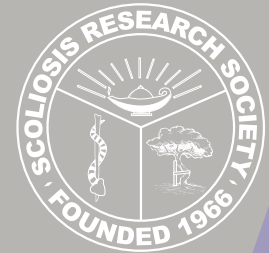


SCOLIOSIS RESEARCH SOCIETY presents

23<sup>RD</sup>  
INTERNATIONAL  
MEETING ON  
ADVANCED  
SPINE  
TECHNIQUES

Sponsored by the  
Scoliosis Research Society



WWW.SRS.ORG

IMAST 2016

**FINAL  
PROGRAM**

JULY 13-16, 2016  
WASHINGTON, D.C., USA

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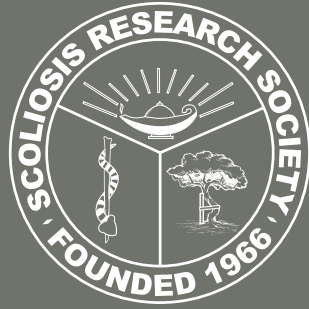
# GENERAL INFORMATION

IMAST2016

23<sup>RD</sup> INTERNATIONAL MEETING ON  
ADVANCED SPINE TECHNIQUES

JULY 13-16, 2016  
WASHINGTON, D.C., USA





**The Scoliosis Research Society  
gratefully acknowledges Globus Medical  
for their overall support of IMAST.**





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## 23<sup>rd</sup> IMAST Venue

Marriott Marquis Washington, D.C.  
901 Massachusetts Avenue NW  
Washington, District of Columbia 20001 USA

## Future Educational Events

### 51<sup>st</sup> Annual Meeting & Course

September 21-24, 2016  
Prague, Czech Republic

### 7<sup>th</sup> Spine Deformity Solutions: A Hands-On Course

October 28-30, 2016  
Hong Kong, China

### 24<sup>th</sup> International Meeting on Advanced Spine Techniques

July 12-15, 2017  
Cape Town, South Africa

### Bali, Indonesia

*In Conjunction with the Indonesian Spine Society*  
August 10-11, 2016

### Santiago, Chile

*In Conjunction with the Chilean Spine Society*  
November 16-17, 2016

### Kyoto, Japan

*In Conjunction with the Japanese Spine Society*  
November 17-19, 2016



## CHAIR'S MESSAGE

Dear Participant,

I would like to personally welcome you to Washington, D.C., for what promises to be an inspiring academic meeting. As a Society we continue to make incredible strides in the field of spinal deformities and are excited to showcase these advancements at the 23<sup>rd</sup> IMAST with our colleagues from around the world.

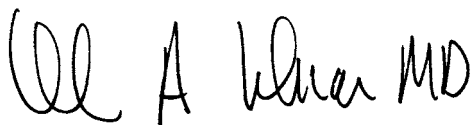
To continue providing a world-class meeting with the best educational value and at the request of our delegation, we are again offering video-based sessions, after their successful debut in 2015. These sessions include "Surgical Techniques: A Video-Based Session" on Friday from 10:30-11:55. We will also continue to offer Special Symposia sessions on Wednesday, July 13 from 15:00-16:45. The symposia topics will be "Modern Perspectives on Spine Care: Where Is Healthcare Going?" and "Novel Treatment Techniques in Spinal Deformity." After the symposium we encourage delegates to take part in the Hands-On Workshops which will be followed by the Welcome Reception in the exhibit hall.

The program also includes the popular complication and debates series, instruction course lectures (ICLs), roundtable case discussions, and four and two-minute podium presentations; all led by an international and multidisciplinary faculty. We encourage all delegates to engage in the interactive and innovative program we have planned.

Along with the exciting program, Washington, D.C. is a must-see city with a magnificent assortment of monuments, museums and attractions. When you have time in your schedule we invite you to take advantage of these opportunities and see what this great city has to offer!

I am honored to serve as your IMAST Chairman this year. I want to thank those whose leadership and diligent efforts have created such a successful meeting, including; David W. Polly, Jr., MD; Kenneth MC Cheung, MD; Todd J. Albert, MD; John P. Dormans, MD; Henry F.H. Halm, MD, IMAST Committee Co-Chair and the IMAST Committee.

With warmest personal regards,



Ronald A. Lehman, Jr., MD  
IMAST Committee Chair



### IMAST Mobile App

A mobile app will be available to all delegates during the 23<sup>rd</sup> IMAST. The app is designed to provide all the information about Washington, D.C. and the meeting in one convenient location and can be accessed from any smart phone or tablet with an internet connection.

To download the 23<sup>rd</sup> IMAST Mobile App: **1. Search for "IMAST2016" in the App Store or Google Play and install 2. Open the downloaded app to begin using the app right away**

Download all abstracts and the final program right from the app!

- Once downloaded, delegates can access all static content, including the agenda, speaker listing and info booth, on the app without an internet connection.
- A detailed IMAST agenda allows delegates to create a personalized schedule.
- Exhibitor information includes exhibit floor plan, company descriptions and the Hands-On Workshop schedule.
- An "information booth" features everything you need to know about IMAST, and its host city of Washington, D.C., including scientific and social program details, housing information, as well as D.C. dining and attractions.
- Maps of the meeting space at the Marriott Marquis
- 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.

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

# 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 sessions, 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 and regional 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 and apply that analysis to treatment decisions.
- Present a variety of new objective cost and outcome analyses.
- Formulate a pre-operative plan and analyze its results.
- Identify how attention to safety issues facilitates risk-stratification.

## 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 16.5 *AMA PRA Category 1 Credit(s)*<sup>™</sup>. 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 Continuing Medical Education (CME) activity conforms to the generally accepted standards of experimental design, data collection and analysis.

## 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.

## CME Information

CME certificates will be available to pre-registered delegates upon the opening of the meeting at [www.srs.org/imast2016/](http://www.srs.org/imast2016/). Delegates who registered onsite may access their certificates after August 1, 2016.

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, and then will generate a PDF certificate which may be printed or saved to the delegate's computer. Session attendance is 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](mailto:meetings@srs.org) for any questions. SRS asks that all CME certificates be claimed no later than November 1, 2016.

Certificates of attendance will be emailed to each delegate upon checking in at the registration desk at the meeting. Delegates will not receive a paper copy of the certificate in their registration materials. If you would like a paper copy, please stop at the registration desk before the close of the meeting. Evaluations will be available to all attendees at the commencement of the meeting. Evaluations are available at [www.srs.org/imast2016/](http://www.srs.org/imast2016/).



# GENERAL MEETING INFORMATION

## Session Information

### Instructional Course Lectures (ICLs)

There will be four (4) 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 four (4) 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. 21.

### Complications Series

The complications 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. 21.

### Two-Minute Point Presentations

Two-Minute Point Presentations will continue in the abstract portion of the program this year. These four (4) lightning rounds were selected from the abstracts submitted to the 2016 meetings. The sessions will follow a similar format to the traditional podium presentations, however, with a limited number of slides and time. Two-Minute Point presentations will also be available for review on the Two-Minute Point kiosks located in the Eastern Market room on Meeting Level 3. The Two-Minute Point Presentations are also available on a USB drive included with your registration materials.

*Two-Minute Point Presentation Kiosks are supported, in part, by a grant from K2M.*

### Special Symposia

We encourage delegates to take part in the following afternoon activities on Wednesday, July 13.

Special Symposia – 15:00-16:45 (sessions run concurrently)

1A. Modern Perspectives on Spine Care: Where is Healthcare Going?

1B. Novel Treatment Techniques in Spinal Deformity

Each symposium will cover new and innovative topics featuring five different lectures from world-class faculty.

After the symposia we encourage delegates to take part in the Hands-On Workshops (HOWs) from 17:00-19:00 which will be followed by the Welcome Reception in the Exhibit Hall from 19:00-21:00.

## Attire

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

## Exhibits & Hands-On Workshops

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.

Each Hands-On Workshop (HOW) 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 of the Marriott Marquis Washington, D.C.

To log on select...

Network = IMAST2016

Password = spine2016

Note: Internet cookies must be enabled to connect

## Internet Kiosks

Delegates without laptops may access complimentary Internet kiosks located in the Eastern Market Room on Meeting Level 3.

*Internet Kiosks are supported, in part, by a grant from Orthofix.*

## Language

Presentations and course materials will be provided in English.

## No Smoking Policy

Smoking is not permitted during any IMAST activity or event.

## Presentation Upload Area

Location: Salon 1-5 (Main session hall)

Presenters may upload their PowerPoint presentations in the Speaker Ready Area located at the back of the main session room, Salon 1-5

### Hours:

Wednesday, July 13 14:00-21:00 (during the Welcome Reception)

Thursday, July 14 7:30-18:30

Friday, July 15 7:30-18:00

Saturday, July 16 7:45-12:30

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

# GENERAL MEETING INFORMATION

## Registration Desk Hours

Location: Meeting Level 2 Foyer

Wednesday, July 13 14:00-21:00 (during the Welcome Reception)

Thursday, July 14 7:30-18:00

Friday, July 15 7:30-16:45

Saturday, July 16 8:15-11:30

## Video Recording Prohibited

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

## Video Archives

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

# SOCIAL EVENTS

## Welcome Reception

All registered delegates and registered guests are invited to pick up their registration materials and to attend the IMAST Welcome Reception on Wednesday, July 13 from 19:00-21:00. The reception will be hosted in the Exhibit Hall in Salon 6 of the Marquis Ballroom on Meeting Level 2 of the Marriott Marquis Washington, D.C., where beverages and light hors d' oeuvres will be served. There is no charge for registered delegates, though a ticket must 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.

We encourage delegates to take part in the following afternoon activities before the Welcome Reception on Wednesday, July 13.

### 15:00 – 16:45 Special Symposia

1A. Modern Perspectives on Spine Care: Where is Healthcare Going?

1B. Novel Treatment Techniques in Spinal Deformity

### 17:00 – 19:00 Hands-On Workshops with Beverages & Snacks

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

## Course Reception

IMAST delegates and registered guests are invited to take part in a closing reception at the Smithsonian National Zoological Park on Friday, July 15 from 19:00 – 22:00. Join us at this amazing zoo for a wild night of networking and delicious cuisine from the area. Tickets are \$25 USD each for registered delegates and \$30 USD each for registered guests and must 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. Casual attire is appropriate for the Course Reception but please keep in mind the event will be both indoors and outdoors and there will be some walking and uneven pavement so we recommend wearing sensible shoes.

## Membership Info Session

Prospective members and new candidate members are invited to attend a membership information session Friday, July 15 from 16:45 – 17:00 in Salon 14 - don't miss this opportunity to learn more about the SRS!

## Optional Tours

Please visit [www.srs.org/imast2016/tours](http://www.srs.org/imast2016/tours) for a list of some of the incredible attractions available for you to visit while in D.C.

Washington D.C. offers a large number of tours and attractions for little to no cost! These tours and attractions are available to any resident or visitor to D.C. Due to the ease and convenience of tours and attractions, SRS will not be providing any scheduled tours. When you find you have time in your schedule, be sure to take advantage of these opportunities and see what this great city has to offer!



