, neurosurgeons and researchers in all geographic locations who are willing to commit to a clinical practice which includes at least 20% spinal deformity. Candidate Fellows stay in that category for five years, during which time they must demonstrate their interest in spinal deformity and in the goals of the Scoliosis Research Society. Candidate Fellows may serve on SRS committees. After five years, those who complete all requirements are eligible to apply for Active Fellowship in the Society. Candidate Fellowship does not include the right to vote or hold office.

Associate Fellowship (membership) is for distinguished members of the medical profession including nurses, physician assistants, as well as orthopaedic surgeons, neurosurgeons, scientists, engineers and specialists who have made a significant contribution to scoliosis or related spinal deformities who do not wish to assume the full responsibilities of Active Fellowship. Associate Fellows may not vote or hold office, but may serve on committees.

See website for membership requirement details.

PROGRAMS AND ACTIVITIES

SRS is focused primarily on education and research through the Annual Meeting, the International Meeting on Advanced Spine Techniques (IMAST), Worldwide Conferences, a Global Outreach Program, the Research Education Outreach (REO) Fund which provides grants for spine deformity research, and development of patient education materials.

WEBSITE INFORMATION

For the latest information on SRS meetings, programs, activities and membership please visit www.srs.org. The SRS Website Committee works to ensure that the website information is accurate, accessible and tailored for target audiences. Site content is varied and frequently uses graphics to stimulate ideas and interest. Content categories include information for medical professionals, patients/public, and SRS members.

For more information and printable membership applications, please visit the SRS website at www.srs.org.

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SCOLIOSIS RESEARCH SOCIETY PRESENTS

IMAST

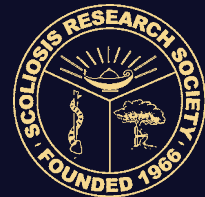
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WWW.SRS.ORG

Registration open – February 2014
Abstract submission open – November 1, 2013
Abstract deadline – February 1, 2014

VALENCIA abstracts JULY 16-19
2014

SCOLIOSIS RESEARCH SOCIETY
49th ANNUAL MEETING & COURSE
SEPTEMBER 10-13, 2014



A N C H O R A G E ALASKA USA

Registration open - April 2014
Abstract submission open - November 1, 2013
Abstract deadline - February 1, 2014

www.srs.org



Meeting Overview

Wednesday, July 10, 2013	
8:00-15:00	Board of Directors Meeting Exhibit Set-Up
14:00-19:30	Registration Open
15:00-17:00	*Hands-On Workshops with Beverages, Snacks
17:00-19:30	Welcome Reception
Thursday, July 11, 2013	
7:00-16:30	Exhibits Open Registration Open
7:00-7:40	Breakfast & Exhibit Viewing *Hands-On Workshop with Breakfast
7:40-9:10	General Session
9:10-9:25	Walking Break
9:25-10:25	Concurrent Roundtable Sessions 1A-D
10:25-10:35	Refreshment Break
10:35-11:50	Concurrent Abstract & Debate Sessions
12:00-13:00	Exhibit Viewing with Lunch *Hands-On Workshops with Lunch
13:10-14:10	Concurrent Abstract & Complication Series
14:10-14:20	Refreshment Break
14:20-15:20	Instructional Course Lectures 1A-D
15:20-15:30	Walking Break
15:30-16:30	*Hands-On Workshops with Beverages, Snacks
*Denotes Non-CME Session	

Friday, July 12, 2013	
7:00-16:00	Exhibits Open Registration Open
7:00-7:45	Breakfast & Exhibit Viewing *Hands-On Workshop with Breakfast
7:45-8:45	Concurrent Abstract and Debate Sessions
8:45-9:15	Refreshment Break
9:15-10:15	Concurrent Roundtable Sessions 2A-D
10:15-10:25	Walking Break
10:25-11:50	Concurrent Abstract & Complication Series
12:00-13:00	Exhibit Viewing with Lunch *Hands-On Workshops with Lunch Member Information Session
13:10-14:10	Concurrent Roundtable Sessions 3A-D
14:10-14:20	Refreshment Break
14:20-15:20	Instructional Course Lectures 2A-D
15:20-15:30	Walking Break
15:30-16:30	*Hands-On Workshop with Beverages, Snacks
19:00-22:00	Course Reception
Saturday, July 13, 2013	
7:00-12:15	Registration Open Exhibits Closed
7:00-7:45	Breakfast
7:45-8:45	Instructional Course Lectures 3A-D
8:45-9:00	Walking Break
9:00-10:30	Concurrent Abstract and Debate Sessions
10:30-10:45	Refreshment Break
10:45-12:15	Concurrent Abstract and Complications Series
12:15	Meeting Adjourns
*Denotes Non-CME Session	