# MEETING OVERVIEW

	Tuesday, July 12	Wednesday, July 13	Thursday, July 14	Friday, July 15	Saturday, July 16
Morning	8:00 – 17:00 Exhibit Setup	8:00 – 12:00 Exhibit Setup/ Exhibitor Registration Open Board of Directors Meeting	*7:30 – 8:30 Hands-On Workshops with Breakfast 7:30 – 18:00 Delegate Registration Open 8:15 – 8:45 Breakfast & Exhibit Viewing 8:45 – 10:15 General Session: Whitecloud Clinical Award Nominees & Presidential Address 10:15 – 11:00 Refreshment Break & Exhibit Viewing 11:00 – 12:15 Concurrent Abstract Sessions & Debate Session 12:15 – 12:30 Walking Break	*7:30 – 8:30 Hands-On Workshops with Breakfast 7:30 – 16:45 Delegate Registration Open 8:00 – 8:40 Breakfast & Exhibit Viewing 8:40 – 9:40 Concurrent Abstract Sessions & Debate Session 9:40 – 10:30 Refreshment Break & Exhibit Viewing 10:30 – 11:55 Concurrent Abstract Sessions & Complications Series 11:55 – 12:05 Walking Break	8:15 – 11:30 Delegate Registration Open 8:15 – 8:45 Breakfast/Exhibits Closed 8:45 – 9:45 Concurrent ICLs 9:45 – 10:00 Refreshment Break 10:00 – 11:00 Concurrent Debate Series 11:00 – 11:30 Walking Break & Lunch Buffet
Afternoon		12:00 – 14:00 Exhibit Setup Board of Directors Meeting 14:00 – 21:00 Delegate Registration Opens 15:00 – 16:45 Symposia A Symposia B 16:45 – 17:00 Walking Break	*12:30 – 13:30 Lunch Exhibit Viewing Hands-On Workshops 13:45 – 14:45 Concurrent ICLs & Two-Minute Point Presentations 14:45 – 15:00 Walking Break 15:00 – 15:55 Concurrent Abstract Sessions/ Complications Series & Point Presentations 15:55 – 16:15 Refreshment Break & Exhibit Viewing 16:15 – 17:15 Concurrent Roundtable & Abstract Sessions 17:15 – 17:30 Walking Break	*12:05 – 13:05 Lunch Exhibit Viewing Hands-On Workshops 13:15 – 14:15 Concurrent Roundtable Sessions & Two-Minute Point Presentations 14:15 – 14:30 Walking Break & Exhibit Viewing 14:30 – 15:30 Concurrent Abstract Sessions & Debates, ICLs 15:30 – 15:45 Walking Break 15:45 – 16:45 Concurrent ICLs & 2-Minute Point Presentations	11:30 – 13:00 Lunch with the Experts 13:00 Adjourn
Evening		*17:00 – 19:00 Hands-On Workshops with Beverages & Snacks *19:00 – 21:00 Welcome Reception in Exhibit Hall	*17:30 – 18:30 Hands-On Workshops with Beverages & Snacks Free Evening	*19:00 – 22:00 Course Reception	

\*Denotes Non-CME Session

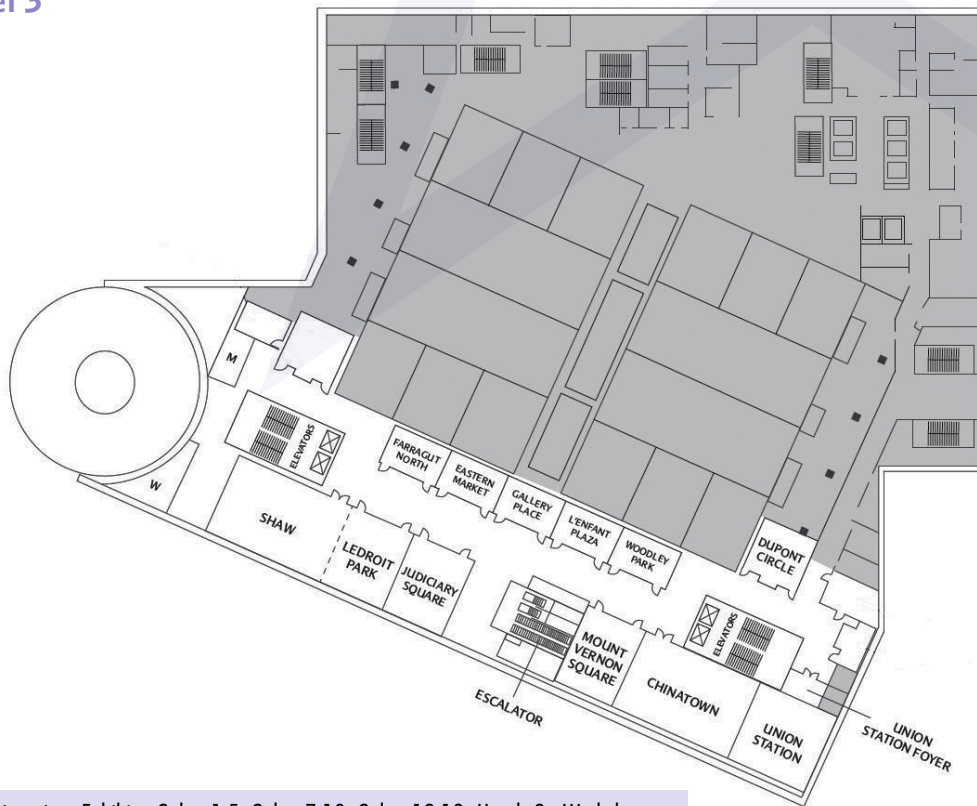


# MARRIOTT MARQUIS FLOOR PLAN

## Meeting Level 2



## Meeting Level 3



Meeting Level 2-Registration, Exhibits, Salon 1-5, Salon 7-10, Salon 12-13, Hands-On Workshops

Meeting Level 3-Internet & Point Kiosks, Chinatown, Shaw/Ledroit Park, Hands-On Workshops





# AUTHOR DISCLOSURES

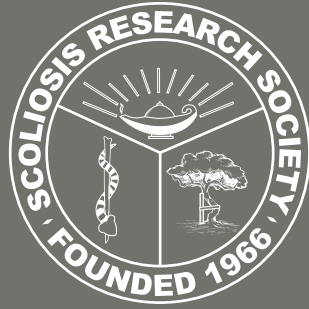
IMAST2016

23<sup>RD</sup> INTERNATIONAL MEETING ON  
ADVANCED SPINE TECHNIQUES

JULY 13-16, 2016  
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**The Scoliosis Research Society  
gratefully acknowledges K2M for  
their support of the Two-Minute Point  
Presentation Kiosks.**



# AUTHOR DISCLOSURES

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Lawrence L. Haber, MD	United States	No Relationships
Yong Hai, MD, PhD	People's Republic of China	No Financial Relationships
Henry F.H. Halm, MD	Germany	NuVasive (b, g)

If noted, the Relationship(s) disclosed are as follows:

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



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Fiona Wai Ping Yu, MPH	Hong Kong	No Relationships
Haiming Yu, MD	United Kingdom	No Relationships
Yang Yu, MD, PhD	People's Republic of China	No Relationships
Selcen Yuksel, PhD	Turkey	No Relationships
Martin Žabka, MD, PhD	Slovakia	No Relationships
Faissal Zahrawi, MD	United States	Mazor Robotics (a, b); Sentio (b)
Joseph M. Zavatsky, MD	United States	Amedia (b, e); DePuy Synthes (b); Safe Wire (b, g); Sentio (b, g); Stryker Spine (b); Vivex (b, g); Zimmer Biomet (b, g);
Aye Sandar Zaw	Singapore	No Relationships
Hong Zhang, MD	United States	No Relationships
Jianguo Zhang, MD	People's Republic of China	No Relationships
XueSong Zhang, MD	People's Republic of China	No Relationships
Yue Zhang, PhD	United States	No Relationships
Guoquan Zheng	People's Republic of China	No Relationships
Zhaomin Zheng, MD, PhD	People's Republic of China	No Relationships
Chunguang Zhou, MD, PhD	People's Republic of China	No Relationships
Qianyu Zhuang, MD	People's Republic of China	No Relationships
Ze-zhang Zhu, MD	People's Republic of China	No Relationships

If noted, the Relationship(s) disclosed are as follows:

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



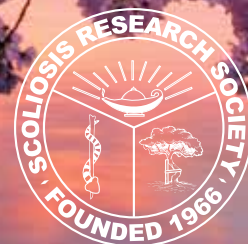


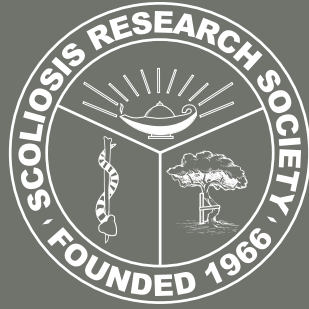
# MEETING AGENDA

IMAST 2016

23<sup>RD</sup> INTERNATIONAL MEETING ON  
ADVANCED SPINE TECHNIQUES

JULY 13-16, 2016  
WASHINGTON, D.C., USA





**The Scoliosis Research Society  
gratefully acknowledges Medtronic for  
their support of the Welcome Reception,  
Newsletter and Refreshment Breaks.**





# MEETING AGENDA

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

Wednesday, July 13, 2016

14:00 – 21:00 **Registration Open**

MEETING LEVEL 2 FOYER

15:00 – 16:45 **Concurrent Sessions 1A-B: Special Symposia**

## 1A. Modern Perspectives on Spine Care: Where Is Healthcare Going?

ROOM: SALON 12-13

Moderators: Steven D. Glassman, MD & David W. Polly, Jr., MD

15:00 - 15:12

**SAVES System in a European Population: Lessons for the World**

*Benny T. Dahl, MD, PhD, DMSci*

15:12 - 15:24

**Societal Perspectives on Elderly Spine Problems: When to Say “No”**

*Marinus De Kleuver, MD, PhD*

15:24 - 15:34

**Discussion**

15:34 - 15:46

**JetBlue, Walmart and Lowes: Why Are Large Multinational Companies Choosing Centers of Excellence in Spine Care?**

*Rajiv K. Sethi, MD*

15:46 - 15:58

**How to Build a “Center of Excellence” Around Quality and Risk Stratification**

*Stephen L. Ondra, MD*

15:58 - 16:08

**Discussion**

16:08 - 16:32

**Modern Approach to Regulatory Activities in the Spinal Arena**

*Anton Dmitriev, PhD*

16:32 - 16:45

**Discussion**

## 1B. Novel Treatment Techniques in Spinal Deformity

ROOM: SALON 7-10

Moderators: Neel Anand, MD, Mch Orth & Dean M. Chou, MD

15:00 - 15:15

**Spinal Deformity and MIS: When it Can Be Used, What Are the Limits of MIS Deformity Surgery and When to Go Open**

*Praveen V. Mummaneni, MD*

15:15 - 15:30

**Anterior Column Realignment: How Much Lordosis Can Realistically Be Achieved and How Much Risk is There to Anterior Vasculature?**

*Juan S. Uribe, MD*

15:30 - 15:45

**Discussion**

15:45 - 16:00

**The Ante-Psoas Approach for Spinal Deformities**

*Ronald A. Lehman, Jr., MD*

16:00 - 16:15

**Robotic Surgery Compared with Navigation**

*Christopher R. Good, MD*

16:15 - 16:30

**Case Presentations with Panel Discussion**

*Ronald A. Lehman, Jr., MD; Praveen V. Mummaneni, MD; Neel Anand, MD, Mch Orth; Dean Chou, MD; Juan S. Uribe, MD; S. Samuel Bederman, MD, PhD, FRCSC*

16:30 - 16:45

**Discussion**



# MEETING AGENDA

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## Wednesday, July 13, 2016

16:45 – 17:00 **Walking Break**

17:00 – 19:00 **\*Hands-On Workshops**

ROOM: SALON 14, SALON 15

(See "Exhibits and Hands-On Workshops (HOW) section on page 191 for more information)

19:00 – 21:00 **Welcome Reception in the Exhibit Hall**

ROOM: SALON 6

## Thursday, July 14, 2016

7:30 – 18:00 **Registration Open**

MEETING LEVEL 2 FOYER

7:30 – 8:30 **\*Hands-On Workshops with Breakfast**

ROOMS: SALON 14; SALON 15; JUDICIARY SQUARE

(See Exhibits and Hands-On Workshops (HOW) section on page 191 for more information)

8:15 – 17:30 **Exhibits Open**

ROOM: SALON 6

8:15 – 8:45 **Exhibit Viewing & Breakfast**

ROOM: SALON 6

8:45 – 10:15 **General Session and Whitecloud Clinical Nominees**

ROOM: SALON 1-5

Moderators: Ronald A. Lehman, Jr., MD & Christopher I. Shaffrey, MD

8:45 - 8:50 **Welcome Address**

*Ronald A. Lehman, Jr., MD*

*IMAST Committee Chair*

8:50 - 8:54

**Paper 1: Surgical Planning of Anterior Vertebral Body Tethering in Pediatric Idiopathic Scoliosis<sup>†</sup>**

*Nikita Cobetto, BS, MS; Carl-Eric Aubin, PhD, P.Eng.; Stefan Parent, MD, PhD*

8:54 - 8:58

**Paper 2: Treatment of Severe Scoliosis: Role of Traction Halo vs Progressive Magnetic Temporary Bar For Correction and Fusion in Two Separate Times (An Innovative Technique)<sup>†</sup>**

*Tiziana Greggi, MD; Elena Maredi, MD; Francesco Vommaro, MD; Stefano Giacomini, MD; Mario Di Silvestre, MD; Andrea Baioni, MD*

8:58 - 9:02

**Paper 3: Selective Thoracic Fusion with Spontaneous Improvement of Lumbar Curve in Adolescent Idiopathic Scoliosis Patients<sup>†</sup>**

*Shyam Kishan, MD; Dennis Raymond Knapp, MD; Mark D. Rahm, MD; Karl E. Rathjen, MD; Virginie Lafage, PhD; Matthew E. Cunningham, MD, PhD; Oheneba Boachie-Adjei, MD; Hongda Bao, MD, PhD; Julie Lynn Reigrot, MS*

9:02 - 9:09

**Discussion**

9:09 - 9:13

**Paper 4: Comparison of the Risk of Spinal Cord Injury during Different Surgical Steps in Severe Thoracic Scoliosis Posterior Approach Vertebral Column Resection<sup>†</sup>**

*Yang Junlin, MD, PhD; Huang Zifang, MD, PhD*

# MEETING AGENDA

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Thursday, July 14, 2016

- 9:13 - 9:17 **Paper 5: Risk Factors for Revision Surgery Following Primary Adult Spinal Deformity Surgery in Patients 65 Years and Older<sup>†</sup>**  
*Varun Puvanesarajah; Francis H. Shen, MD; Jourdan M. Cancienne, MD; Amit Jain, MD; Adam L. Shimer, BS, MD; Hamid Hassanzadeh, MD*
- 9:17 - 9:21 **Paper 6: Assessment of a Novel Adult Cervical Deformity (ACD) Frailty Index (FI) as a Component of Preoperative Risk Stratification<sup>†</sup>**  
*Emily Kristine Miller, BA; Tamir Ailon, MD, FRCSC, MPH; Brian James Neuman, MD; Eric O. Klineberg, MD; Gregory M. Mundis, Jr., MD; Daniel M. Sciubba, MD; Khaled M. Kebaish, MD, FRCSC; Virginie Lafage, PhD; Justin K. Scheer, BS; Justin S. Smith, MD, PhD; D.Kojo Hamilton, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group*
- 9:21 - 9:28 **Discussion**
- 9:28 - 9:32 **Paper 7: Primary vs Revision Adult Cervical Deformity: A Prospective Multicenter Study with 1-Year Follow-up<sup>†</sup>**  
*Alex Soroceanu, MD, MPH, FRCSC; Justin S. Smith, MD, PhD; Munish Chandra Gupta, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Robert A. Hart, MD; Virginie Lafage, PhD; Douglas C. Burton, MD; Justin K. Scheer, BS; Frank J. Schwab, MD; Thomas J. Errico, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; International Spine Study Group*
- 9:32 - 9:36 **Paper 8: Location of Correction Within the Lumbar Spine Impacts Acute Adjacent Segment Kyphosis<sup>†</sup>**  
*Renaud Lafage, MS; Ibrahim Obeid, MD; Barthelemy Liabaud, MD; Shay Bess, MD; Douglas C. Burton, MD; Justin S. Smith, MD, PhD; Cyrus M. Jalaj, BA; Richard Hostin, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group*
- 9:36 - 9:40 **Paper 9: Incidence of Proximal Junctional Kyphosis in Patients with Adult Spinal Deformity Fused to the Pelvis: A ScolioRisk-1 Sub-analysis<sup>†</sup>**  
*Amit Jain, MD; Floreana Naef Kebaish, MD; Lawrence G. Lenke, MD; Yong Qiu, MD; Yukihiko Matsuyama, MD, PhD; Christopher P. Ames, MD; Michael G. Fehlings, MD, PhD, FRCSC; Benny T. Dahl, MD, PhD; Hossein Mehdian, MD; Kenneth MC Cheung, MD; Frank J. Schwab, MD; Ferran Pellisé, MD; Leah Yacat Carreon, MD, MSc; Christopher I. Shaffrey, MD; Khaled M. Kebaish, MD, FRCSC*
- 9:47 - 9:52 **Discussion**
- 9:47 - 9:52 **Introduction of the SRS President**  
*Kenneth MC Cheung, MD, SRS President-Elect*
- 9:52 - 10:07 **Keynote Address**  
*David W. Polly, Jr., MD, SRS President*
- 10:07 - 10:15 **Preview of 51<sup>st</sup> Annual Meeting – Prague, Czech Republic and 24<sup>th</sup> IMAST – Capetown, South Africa**  
*Martin Repko, MD, PhD and Robert N. Dunn, MMed FCS(SA) Orth, Local Hosts*

10:15 – 11:00 **Refreshment Break & Exhibit Viewing**

ROOM: SALON 6



# MEETING AGENDA

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

Thursday, July 14, 2016

11:00 – 12:15 **Concurrent Sessions 2A-C: Abstract Sessions and Debate Series**

## 2A. Whitecloud Basic Science Nominees and Top-Scoring Abstracts

ROOM: SALON 1-5

Moderators: James O. Sanders, MD & Justin S. Smith, MD, PhD

- 11:00 - 11:04 **Paper 10: Microarray and Integrated Gene Network Analysis Identify Differential Genes Expression Profiles and Pathways of Bone Marrow Mesenchymal Stem Cells of Adolescent Idiopathic Scoliosis Patients\***  
*Qianyu Zhuang, MD; Jianguo Zhang, MD; Guixing Qiu, MD*
- 11:04 - 11:08 **Paper 11: Do Surgeons' Hands Get Re-Contaminated in Operations Longer than Three Hours? A Pilot Study\***  
*Pooria Hosseini, MD, MSc; Gregory M. Mundis, Jr., MD; Robert K. Eastlack, MD; Jeff B. Pawelek; Stacie Nguyen, MPH; Behrooz A. Akbarnia, MD*
- 11:08 - 11:12 **Paper 12: Comprehensive Biomechanical Analysis of Three Lumbopelvic Reconstruction Techniques Following Total Sacrectomy: An In Vitro Human Cadaveric Model\***  
*Bryan W. Cunningham, PhD; Mohamad Bydon, MD; Ashley A. Murgatroyd, BS; Kenneth Mullinix, BS; Ziya L. Gokaslan, MD*
- 11:12 - 11:18 **Discussion**
- 11:18 - 11:22 **Paper 13: The Effect of Anti-Microbial Irrigations on Osteoblasts and Bone Formation: An in Vitro Comparison of Vancomycin, Gentamicin and Povidone-Iodine.\***  
*Ashleigh Marie Philp; Matthew Peter Newton Ede, FRCS T&Q; Simon W. Jones, PhD*
- 11:22 - 11:26 **Paper 14: Correlations Between Quantitative T2 and T1  $\rho$  MRI Parameters and Mechanics and Biochemical Content in a Rabbit Intervertebral Disc Degeneration Model\***  
*Sarah Gullbrand, PhD; John Martin, PhD; Beth Ashinsky, MS; Lachlan Smith, PhD; Vincent Arlet, MD; Robert Mauck, PhD;... Harvey Smith*
- 11:26 - 11:30 **Paper 15: Location of Prophylactic Vertebral Cement Above Long-Instrumented Constructs Affects Junctional Endplate Stress: A Finite Element Model\***  
*Joseph M. Zavatsky, MD; David Charles Briski, BS*
- 11:30 - 11:37 **Discussion**
- 11:37 - 11:41 **Paper 16: What is the Optimal Vasopressor For Augmenting Cord Perfusion After Spinal Cord Injury?**  
*Brian K. Kwon, MD, PhD, FRCSC; Kitty So, BS; Neda Manouchehri; Elena Okon, PhD; Katelyn Shortt, BS; Ana Gheorghe, BS; Femke Streijger, PhD*
- 11:41 - 11:45 **Paper 17: The Posterior use of BMP-2 in Cervical Deformity Surgery Does Not Result in Increased Complications: A Prospective Multicenter Study**  
*Han Jo Kim, MD; Hongda Bao, MD, PhD; Sravisht Iyer, MD; Justin S. Smith, MD, PhD; Munish Chandra Gupta, MD; Todd J. Albert, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, Jr., MD; Peter G. Passias, MD; Brian James Neuman, MD; Eric O. Klineberg, MD; Virginie Lafage, PhD; Christopher P. Ames, MD; International Spine Study Group*
- 11:45 - 11:49 **Paper 18: How Common is the Poniculus Posticus? A CT Based Analysis of 3,000 Patients**  
*Ahmed Saleh, MD; Jillian Sara Gruber, BA; Wajeeh Bakhsh, MD; Paul T. Rubery, MD; Addisu Mesfin, MD*
- 11:49 - 11:56 **Discussion**
- 11:56 - 12:00 **Paper 19: Is There a Correlation Between Thoracolumbar Kyphosis Correction and Pulmonary Function Change in Ankylosing Spondylitis Patients After Pedicle Subtraction Osteotomy? A 2-Year Follow-up Analysis**  
*Bangping Qian, MD; Hao Liu, MD, PhD; Yong Qiu, MD*

# MEETING AGENDA

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Thursday, July 14, 2016

- 12:00 - 12:04 **Paper 20: National Administrative Databases in Adult Spinal Deformity Surgery: A Cautionary Tale**  
*Aaron James Buckland, MBBS, FRACS; Gregory Wyatt Poorman, BA; Cyrus M. Jalai, BA; Eric O. Klineberg, MD; Michael P. Kelly, MD, MS; Peter G. Passias, MD; International Spine Study Group*
- 12:04 - 12:08 **Paper 21: Outcomes and Complications of Sacropelvic Fixation Using the S2 Alar-Iliac (S2AI) Technique in Adult Spinal Deformity Patients Fused to the Sacrum: A Minimum Two-Year Follow-up Study**  
*Tina Raman, BS, MD, MS; Emily Kristine Miller, BA; Kareem Jamal Kebaish; Hamid Hassanzadeh, MD; Paul D. Sponseller, MD; Khaled M. Kebaish, MD, FRCSC*
- 12:08 - 12:15 **Discussion**

## 2B. Early Onset Scoliosis and AIS Abstracts

ROOM: SALON 12-13

Moderators: John P. Dormans, MD & Suken A. Shah, MD

- 11:00 - 11:04 **Paper 22: Radiographic Outcome Differences in Growing Rod Constructs Using Tandem vs. Wedding Band Connectors**  
*Matthew E. Oetgen, MD; Allison Matthews, MS; Yunfei Wang, PhD; Laurel C. Blakemore, MD; Anna M. McClung, RN, BSN; Jeff B. Pawelek; Paul D. Sponseller, MD; Francisco Javier Sanchez Perez-Grueso, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group*
- 11:04 - 11:08 **Paper 23: Exercise Tolerance in Growing Rod "Graduates": New Respiratory Functional Outcome Measure**  
*Charles E. Johnston, MD; Kelly Jeans, MS; Dong-Phuong Tran, MS; Anna M. McClung, RN, BSN*
- 11:08 - 11:12 **Paper 24: The Efficacy of Halo-Gravity Traction in the Treatment of Severe Spinal Deformity**  
*Zhaomin Zheng, MD, PhD; Huafeng Wang; Hua Wang, PhD; Hui Liu, MD; Jianru Wang, MD*
- 11:12 - 11:18 **Discussion**
- 11:18 - 11:22 **Paper 25: Five or More Proximal Anchors, Including Upper End Vertebra, Protects Against Reoperation**  
*Liam R Harris, BS; Lindsay M. Andras, MD; Gregory M. Mundis, Jr., MD; Paul D. Sponseller, MD; John B. Emans, MD; David L. Skaggs, MD, MMM; Growing Spine Study Group*
- 11:22 - 11:26 **Paper 26: A Pilot Cadaveric Study of the Safety and Efficacy of Magnetic-Controlled Growing Rods After Exposure to Magnetic Resonance Imaging**  
*Selina C. Poon, MD; Adam Graver, MD; Stephen F Wendolowski, BS; Rachel Claire Gecelter, BS; Yen Hsun Chen, BS, MD; Ryan Avey Nixon, MD; Jon-Paul DiMauro, MD; Terry D. Amaral, MD*
- 11:26 - 11:30 **Paper 27: Effectiveness of Rib Osteotomies in Correction of Severe Spinal Deformity Treated with Halo Gravity Traction and Posterior Spinal Fusion**  
*Cristina Sacramento Dominguez, MD, PhD; Ferran Pellisé, MD; Jennifer Ayamga, MPhil; Theresa Yirerong, MPH; Harry Akoto, MD; Irene Adorkor Wulff, MD; Oheneba Boachie-Adjei, MD; FOCOS Spine Research Group*
- 11:30 - 11:37 **Discussion**
- 11:37 - 11:41 **Paper 28: Minimal Invasive Surgical Technique in Adolescent Idiopathic Scoliosis Surgery**  
*Jae Hyuk Yang, MD, PhD; Dong-Gune Chang, MD; Suh Woo Seung, MD; Soo Hyun Kim, MD; Chang Hwa Ham, MD*
- 11:41 - 11:45 **Paper 29: Learning Curve of Mini-Open Correction and Fusion for Adolescent Idiopathic Scoliosis (AIS) Correction: A Single Surgeon's 5 Year Experience**  
*Matthew J. Geck, MD; Devender Singh, PhD; Eric Truumees, MD; Dana Hawthorne, PA-C*
- 11:45 - 11:49 **Paper 30: Gabapentin Decreases Time to Meeting Physical Therapy Goals in Patients with Idiopathic Scoliosis Undergoing Posterior Spinal Fusion**  
*James Joseph Thomas, MD; Sumeet Garg, MD; Mark A. Erickson, MD, MMM; Nicole Michael, BA; Nikki Bloch, BA; Mindy Cohen, MD*



# MEETING AGENDA

† = Whitecloud Award Nominee – Best Clinical Paper

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## Thursday, July 14, 2016

- 11:49 - 11:56 **Discussion**
- 11:56 - 12:00 **Paper 31: Comparative Analysis of Radiological and Clinical Outcomes between Minimal Invasive and Conventional Surgery in Adolescent Idiopathic Scoliosis**  
*Jae Hyuk Yang, MD, PhD; Dong-Gune Chang, MD; Suh Woo Seung, MD, PhD; Tae Jin Lee, MD; Chang Hwa Ham, MD*
- 12:00 - 12:04 **Paper 32: Are Flexible Braces as Effective as Rigid Braces in Non-Operative Management of Adolescent Idiopathic Scoliosis?**  
*Nanjundappa S. Harshavardhana, MD, MS; Vincent Arlet, MD*
- 12:04 - 12:08 **Paper 33: Randomized Trial of Healing Therapy Effects on Pain and Anxiety in Adolescent Idiopathic Patients Undergoing Posterior Instrumentation**  
*Natalie McNeil, BHSP, RMSKS, RT; Tracey Bastrom, MA; Carrie E. Bartley, MA; Burt Yaszay, MD; Peter O. Newton, MD*
- 12:08 - 12:15 **Discussion**

### 2C. Debate Series 1

ROOM: SALON 7-10

Moderators: Frank J. Schwab, MD & Mark Weidenbaum, MD

- 11:00 - 11:37 **Debate 1: Adult Degenerative Scoliosis: Selecting the Optimal UIV**  
Position 1: Munish C. Gupta, MD  
Position 2: Michael F. O'Brien, MD
- 11:37 - 12:15 **Debate 2: Never Decompress Next to a Fused Level!**  
Pro: Christopher J. DeWald, MD  
Con: Benny T. Dahl, MD, PhD, DMSci

12:15 – 12:30 **Walking Break**

12:30 – 13:30 **Exhibit Viewing & Lunch**

ROOM: SALON 6

### \*Hands-On Workshops with Lunch

ROOMS: SALON 14; SALON 15; MT. VERNON SQUARE; JUDICIARY SQUARE

(See "Exhibits and Hands-On Workshops (HOW) section on page 191 for more information)

13:30 – 13:45 **Walking Break**

13:45 – 14:45 **Concurrent Sessions 3A-D: Instructional Course Lectures and Two-Minute Point Presentations**

### 3A. Adult Deformity: Clinical and Radiographic Evolution

ROOM: SALON 1-5

Moderators: Ian J. Harding, BA, FRCS(Orth) & Christopher I. Shaffrey, MD

- 13:45 - 13:55 **When To Say "When" in Adult Spinal Deformity**  
*Steven D. Glassman, MD*
- 13:55 - 14:05 **How Do I Approach Adult Degenerative Scoliosis?**  
*Tyler Koski, MD*
- 14:05 - 14:15 **In What Cases Can I Obtain Correction Without Performing Osteotomies?**  
*Thomas J. Errico, MD*



# MEETING AGENDA

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Thursday, July 14, 2016

14:15 - 14:25 **Osteotomy Planning: What Factors Force My Hand in Performing Osteotomies?**  
*Lawrence G. Lenke, MD*

14:25 - 14:45 **Discussion**

## 3B. Management of Primary Spine Tumors

ROOM: SALON 7-10

*Moderators: Jacob M. Buchowski, MD, MS & Michael J. Yaszemski, MD, PhD*

13:45 - 13:55 **Evaluation and Treatment Decisions in Metastatic Spine Disease**  
*Benny T. Dahl, MD, PhD, DMSci*

13:55 - 14:05 **Surgical Techniques and Outcomes in Metastatic Spine Disease**  
*Daniel M. Sciubba, MD*

14:05 - 14:15 **Role of Radiotherapy and Ablation in Metastatic Spine Disease**  
*Dean Chou, MD*

14:15 - 14:25 **Evaluation and Treatment of Primary Spine Tumors**  
*Peter S. Rose, MD*

14:25 - 14:45 **Discussion**

## 3C. AIS: Clinical and Radiographic Evolution

ROOM: SALON 12-13

*Moderators: Peter O. Newton, MD & Harry L. Shufflebarger, MD*

13:45 - 13:55 **Role of Tethering for the Treatment of AIS**  
*Amer F. Samdani, MD*

13:55 - 14:05 **Where, When and How Do We Brace Patients with AIS**  
*Stefan Parent, MD, PhD*

14:05 - 14:15 **When Should a 3C Undergo a Selective Thoracic Fusion?**  
*Suken A. Shah, MD*

14:15 - 14:25 **What Is on the Horizon for AIS**  
*Jahangir K. Asghar, MD*

14:25 - 14:45 **Discussion**

## 3D. Two-Minute Point Presentations

ROOM: SHAW / LEDROIT PARK

*Moderators: Todd J. Albert, MD & Serena Hu, MD*

13:45 - 13:47 **Paper 34: Is High Implant Density in Lenke 1B & 1C Beneficial?**  
*Bekir Eray Kilinc, MD; Dong-Phuong Tran, MS; Charles E. Johnston, MD; Chan-Hee Jo, PhD*

13:47 - 13:49 **Paper 35: Initial and Long-Term Changes in 3D Position of Upper and Lower Instrumented Vertebrae following Surgery for Adolescent Idiopathic Scoliosis**  
*Dino Colo, MD; Suken A. Shah, MD; Julian D Rose, BS; Saba Pasha, PhD; Rene M. Castelein, MD, PhD*

13:49 - 13:51 **Paper 36: Can Areal and Volumetric Bone Mineral Density (BMD) Predicts Risk of Surgery in Newly Diagnosed Girls with Adolescent Idiopathic Scoliosis (AIS)?**  
*Benjamin Hon Kei Yip, PhD; Fiona Wai Ping Yu, MPH; Vivian Wing Yin Hung, MPhil; Tsz Ping Lam, MD; Ling Qin, PhD; Bobby Kin Wah Ng, MD; Jack C.Y. Cheng, MD*



# MEETING AGENDA

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Thursday, July 14, 2016

- 13:51 - 13:53 **Paper 37: Comparison of Bending vs Fulcrum vs Traction X-ray Under General Anesthesia (TrUGA) for the Assessment of the Curve Flexibility and Prediction of Correction in AIS**  
*Ozcan Kaya, MD; Sinan Kahraman, MD; Gurkan Gumussuyu, MD; Gokhan Peker, MD; Bulent Guneri, MD; Kursad Aytekin; Amjad Alrashdan, MD; Fehmi Doruk Kuran, MD; Tunay Sanli, MA; Bekir Yavuz Ucar, PhD; Meric Enercan, MD; Azmi Hamzaoglu, MD*
- 13:53 - 13:55 **Paper 38: Two Year Clinical and Radiographic Outcomes of Mini Open Correction and Fusion for Adolescent Idiopathic Scoliosis (AIS)**  
*Matthew J. Geck, MD; Devender Singh; Eric Truumees, MD; Dana Hawthorne, PA-C*
- 13:55 - 14:05 **Discussion**
- 14:05 - 14:07 **Paper 39: The Impact of Obesity on Compensatory Mechanisms in Response to Progressive Sagittal Malalignment**  
*Cyrus M. Jalaj, BA; Bassel G. Diebo, MD; Dana Leslie Cruz, BS; Gregory Wyatt Poorman, BA; Shaleen Vira, MD; Aaron James Buckland, MBBS, FRACS; Renaud Lafage, MS; Shay Bess, MD; Frank J. Schwab, MD; Thomas J. Errico, MD; Virginie Lafage, PhD; Peter G. Passias, MD*
- 14:07 - 14:09 **Paper 40: National Trends for Primary and Revision Posterior Lumbar Fusions throughout the United States**  
*Comron Saifi, MD; Alex Ha, MD; Alejandro Cazzulino, BA; Melvin Chugh Makhni, MD, MBA; Charla R. Fischer, MD; Yongjung Jay Kim, MD; Mark Weidenbaum, MD; Ronald A. Lehman, Jr., MD; Lawrence G. Lenke, MD*
- 14:09 - 14:11 **Paper 41: The Sexual Activity Question in the Oswestry Disability Index: An Analysis of Elderly Adult Spinal Deformity Patients**  
*Evalina L. Burger, MD; Vincent Fiere, MD; Sean Molloy, FRCS (Orth) MSc; Michael S. Chang, MD*
- 14:11 - 14:13 **Paper 42: Horizontal Leveling of L4 and L5 in Long Fusions to the Pelvis Results in Improved Coronal Balance**  
*Taylor Elizabeth Dear, BS; Sam G. Keshen, BS; Noah D Lewis; Aaron M Gazendam, BS; Stephen J. Lewis, MD, FRCSC, MS*
- 14:13 - 14:15 **Paper 43: Perioperative and Intraoperative Predictors of ICU Length of Stay in Adult Spinal Deformity Surgery**  
*Aaron M Gazendam, BS; Jennifer Cape, BS; Sam G. Keshen, BS; Jeffrey Singh, MD, MS; Stephen J. Lewis, MD, FRCSC, MS*
- 14:15 - 14:25 **Discussion**
- 14:25 - 14:27 **Paper 44: A Japanese Nationwide Multicenter Survey on Perioperative Complications of Corrective Fusion Surgery for Adult Spinal Deformity**  
*Yu Yamato, MD, PhD; Yukihiko Matsuyama, MD, PhD; Kazuhiro Hasegawa, MD, PhD; Morio Matsumoto, MD*
- 14:27 - 14:29 **Paper 45: Dynamic Posterior Stabilization without Fusion in Degenerative Lumbar Scoliosis of Elderly Patients (Over 75 Years): Is it Effective ?**  
*Mario Di Silvestre, MD; Andrea Baioni, MD; Tiziana Greggi, MD; Francesco Vommara, MD; Elena Maredi, MD; Stefano Giacomini, MD; Antonio Scarale, MD*
- 14:29 - 14:31 **Paper 46: Comparison of Posterior Spinal Fusion with Anterior–Posterior Spinal Fusion using MIS-ALIF for Adult Spinal Deformity with Global Sagittal Malalignment**  
*Tsuyoshi Sakuma, MD, PhD; Toshiaki Kotani, MD, PhD; Tsutomu Akazawa, MD, PhD; Shohei Minami, MD, PhD*
- 14:31 - 14:33 **Paper 47: Clinical and Radiographic Risk Factor for Knee-spine Syndrome in 535 Elderly Volunteers: Retrospective TOEI Study**  
*Sho Kobayashi, MD, PhD; Daisuke Togawa, MD; Tomohiko Hasegawa, MD, PhD; Yu Yamato, MD, PhD; Shin Oe, MD; Tomohiro Banno, MD; Yuki Mihara, MD; Yukihiko Matsuyama, MD, PhD*

# MEETING AGENDA

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

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14:33 - 14:35 **Paper 48: Fundamental Differences and Changes in Pelvic Parameters Depending on Age, Gender, and Race**  
*Robert Kent Merrill, BS; Dante M. Leven, DO; Jun S. Kim, MD; Joshua Joe Meaike, BS; Kelly I. Suchman, BS; Joung Heon Kim, BS; Rachel Samantha Bronheim, BA; Sunder Shyam Gidumal, BS; Samuel K. Cho, MD*

14:35 - 14:45 **Discussion**

14:45 – 15:00 **Walking Break**

15:00 – 15:55 **Concurrent Sessions 4A-D: Concurrent Abstract Sessions, Complication Series, and Two-Minute Point Presentations**

## 4A. Adolescent Idiopathic Scoliosis Abstracts

ROOM: SALON 1-5

Moderators: David L. Skaggs, MD, MMM & Firoz Miyanji, MD, FRCSC

15:00 - 15:04 **Paper 49: Comparison of Active and Passive Correction of AIS using Vertebral Staples versus Tethers: A Medium Term Follow-up Study**

*John T. Braun, MD*

15:04 - 15:08 **Paper 50: Preservation of Spine Motion in the Surgical Treatment of AIS Patients using an Innovative Apical Fusion Technique: A 2 Year Follow-up Study**

*Behrooz A. Akbarnia, MD; Allen L. Carl, MD; Michael P. Grevitt, FRCS (Orth); Colin Nnadi, MD; Martin Repko, MD, PhD; Dennis G. Grandall, MD; Pooria Hosseini, MD, MSc; Ufuk Aydinli, MD; Martin Žabka, MD, PhD; Steven J. Seme, MS*

15:08 - 15:12 **Paper 51: Selection of the Lowest Instrumented Vertebra in Lenke 1B Curve**

*Hong Zhang, MD; Daniel J. Sucato, MD, MS; B. Stephens Richards, III, MD,*

15:12 - 15:18 **Discussion**

15:18 - 15:22 **Paper 52: Comparison of Severe and Rigid Scoliosis Treated by Anterior Release and Posterior Fusion with and without Internal Distraction**

*Chunguang Zhou, MD, PhD*

15:22 - 15:26 **Paper 53: Clinical Outcome of Idiopathic Scoliosis Surgery: Is There a Difference Between Young Adult Patients and Adolescent Patients?**

*William Francis Lavelle, MD; Xiaobang Hu, PhD; Swamy Kurra, MD; Isador H. Lieberman, MD, MBA, FRCSC*

15:26 - 15:30 **Paper 54: Fusion Decision-making of Lumbar Curves in Lenke C Modifiers**

*Hong Zhang, MD; Daniel J. Sucato, MD, MS; B. Stephens Richards, III, MD; Linfeng Wang, MD*

15:30 - 15:35 **Discussion**

15:35 - 15:39 **Paper 55: LEAN Process Mapping to Improve the Value of Spinal Fusion for Idiopathic Scoliosis**

*Matthew F. Oetgen, MD; Benjamin D. Martin, MD; Shannon M. Kelly, MD; Sophie Pestieau, MD; Karen Thomson, MD*

15:39 - 15:43 **Paper 56: The Change of Cervical Spine Alignment Along with Aging in Asymptomatic Population**

*Chen Yiwei; Zhong Junlong; Zhimin Pan, MD; Zhou Song, PhD; Chen Jiangwei, PhD; Kai Cao, MD, PhD*

15:43 - 15:47 **Paper 57: Can Surgery for Adolescent Idiopathic Scoliosis be an Allogeneic Blood Transfusion Free Event?**

*John T. Smith, MD; John A Heflin, MD*

15:47 - 15:55 **Discussion**



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## 4B. Complications & Infection Abstracts

ROOM: SALON 12-13

Moderators: Christopher L. Hamill, MD, Sean Molloy, FRCS (Orth) MSc

- 15:00 - 15:04 **Paper 58: Thromboembolic Disease in Adult Spinal Deformity Surgery: Incidence and Risk Factors in 737 Patients**  
*Han Jo Kim, MD; Bassel G. Diebo, MD; Sravisht Iyer, MD; Michael P. Kelly, MD, MS; Daniel M. Sciubba, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Gregory M. Mundis, Jr., MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Christopher P. Ames, MD; Eric O. Klineberg, MD; International Spine Study Group*
- 15:04 - 15:08 **Paper 59: Early Postoperative Surgical Site Infections in the Scolio-Risk 1 Cohort of Complex Spinal Deformity Patients Still Allowed For Improved Health Related Quality of Life Outcomes at 2 Year Follow-Up**  
*Amit Jain, MD; Floreana Naef Kebaish, MD; Lawrence G. Lenke, MD; Christopher P. Ames, MD; Michael G. Fehlings, MD, PhD, FRCS; Hossein Mehdiian, MD; Frank J. Schwab, MD; Yukihiko Matsuyama, MD, PhD; Christopher I. Shaffrey, MD; Kenneth MC Cheung, MD; Yong Qiu, MD; Ferran Pellisé, MD; Leah Yacat Carreon, MD, MSc; Benny T. Dahl, MD, PhD; Khaled M. Kebaish, MD, FRCS*
- 15:08 - 15:12 **Paper 60: Consumptive and Dilutional Coagulopathies: The Next Treatable Bleeding Disorder in Scoliosis Patients?**  
*Courtney Baker, BS; Christopher Wallace, BS; William Oelsner, BS; David Gailani, MD; Allison Wheeler, MD, MSCI; Thanh Nguyen, MD; Megan Mignemi, BS, MD; Steven Lovejoy, MD; Gregory A. Mencia, MD; Jonathan Schoenecker, MD, PhD; Jeffrey Martus, MD*
- 15:12 - 15:18 **Discussion**
- 15:18 - 15:22 **Paper 61: The Effect of Vancomycin Powder on the Rates of Infection and Pseudarthrosis in Lumbar Spine Surgery: A Retrospective Analysis of 453 Patients**  
*Sukanta Maitra, MD; Jordan R. Kump, BS; Zach Lee, BS; Yue Zhang, PhD; Stephen Pehler, MD; William Ryan Spiker, MD; Brandon Douglas Lawrence, MD; Darrel S. Brodke, MD*
- 15:22 - 15:26 **Paper 62: Nasal Swab Screening for Staphylococcus Aureus in Spinal Deformity Patients Treated with Growing Rods**  
*June C. Smith, MPH; Scott John Luhmann, MD*
- 15:26 - 15:30 **Paper 63: Examining the Anti-Biofilm and Osteoconductive Properties of a PEEK-Silver Zeolite Composite in Spine**  
*Sriram Sankar, MS; Nitin Bhatia, MD; Matthew J. Geck, MD*
- 15:30 - 15:35 **Discussion**
- 15:35 - 15:39 **Paper 64: Medical Complications in 3,519 Surgically Treated Elderly Patients with Adult Spinal Deformity: Comparison of Multicenter Surgeon Maintained vs. Medicare Claims Database**  
*Amit Jain, MD; Hamid Hassanzadeh, MD; Varun Puvanarajah; Eric O. Klineberg, MD; Michael P. Kelly, MD, MS; D.Kojo Hamilton, MD; Virginie Lafage, PhD; Aaron James Buckland, MBBS, FRACS; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Khaled M. Kebaish, MD, FRCS; International Spine Study Group*
- 15:39 - 15:43 **Paper 65: Morbidity of Adult Spinal Deformity Surgery in Elderly Has Declined Over Time**  
*Peter G. Passias, MD; Gregory Wyatt Poorman, BA; Cyrus M. Jalai, BA; Brian James Neuman, MD; Rafael De la Garza-Ramos, MD; Emily Kristine Miller, BA; Amit Jain, MD; Daniel M. Sciubba, MD; Virginie Lafage, PhD*

# MEETING AGENDA

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15:43 - 15:47 **Paper 66: Impact of New Motor Deficit on Early HRQOL After Adult Spinal Deformity Surgery: Subanalysis of 272 Patients From Scolio Risk 1 Prospective Study**

*Rajiv Saigal, MD, PhD; Sigurd H. Berven, MD; Virginie Lafage, PhD; Michael P. Kelly, MD, MS; Benny T. Dahl, MD, PhD; Kenneth MC Cheung, MD; Leah Yacat Carreon, MD, MSc; Frank J. Schwab, MD; Kathrin Espinoza-Rebmann, MS; Christopher I. Shaffrey, MD; Michael G. Fehlings, MD, PhD, FRCSC; Lawrence G. Lenke, MD; Christopher P. Ames, MD*

15:47 - 15:55 **Discussion**

## 4C. My Worst Complication Session: Strategies to Prevent/Manage

ROOM: SALON 7-10

*Moderators: Sigurd H. Berven, MD & Yan Wang, MD*

15:00 - 15:18 **Complication 1: Adult Deformity**

*Tyler Koski, MD*

15:18 - 15:36 **Complication 2: Cervical Trauma**

*Christopher I. Shaffrey, MD*

15:36 - 15:55 **Complication 3: Tumor**

*Peter S. Rose, MD*

## 4D. Two-Minute Point Presentations

ROOM: SHAW / LEDROIT PARK

*Moderators: Marinus De Kleuver, MD, PhD & Praveen V. Mummaneni, MD*

15:00 - 15:02 **Paper 67: Osteoporosis Increases Radiographic Failure After Transforaminal Lumbar Interbody Fusion**

*Scott C. Wagner, MD; Peter M Formby, MD; Daniel G. Kang, MD; Melvin D. Helgeson, MD; Ronald A. Lehman, Jr., MD; Theodore Steelman, MD*

15:02 - 15:04 **Paper 68: Psychological Burden of Spinal Deformity: A Comparative Analysis with Three Disabling Chronic Diseases**

*Bassel G. Diebo, MD; Cyrus M. Jalai, BA; Gregory Wyatt Poorman, BA; Thomas J. Errico, MD; Virginie Lafage, PhD; Peter G. Passias, MD*

15:04 - 15:06 **Paper 69: Evoked Potentials Monitoring Strategy of Osteotomy and Non-Osteotomy in Spinal Deformity**

*Yang Junlin, MD, PhD; Huang Zifang, MD, PhD*

15:06 - 15:08 **Paper 70: Concurrent Validity and Responsiveness of PROMIS Health Related Quality of Life Assessment in Patients with Lumbar Degenerative Spine Disease**

*Shalini L. Selvarajah, MD; Brian James Neuman, MD; Richard L. Skolasky, ScD*

15:08 - 15:10 **Paper 71: Impact of Obesity on Complications and Outcomes: A Comparison of Fusion and Non-Fusion Spine Surgery**

*Ikemefuna Onyekwelu, MD; Steven D. Glassman, MD; Anthony Asher, MD; Christopher I. Shaffrey, MD; Praveen V. Mummaneni, MD; Leah Yacat Carreon, MD, MSc*

15:10 - 15:20 **Discussion**

15:20 - 15:22 **Paper 72: Acetabular Component Orientation in the Setting of Spinal Deformity Correction**

*Aaron James Buckland, MBBS, FRACS; Robert A. Hart, MD; Gregory M. Mundis, Jr., MD; Daniel M. Sciubba, MD; Renaud Lafage, MS; Thomas J. Errico, MD; Shay Bess, MD; Jonathan Vigdorchik, MD; Ran Schwarzkopf, MD; Virginie Lafage, PhD; International Spine Study Group*



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- 15:22 - 15:24 **Paper 73: Novel “Dual Construct” for the Management of Complex Spinal Reconstructions: Evaluation of 57 Consecutive Patients**  
*Francis H. Shen, MD; Varun Puvanesarajah; Hamid Hassanzadeh, MD; Rosemarie E. Tyger; Rebecca E. Lehman; Anuj Singla, MD; Adam L. Shimer, BS, MD*
- 15:24 - 15:26 **Paper 74: Anterior Column Realignment: A Detailed Analysis of Neurologic Risk and Radiographic Outcomes**  
*Rajiv Saigal, MD, PhD; Gregory M. Mundis, Jr., MD; Robert K. Eastlack, MD; Stacie Nguyen, MPH; Ali Bagheri, MD; Ramin Bagheri, MD; Behrooz A. Akbarnia, MD*
- 15:26 - 15:28 **Paper 75: The Safety and Efficacy of Intraoperative Acute Normovolaemic Haemodilution (ANH) in Complex Spine Surgery at an SRS GOP Site in Ghana**  
*Irene Adarkor Wulff, MD; Jennifer Ayamga, MPhil; Robert Djagbletey; Cornelia Quarcoopome; Theresa Yirerong, MPH; Oheneba Boachie-Adjei, MD; FOCOS Spine Research Group*
- 15:28 - 15:30 **Paper 76: Retrospective Comparative Review of Robotic-Guidance vs Freehand Instrumentation in 705 Adult Degenerative Spine Patients Operated in Minimally Invasive (MIS) and Open Approaches**  
*Thomas Sweeney, MD, PhD; Andrew F. Cannestra, MD, PhD; Kornelis Poelstra, MD, PhD; Samuel R. Schroerlucke, MD*
- 15:30 - 15:40 **Discussion**
- 15:40 - 15:42 **Paper 77: Sacral Screw Strain in a Long Posterior Spinal Fusion Construct with Sacral Alar-Iliac (S2AI) versus Iliac Fixation**  
*Daniel G. Kang, MD; Ronald A. Lehman, Jr., MD; Scott C. Wagner; Robert W. Tracey, MD; John P. Cody, MD; Khaled M. Kebaish, MD, FRCSC; Lawrence G. Lenke, MD*
- 15:42 - 15:44 **Paper 78: Changes Following Acute Traumatic Cervical Spinal Cord Injury: A Prospective Pilot Study on Serial MRIs**  
*Joost Rutges, MD, PhD; Brian K. Kwon, MD, PhD, FRCSC; Marcel F. Dvorak, MD, FRCSC*
- 15:44 - 15:46 **Paper 79: Prediction of Muscular Volume of Functional Groups from a Reduced Set of MRI Slices**  
*Celia Amabile, MS; Bertrand Moal, PhD; Nicolas Bronsard, MD, PhD; Wafa Skalli, PhD; Virginie Lafage, PhD*
- 15:46 - 15:48 **Paper 80: Operative Management of Combat Spine Trauma**  
*Scott C. Wagner, MD; Peter M. Formby, MD; Gregory S. Van Blarcum, MD; Alfred J. Pisano, MD; Daniel G. Kang, MD; Ronald A. Lehman, Jr., MD; Jonathan Seavey, MD, MS*
- 15:48 - 15:55 **Discussion**
- 15:55 – 16:15 **Refreshment Break & Exhibit Viewing**  
ROOM: SALON 6



# MEETING AGENDA

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Thursday, July 14, 2016

## 16:15 – 17:15 Concurrent Sessions 5A-D: Abstract Session and Roundtable Sessions

### 5A. Cervical Spine Trauma

ROOM: SALON 12-13

Moderators: *Todd J. Albert, MD & Michael G. Fehlings, MD, PhD, FRCSC*

#### Case Presenters

16:15 - 16:30 *Brian K. Kwon, MD, PhD, FRCSC*  
16:30 - 16:45 *James S. Harrop, MD*  
16:45 - 17:00 *Vincent C. Traynelis, MD*  
17:00 - 17:15 *Marcel F. Dvorak MD, FRCSC*

### 5B. Adolescent Idiopathic Scoliosis

ROOM: SALON 1-5

Moderators: *John P. Dormans, MD & B. Stephens Richards, III, MD*

#### Case Presenters

16:15 - 16:30 *Daniel J. Sucato, MD, MS*  
16:30 - 16:45 *Stefan Parent, MD, PhD*  
16:45 - 17:00 *Firoz Miyanji, MD, FRCSC*  
17:00 - 17:15 *Thomas J. Errico, MD*

### 5C. Adult Degenerative Scoliosis

ROOM: SALON 7-10

Moderators: *Christopher P. Ames, MD & Henery F.H. Halm, MD*

#### Case Presenters

16:15 - 16:30 *Justin S. Smith, MD, PhD*  
16:30 - 16:45 *Sebastien Charosky, MD*  
16:45 - 17:00 *Khaled M. Kebaish, MD*  
17:00 - 17:15 *Serena Hu, MD*

### 5D. Innovative & Diagnostic Methods Abstracts

ROOM: SHAW / LEDROIT PARK

Moderators: *Rick C. Sasso, MD & Juan S. Uribe, MD*

- 16:15 - 16:19 **Paper 81: Three-Dimensional Analysis of Severe AIS Curve Correction with Anterior Vertebral Tethers**  
*John T. Braun, MD*
- 16:19 - 16:23 **Paper 82: Pedicled Vascularized Bone Grafts for Posterior Occipitocervical and Cervicothoracic Fusion: A Cadaveric Feasibility Study**  
*Michael Bohl, MD; Michael Mooney, MD; Joshua Catapano, MD; Kaith Almefty, MD; Jay D. Turner, MD, PhD; Mark Preul, MD; Edward Reece, MD; Udaya K. Kakarla, MD*
- 16:23 - 16:27 **Paper 83: Novel Methods of Spinal Cord Injury Treatment Using Magnetic Nanoparticles in Combination with Electromagnetic Field**  
*Arcadii Kazmin, MD; Sergey Kolesov, MD, PhD; Maxim Sazhnev, MD, PhD; Andrey A. Panteleyev, MD*
- 16:27 - 16:33 **Discussion**
- 16:33 - 16:37 **Paper 84: First Report From MIS ReFRESH: A Prospective, Comparative Study of Robotic-Guidance vs. Freehand Pedicle Screw Placement in Minimally Invasive Lumbar Surgery**  
*Faissal Zahrawi, MD; Samuel R. Schroerlucke, MD; Christopher R. Good, MD; Michael Y. Wang, MD*



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- 16:37 - 16:41 **Paper 85: A Novel Posterior Rod-Link-Reducer System Provides Safer Easier and Better Correction of Severe Scoliosis**  
*Hong Zhang, MD; Daniel J. Sucato, MD, MS*
- 16:41 - 16:45 **Paper 86: A Randomized Control Trial of Low Radiation Imaging During Minimally Invasive Spine Fusion**  
*Sarah Byrd, BS, MS, RN, Nurse Practitioner; David A. Vincent, MD*
- 16:45 - 16:49 **Paper 87: Diagnosing The Undiagnosed: Osteoporosis in Patients Undergoing Lumbar Fusion**  
*Scott C. Wagner, MD; Peter M. Formby, MD; Daniel G. Kang, MD; Melvin D. Helgeson, MD; Ronald A. Lehman, Jr., MD; Theodore Steelman, MD*
- 16:49 - 16:56 **Discussion**
- 16:56 - 17:00 **Paper 88: Pelvic Incidence: A Fixed Value or Can You Change it?**  
*Howard M. Place, MD; Ann M. Hayes, DPT, MHS, OCS; Andy M. Hayden, BS; Jennifer Lynn Brechbuhler, RN; Heidi Israel, PhD; Stephen B. Huebner, MD*
- 17:00 - 17:04 **Paper 89: Incidence of Lumbar Plexopathy Utilizing Mechanomyography (MMG) for Transpoas Lateral Lumbar Interbody Fusion (LLIF)**  
*Joseph M. Zavatsky, MD; David Charles Briski, MD; Bradford S. Waddell, MD*
- 17:04 - 17:09 **Paper 90: Does Pelvic Incidence Increase with Age? An Analysis of 1625 Adults**  
*Hongda Bao, MD, PhD; Barthelemy Liabaud, MD; Jeffrey J. Varghese, BS; Renaud Lafage, MS; Bassel G. Diebo, MD; Cyrus M. Jalai, BA; Subaraman Ramchandran, MD; Gregory Wyatt Poorman, BA; Dana Leslie Cruz, BS; Thomas J. Errico, MD; Themistocles S. Protopsaltis, MD; Peter G. Passias, MD; Aaron James Buckland, MBBS, FRACS; Frank J. Schwab, MD; Virginie Lafage, PhD*
- 17:09 - 17:15 **Discussion**

17:15 – 17:30 **Walking Break**

17:30 – 18:30 **\*Afternoon Hands-On Workshops with Beverages and Snacks**

ROOMS: SALON 14; SALON 15; JUDICIARY SQUARE

(See "Exhibits and Hands-On Workshops (HOW) section on page 191 for more information)

## Friday, July 15, 2016

7:30 – 16:45 **Registration Open**

MEETING LEVEL 2 FOYER

7:30 – 8:30 **\* Hands-On Workshops with Breakfast**

ROOMS: SALON 14

(See "Exhibits and Hands-On Workshops (HOW) section on page 191 for more information)

8:00 – 17:00 **Exhibits Open**

ROOM: SALON 6

8:00 – 8:40 **Exhibits Viewing & Breakfast**

ROOM: SALON 6

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Friday, July 15, 2016

8:40 – 9:40 **Concurrent Sessions 6A-C: Abstract Sessions and Debate Series**

## 6A. Adult Deformity Abstracts

ROOM: SALON 1-5

Moderators: Christopher P. Ames, MD & Thomas J. Errico, MD

8:40 - 8:44 **Paper 91: Factors Associated with the Development of and Revision for Proximal Junctional Kyphosis in 458 Consecutive Adult Spinal Deformity Patients**

*Fred Nicholls, MD, FRCSC, MA; Junseok Bae, MD; Alexander Theologis, MD; Murat S. Eksi, MD; Christopher P. Ames, MD; Sigurd H. Berven, MD; Shane Burch, MD; Bobby Tay, MD; Vedat Deviren, MD*

8:44 - 8:48 **Paper 92: Inter/Intra-Observer Reliability of T1 Pelvic Angle (TPA), a Radiographic Measure for Global Sagittal Deformity**

*Stephen Plachta, MD; Heidi Israel, PhD, FNP; Ann M. Hayes, DPT, MHS, OCS; Howard M. Place, MD*

8:48 - 8:52 **Paper 93: Combined Antero-Posterior Approach Does Not Increase the Risk of Proximal Junctional Kyphosis in Adult Spinal Deformity**

*Vincent Fiere, MD; Evalina L. Burger, MD; Sean Molloy, FRCS (Orth) MSc; Michael S. Chang, MD*

8:52 - 8:59 **Discussion**

8:59 - 9:03 **Paper 94: Relationship Between Knee Osteoarthritis and Spinopelvic Sagittal Alignment: Knee-Spine Syndrome**

*Tatsuya Yasuda, MD; Tomohiko Hasegawa, MD, PhD; Yu Yamato, MD, PhD; Sho Kobayashi, MD, PhD; Daisuke Togawa, MD; Shin Oe, MD; Yukihiko Matsuyama*

9:03 - 9:07 **Paper 95: Risk of Total Hip Arthroplasty Dislocation after Adult Spinal Deformity Correction**

*Aaron James Buckland, MBBS, FRACS; Robert A. Hart, MD; Gregory M. Mundis, Jr., MD; Daniel M. Sciubba, MD; Renaud Lafage, MS; Thomas J. Errico, MD; Shay Bess, MD; Jonathan Vigdorichik, MD; Ran Schwarzkopf, MD; Virginie Lafage, PhD; International Spine Study Group*

9:07 - 9:11 **Paper 96: Spino-Femoral Muscles Affect Sagittal Alignment and Compensatory Recruitment: A New Look into Soft Tissues in Adult Spinal Deformity**

*Hongda Bao, MD, PhD; Bertrand Moal, PhD; Shaleen Vira, MD; Dana Leslie Cruz, BS; Celia Amabile, MS; Thomas J. Errico, MD; Frank J. Schwab, MD; Wafa Skalli, PhD; Virginie Lafage, PhD*

9:11 - 9:18 **Discussion**

9:18 - 9:22 **Paper 97: Towards the Development of a Global Core Outcome Set for Adult Spinal Deformity.**

*Sayf Faraj, BS; Miranda L. van Hooff, MS; Tsjitske Haanstra, PhD; Roderick Maurits Holewijn, BS; Niccolle Germscheid, MS; Marinus De Kleuver, MD, PhD*

9:22 - 9:26 **Paper 98: Predictors of Health-related Quality-of-Life After Complex Adult Spinal Deformity Surgery: A Scolio-RISK-1 Secondary Analysis**

*Leah Yacat Carreon, MD, MSc; Steven D. Glassman, MD; Christopher I. Shaffrey, MD; Michael G. Fehlings, MD, PhD, FRCSC; Benny T. Dahl, MD, PhD, DMSci; Christopher P. Ames, MD; Yukihiko Matsuyama, MD, PhD; Yong Qiu, MD; Hossein Mehdian, MD; Kenneth MC Cheung, MD; Frank J. Schwab, MD; Ferran Pellisé, MD; Khaled M. Kebaish, MD, FRCSC; Lawrence G. Lenke, MD*

9:26 - 9:30 **Paper 99: The Seattle Spine Team Predictive Risk Model for 30-Day Postoperative Complications in Adult Spinal Deformity Surgery.**

*Quinlan Buchlak, BS, MS; Alicia M. Edwards, BS, MBA; Kellen Aaron Nold, MS, PA-C; Jean-Christophe A. Leveque, MD; Rajiv K. Sethi, MD*

9:30 - 9:40 **Discussion**



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## 6B. Trauma & Tumor Abstracts

ROOM: SALON 12-13

Moderators: Dean Chou, MD & Vincent C. Traynelis, MD

- 8:40 - 8:44 **Paper 100: Predictors of Mortality Following Odontoid Peg Fractures in The Elderly**  
*Abdul Gaffar Dudhniwala, MD, MS, MRCS, FRCS (Orth); Stefan Bajada, MD, PhD, MRCS; Abhimanyu Ved, MD, MRCS; Sashin Ahuja, FRCS*
- 8:44 - 8:48 **Paper 101: Are "Unstable" Burst Fractures Really Unstable? Comparison of Denis Classification and TLICS**  
*Youngmin Kwon, MD; Hyun Woo Lee, MD*
- 8:48 - 8:52 **Paper 102: Upper Cervical and Infra-cervical Compensation in Cervical Deformity Patients**  
*Subaraman Ramchandran, MD; Themistocles S. Protopsaltis, MD; Daniel M. Sciubba, MD; Justin K. Scheer, BS; Alan H. Daniels, MD; Peter G. Passias, MD; Virginie Lafage, PhD; Han Jo Kim, MD; Gregory M. Mundis, Jr., MD; Eric O. Klineberg, MD; Robert A. Hart, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; International Spine Study Group*
- 8:52 - 8:59 **Discussion**
- 8:59 - 9:03 **Paper 103: Characterization and Outcomes of Combat-Related Spinal Cord Injuries Requiring Operative**  
*Gregory Van Blarcum, MD; Scott C. Wagner, MD; Peter Formby, MD; Daniel G. Kang, MD; Ronald A. Lehman, Jr., MD, Jonathan Seavey, MS*
- 9:03 - 9:07 **Paper 104: Long-term Survival after Surgical Treatment of Spinal Metastasis: The Predictive Role of Gender**  
*Dennis Karimi, MS; Søren Schmidt Morgen, MD, PhD; Sidsel Sofie Fruergaard, MD; Martin Gehrchen, MD, PhD; Benny T. Dahl, MD, PhD, DMSci*
- 9:07 - 9:11 **Paper 105: Costs and Readmissions Rates for the Surgical Resection of Primary and Metastatic Spinal Tumors: A Comparative Analysis of 181 Patients**  
*Darryl Lau, MD; Alexander Theologis, MD; Dean Chou, MD; Praveen V. Mummaneni, MD; Shane Burch, MD; Sigurd H. Berven, MD; Vedat Deviren, MD; Christopher P. Ames, MD*
- 9:11 - 9:18 **Discussion**
- 9:18 - 9:22 **Paper 106: Clinical Significances of Preoperative Embolization for Metastatic Spine Disease**  
*Young-Hoon Kim, MD, PhD; Kee-Yong Ha, MD, PhD; Jaewon Lee; Sang-Il Kim, MD*
- 9:22 - 9:26 **Paper 107: The Accuracy of Prognostic Scoring Systems in Predicting Survival of Lung Cancer Patients with Spinal Metastases**  
*Jiong Hao Jonathan Tan Jiong Hao Tan; Kimberly-Anne Tan; Aye Sandar Zaw, MBBS, MPH; Naresh Kumar, FRCSC*
- 9:26 - 9:30 **Paper 108: Functional Outcome of IS Patients**  
*Yang Junlin, MD, PhD; Huang Zifang, MD, PhD*
- 9:30 - 9:40 **Discussion**

## 6C. Debate Series 2

ROOM: SALON 7-10

Moderators: Ronald A. Lehman, Jr., MD & Praveen V. Mummaneni, MD

- 8:40 - 9:10 **Debate 1: MIS Approaches Adult Degenerative Lumbar Scoliosis via Lateral/Oblique Are Best**  
*LLIF/OLIF: Juan S. Uribe, MD  
OPEN: Henry F.H. Halm, MD*
- 9:10 - 9:40 **Debate 2: Reduction of High Grade Spondylolisthesis is Always Required**  
*Pro: John R. Dimar, II, MD  
Con: Stefan Parent, MD, PhD*

# MEETING AGENDA

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Friday, July 15, 2016

9:40 – 10:30 **Refreshment Break & Exhibit Viewing**

ROOM: SALON 6

10:30 – 11:55 **Concurrent Sessions 7A-C: Abstract Sessions & Video-Based Session**

## 7A. Cervical Spine and Deformity Abstracts

ROOM: SALON 7-10

Moderators: Brian K. Kwon, MD, FRCSC & Tushar C. Patel, MD

- 10:30 - 10:34 **Paper 109: Three-column Osteotomy for Correction of Cervical Deformity: Alignment Changes and Early Complications in a Multicenter Prospective Series of 24 Patients**  
*Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Brian James Neuman, MD; Eric O. Klineberg, MD; Frank J. Schwab, MD; Renaud Lafage, MS; Themistocles S. Protopsaltis, MD; Peter G. Passias, MD; Gregory M. Mundis, Jr., MD; Robert A. Hart, MD; Vedat Deviren, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group*
- 10:34 - 10:38 **Paper 110: Compensation Mechanism in Thoraco-Lumbar Segments in Patients with Symptomatic Primary Cervical Kyphosis**  
*Jun Mizutani, MD, PhD; Kushagra Verma, MD; Kenji Endo, MD; Ken Ishii, MD; Kuniyoshi Abumi, MD, PhD; Mitsuru Yagi, MD, PhD; Naobumi Hosogane, MD, PhD; Russell Glenn Strom, MD; Bobby Tay, MD; Vedat Deviren, MD; Christopher P. Ames, MD*
- 10:38 - 10:42 **Paper 111: Complications and Reoperation Rate Following Cervical Lateral Mass Screw Fixation**  
*Daniel G. Kang, MD; Jacob M. Buchowski, MD, MS; Panya Luksanaprukksa, MD; Ronald A. Lehman, Jr., MD; K. Daniel Riew, MD*
- 10:42 - 10:49 **Discussion**
- 10:49 - 10:53 **Paper 112: One-Level vs Two-Level Cervical Total Disc Replacement (TDR) vs Anterior Cervical Discectomy and Fusion (ACDF) at 7-year Follow-up**  
*Hyun W Bae, MD; Reginald James Davis, MD; Michael S. Hisey, MD; Pierce D. Nunley, MD; Robert Jackson, MD*
- 10:53 - 10:57 **Paper 113: Revision Strategies in Cervical Disc Arthroplasty Failures**  
*Daniel G. Kang, MD; Ronald A. Lehman, Jr., MD; Colleen Peters, MA; K. Daniel Riew, MD*
- 10:57 - 11:01 **Paper 114: Long Term Clinical and Radiographic Results of Two-level Cervical Total Disc Replacement from a Level 1 Prospective, Randomized, Clinical Trial**  
*Jeffrey McConnell, MD; Randall Dryer, MD; Todd Lanman, MD; Matthew Gornet, MD; Scott D. Hodges*
- 11:01 - 11:08 **Discussion**
- 11:08 - 11:12 **Paper 115: Does Chewing Gum Hasten the Return of Bowel Function Post-operatively in Patients Undergoing Spinal Surgery?**  
*Grant D Shifflett, MD; Michael Kevin Urban, MD, PhD; Sean Garvin, MD; Michael C. Ho, MD; Sumudu C. Dehipawala, BS; Valeria L. Buschiazzo; Sravisht Iyer, MD; Joseph Nguyen, MPH; Kara C Fields, BS; Alexander P. Hughes, MD; Andrew A. Sama, MD; Russel C. Huang, MD*
- 11:12 - 11:16 **Paper 116: Predictive Factors in Spine Surgery Complication Malpractice Litigation**  
*Roy Ruttiman, MS; Adam E. M. Eltorai, BA; John Mason DePasse, MD; Bielinsky Brea; Mark A. Palumbo, MD; Alan H. Daniels, MD*
- 11:16 - 11:20 **Paper 117: Sacroiliac Pain in Patients with Lumbar and Lumbosacral Fusion. A Comparative Study of 399 Cases.**  
*Hani H. Mhaidli, MD, PhD*
- 11:20 - 11:24 **Paper 118: Morbidity Associated with Anterior Surgical Approaches to the Lumbar Spine is Minimal**  
*John R. Dimar, II, MD; Thomas M. Bergamini, MD; Richard Head, BS; Mladen Djurasovic, MD; Steven D. Glassman, MD; Leah Yacat Carreon, MD, MSc*



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- 11:24 - 11:31 **Discussion**
- 11:31 - 11:35 **Paper 119: Outcomes in Adult Deformity Surgery: What Happens to Those Patients Who are Lost to Follow-up?**  
*Daniel Beckerman, BS; Shane Burch, MD; Linda Racine; Sigurd H. Berven, MD*
- 11:35 - 11:39 **Paper 120: The Health Impact of Symptomatic Adult Cervical Deformity: Comparison to United States Population Norms and Chronic Disease States Based on the EQ5D**  
*Justin S. Smith, MD, PhD; Breton Line, BS; Shay Bess, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Gregory M. Mundis, Jr., MD; Eric O. Klineberg, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; International Spine Study Group*
- 11:39 - 11:43 **Paper 121: Which Clinical Parameters of the Schwab-SRS Classification System for ASD is Significant in Predicting Treatment Outcomes for Surgically Treated Patients?**  
*Selcen Yuksel, PhD; Tiro Mmopelwa, MD; Selim Ayhan, MD; Vugar Nabiyeu, MD; Ferran Pellisé, MD; Alba Vila-Casademunt, BS, MD, MS; Ahmet Alanay, MD; Francisco Javier Sanchez Perez-Grueso, MD; Frank Kleinstück, MD; Ibrahim Obeid, MD; Emre R. Acaroglu, MD; European Spine Study Group*
- 11:43 - 11:47 **Paper 122: Analysis of Lumbar Flexibility on Supine MRI and CT May Reduce the Need for More Invasive Spinal Osteotomy in Adult Spinal Deformity Surgery**  
*Joseph Baker, FRCSI; Louis Marcel Day, BS; Jonathan H. Oren, MD; Michael J. Moses, BA; Aaron James Buckland, MBBS, FRACS; Peter G. Passias, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Shay Bess, MD; Thomas J. Errico, MD; Themistocles S. Protopsaltis, MD*
- 11:47 - 11:55 **Discussion**

## 7B. Lumbar Degenerative & Spondylolisthesis Abstracts

ROOM: SALON 12-13

Moderators: Jeffrey D. Coe, MD & John R. Dimar, II, MD

- 10:30 - 10:34 **Paper 123: Comparison of Stand-Alone, Trans-Psoas Lateral Interbody Fusion to Transforaminal Interbody Fusion for the Treatment of Lumbar Adjacent Segment Disease**  
*Deeptee Jain, MD; Kushagra Verma, MD; Jun Mizutani; Shane Burch, MD; Bobby Tay, MD; Vedat Deviren, MD*
- 10:34 - 10:38 **Paper 124: Does Percutaneous Pedicle Screw Instrumentation Prevent Long Term Adjacent Segment Disease?**  
*Alexander Brothers, MD; Michael J. Faloon, MD, MS; Ki Soo Hwang, MD; Kumar Sinha, MD; Kimona Issa, MD; Conor Dunn, MS; Nikhil Sahai, MD, MPH; Arash Emami, MD*
- 10:38 - 10:42 **Paper 125. Compare the Outcome of Revision Discectomy and Discectomy/Decompression and Instrumented Fusion in Recurrent Lumbar Disc Prolapse**  
*Saumyajit Basu, MD; Sandeep Kumar Kesharwani, MS; Tarun Suri, MS; Amitava Biswas, MS; Sri Krishna Chaitanya Kondety, MS; Sathik Babu, MS; Subhadip Mandal, MS; Trinanjan Sarangi, MD; Soubhadra Chakraborty, MD*
- 10:42 - 10:49 **Discussion**
- 10:49 - 10:53 **Paper 126: Predictors of Hospital Readmission and Surgical Site Infection in the US, Denmark and Japan: Is Risk Stratification a Universal Language?**  
*Steven D. Glassman, MD; Leah Yacat Carreon, MD, MSc; Mikkel Osterheden Andersen, MD; Anthony Asher, MD; Soren Peter Eiskjaer, MD; Martin Gehrchen, MD, PhD; Shiro Imagama, MD, PhD; Ken Ishii; Takashi Kaito, MD, PhD; Yukihiko Matsuyama, MD, PhD; Hiroshi Moridaira, MD, PhD; Praveen V. Mummaneni, MD; Christopher I. Shaffrey, MD; Morio Matsumoto, MD*
- 10:53 - 10:57 **Paper 127: Smoking is an Independent Risk Factor of Reoperation due to Recurrent Lumbar Disc Herniation**  
*Stina Lykke Brogård Andersen, MHS; Elisabeth Corydon Smith; Christian Støttrup, MD; Leah Yacat Carreon, MD, MSc; Mikkel Osterheden Andersen, MD*



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- 10:57 - 11:01 **Paper 128: Comparison of Intrathecal Diamorphine with Conventional Methods of Analgesia Following TLIF (Transforaminal Lumbar Interbody Fusion) Surgery**  
*Ramprabu Krishnan, MBBS, MD, DNB, FRCA; Robert Steven Lee, BS, MD, FRCS (Tr&Orth); Fady Sedra, FRCS(Tr&Orth)*
- 11:01 - 11:08 **Discussion**
- 11:08 - 11:12 **Paper 129: Impact of Pre-operative Diagnosis on Patient Satisfaction Following Lumbar Spine Surgery**  
*Charles H. Crawford, MD; Leah Yacat Carreon, MD, MS; Mohamad Bydon, MD; Anthony Asher, MD; Steven D. Glassman, MD*
- 11:12 - 11:16 **Paper 130: Clinico-radiological Outcomes Following Minimally Invasive Lateral (LLIF) versus Transforaminal Lumbar Interbody Fusion (TLIF)**  
*Fady Sedra, FRCS(Tr&Orth); Robert Steven Lee, BS, MD, FRCS (Tr&Orth); Benan Dala-Ali, MSc; Arash Afsharpad, FRCS Tr&Orth; Lester Wilson, FRCS(Tr&Orth)*
- 11:16 - 11:20 **Paper 131: Patient Reported Outcomes Underestimate the Impact of Major Complications in Patients Undergoing Spinal Surgery for Degenerative Conditions**  
*Borys Gvozdyev, MD; Leah Yacat Carreon, MD, MSc; Christopher Graves, MD; Stephanie Riley, BS; Katlyn E. McGraw, BA; Richard Head, BS; John R. Dimar, II, MD; Steven D. Glassman, MD*
- 11:20 - 11:24 **Paper 132: The Effect of Prophylactic Vertebroplasty on the Incidence of Proximal Junctional Kyphosis and Proximal Junctional Failure Following Posterior Spinal Fusion in ASD: A 5 Year Follow-up Study**  
*Tina Raman BS, MD, MS; Emily Kristine Miller, BA; Christopher T. Martin, MD; Khaled M. Kebaish, MD, FRCSC*
- 11:24 - 11:31 **Discussion**
- 11:31 - 11:35 **Paper 133: BMP Use and the Risk of Revision Surgery Following Long Posterolateral Fusions in the Elderly**  
*Varun Puvanesarajah; Amit Jain, MD; Jourdan M. Cancienne, MD; Adam L. Shimer, BS, MD; Francis H. Shen, MD; Hamid Hassanzadeh, MD*
- 11:35 - 11:39 **Paper 134: Pediatric Patients with Spondylolysis Have High Rates of Vitamin-D Deficiency**  
*Marielle Amoli, MD; Jeffrey R. Sawyer, MD; Robert Tyler Ellis, BS; David Spence, MD; Derek M. Kelly, MD; William C. Warner, MD*
- 11:39 - 11:43 **Paper 135: Complications with Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS-TLIF) in the Morbidly Obese Population with Degenerative Spondylolisthesis**  
*Eiman Shafa, MD; James D. Schwender, MD*
- 11:43 - 11:47 **Paper 136: Cage Subsidence in Lateral Interbody Fusion with Transpoas Approach: Intraoperative Endplate Injury or Late Onset Settling**  
*Kataro Satake, MD; Tokumi Kanemura, MD, PhD; Hidetoshi Yamaguchi, MD; Naoki Segi, MD; Jun Ouchida, MD*
- 11:47 - 11:55 **Discussion**

### 7C. Surgical Techniques: A Video-Based Session

ROOM: SALON 1-5

Moderators: Sigurd H. Berven, MD & Christopher I. Shaffrey, MD

- 10:30 - 10:47 **Pedicle Subtraction Osteotomy**  
*Christopher P. Ames, MD*
- 10:51 - 11:08 **Deformity TLIF**  
*Lawrence G. Lenke, MD*
- 11:12 - 11:29 **Anterior Surgery for Lumbar Scoliosis**  
*Henry F.H. Halm, MD*
- 11:33 - 11:50 **Implant Based Correction Maneuvers to Restore Sagittal Balance**  
*Stephen J. Lewis, MD, MSc, FRCSC*



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11:55 – 12:05 **Walking Break**

12:05 – 13:05 **Exhibit Viewing & Lunch**

ROOM: SALON 6

\* Hands-On Workshops with Lunch

ROOMS: SALON 14; SALON 15; MT. VERNON SQUARE; JUDICIARY SQUARE

(See Exhibits and Hands-On Workshops (HOW) section on page 191 for more information)

13:05 – 13:15 **Walking Break**

13:15 – 14:15 **Concurrent Sessions 8A-E: Roundtable Sessions and Two-Minute Point Presentations**

## 8A. MIS Deformity Correction (Adult and Pediatric)

ROOM: SALON 1-5

Moderators: Richard G. Fessler, MD, PhD & Juan S. Uribe, MD

Case Presenters

13:15 - 13:30 Firoz Miyajni, MD, FRCSC  
13:30 - 13:45 Praveen V. Mummaneni, MD  
13:45 - 14:00 Michael Y. Wang, MD, FACS  
14:00 - 14:15 Suken A. Shah, MD

## 8B. PJK Considerations

ROOM: SALON 7-10

Moderators: Michael F. O'Brien, MD & Frank J. Schwab, MD

Case Presenters

13:15 - 13:30 Benny T. Dahl, MD, PhD, DMSci  
13:30 - 13:45 Serena Hu, MD  
13:45 - 14:00 Justin S. Smith, MD, PhD  
14:00 - 14:15 John C. France, MD

## 8C. Cervical Degenerative Disease and CSM

ROOM: SALON 12-13

Moderators: Michael G. Fehlings, MD, PhD, FRCSC & James S. Harrop, MD

Case Presenters

13:15 - 13:30 Vincent C. Traynelis, MD  
13:30 - 13:45 Brian K. Kwon, MD, PhD, FRCSC  
13:45 - 14:00 Lee H. Riley, MD  
14:00 - 14:15 Rick C. Sasso, MD

## 8D. Thoracolumbar Trauma

ROOM: SHAW / LEDROIT PARK

Moderators: Robert N. Dunn, MMed FCS(SA) Orth & Rajiv K. Sethi, MD

Case Presenters

13:15 - 13:30 Peter S. Rose, MD  
13:30 - 13:45 Michael K. Rosner, MD  
13:45 - 14:00 Marcel F. Dvorak, MD, FRCSC  
14:00 - 14:15 Paul A. Anderson, MD

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## 8E. Two-Minute Point Presentations

ROOM: CHINATOWN

Moderators: Kamal N. Ibrahim, MD, FRCSC, MA & John A.I. Ferguson, FRACS

13:15 - 13:17 **Paper 137: Primary Drivers of Cervical Deformity: Prevalence and Effect of Surgical Treatment Strategies on Post-Operative Alignment**

*Peter G. Passias, MD; Cyrus M. Jalai, BA; Virginie Lafage, PhD; Renaud Lafage, MS; Themistocles S. Protopsaltis, MD; Subaraman Ramchandran, MD; Munish Chandra Gupta, MD; Robert A. Hart, MD; Vedat Deviren, MD; Alex Soroceanu, MD, MPH, FRCSC; Justin S. Smith, MD, PhD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; International Spine Study Group*

13:17 - 13:19 **Paper 138: Predictive Model for Patient-reported Outcomes Scores Following Cervical Spine Deformity Surgical Correction**

*Peter G. Passias, MD; Cheongeun Oh, PhD; Cyrus M. Jalai, BA; Gregory Wyatt Poorman, BA; Renaud Lafage, MS; Bassel G. Diebo, MD; Justin K. Scheer, BS; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Themistocles S. Protopsaltis, MD; Han Jo Kim, MD; Robert A. Hart, MD; Virginie Lafage, PhD; Christopher P. Ames, MD; International Spine Study Group*

13:19 - 13:21 **Paper 139: Cervical Deformity Surgery Does Not Result in Post-operative Dysphagia: A Prospective Cohort Study**

*Han Jo Kim, MD; Hongda Bao, MD, PhD; Sravisht Iyer, MD; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Munish Chandra Gupta, MD; Todd J. Albert, MD; Gregory M. Mundis, Jr., MD; Peter G. Passias, MD; Brian Neuman, MD; Eric Klineberg, MD; Virginie Lafage, PhD; Christopher P. Ames, MD; International Spine Study Group*

13:21 - 13:23 **Paper 140: The Center of Rotation (COR) of Cervical 3-Column Osteotomies (3-CO) for Correction of Cervical Kyphosis**

*Heiko Koller, MD; Michael Mayer, MD, PhD; Juliane Koller, MD; Wolfgang Hitzl, PhD, MSc*

13:23 - 13:25 **Paper 141: Cervical Spine Sagittal Alignment is Different in Standing and Sitting: Are these Changes Predictable?**

*Dennis Hwee Weng Hey, MD; Alex Quok An Teo, BS; Leok-Lim Lau, MD; Gabriel Liu, FRCSC; Hee-Kit Wong, MD*

13:25 - 13:35 **Discussion**

13:35 - 13:37 **Paper 142: Risk Factors For Persistent Axial Neck Pain After Cervical Disc Arthroplasty**

*Scott C. Wagner, MD; Peter M. Formby, MD; Daniel G. Kang, MD; Gregory S. Van Blaricum, MD; Ronald A. Lehman, Jr., MD; Theodore Steelman, MD*

13:37 - 13:39 **Paper 143: Bimodal Incidence and Causes of Proximal Junctional Kyphosis (PJK) in Adult Spinal Deformity (ASD)**

*Munish Chandra Gupta, MD; Bassel G. Diebo, MD; Themistocles S. Protopsaltis, MD; Robert A. Hart, MD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; Renaud Lafage, MS; Justin K Scheer, BS; Han Jo Kim, MD; Shay Bess, MD; Douglas C. Burton, MD; Peter G. Passias, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group*

13:39 - 13:41 **Paper 144: Early and Late Reoperation Rates and Etiologies Are Similar Between cMIS and HYB Techniques for ASD Correction.**

*Robert K. Eastlack, MD; Gregory M. Mundis, Jr., MD; Stacie Nguyen, MPH; Praveen V. Mummaneni, MD; David .O Okonkwo, MD, PhD; Adam Kanter, MD; Neel Anand, MD, Mch Orth; Paul Park, MD; Pierce D. Nunley, MD; Juan S. Uribe, MD; Behrooz A. Akbarnia, MD; Dean Chou, MD; Vedat Deviren, MD; International Spine Study Group*

13:41 - 13:43 **Paper 145: Proximal Junctional Kyphosis (PJK) Can Be Predicted Following Adult Spinal Deformity (ASD) Surgery: Models Based On Regional Alignment Changes Within the Fusion Area**

*Barthelemy Liabaud, MD; Renaud Lafage, MS; Robert A. Hart, MD; Frank J. Schwab, MD; Justin S. Smith, MD, PhD; Han Jo Kim, MD; Richard Hostin, MD; Peter G. Passias, MD; Christopher P. Ames, MD; Gregory M. Mundis, Jr., MD; Douglas C. Burton, MD; Shay Bess, MD; Eric O. Klineberg, MD; Virginie Lafage, PhD; International Spine Study Group*



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- 13:43 - 13:45 **Paper 146: Interbody Cage Height Affects Subsidence Rate After Transforaminal Lumbar Interbody Fusion**  
*Scott C. Wagner, MD; Peter M. Formby, MD; Daniel G. Kang, MD; Melvin D. Helgeson, MD; Ronald A. Lehman, Jr., MD; Theodore Steelman, MD*
- 13:45 - 13:55 **Discussion**
- 13:55 - 13:57 **Paper 147: Natural History of Proximal Junctional Kyphosis following Posterior Correction and Fusion for Congenital Scoliosis**  
*Xu Sun, MD, PhD; Xi Chen, MD; Zhonghui Chen, MD, PhD; Yong Qiu, MD; Ze-zhang Zhu, MD; Bing Wang, MD, PhD; Bangping Qian, MD; Yang Yu, MD, PhD*
- 13:57 - 13:59 **Paper 148: Comparative Analysis of Surgical Outcomes of Posterior Vertebral Column Resection by the Age at the Time of Surgery in the Treatment of Congenital Scoliosis: Greater than 10-Year Follow-up**  
*Dong-Gune Chang, MD; Se-II Suk, MD; Jin-Hyok Kim, MD; Dong-Ju Lim, MD; Suh Woo Seung, MD, PhD; Jung-Hee Lee, MD, PhD; Jae Hyuk Yang, MD, PhD; Jung Sub Lee, MD, PhD; Woojin Cho, MD, PhD*
- 13:59 - 14:01 **Paper 149: The Impact of Prosthetic Rib Treatment on Respiratory Assistance Requirement**  
*Sarah B. Nossow, MD; Robert M. Campbell, Jr., MD; Oscar Henry Mayer, MD; John T. Smith, MD; Sumeet Garg, MD; John M. Flynn, MD; Children's Spine Study Group; Patrick J. Cahill, MD*
- 14:01 - 14:03 **Paper 150: Rib Based Posterior Growing Rod Construct Implantation to Treat Children with Early Onset Scoliosis without Rib Abnormalities: A Prospective Multicenter Study**  
*Ron El-Hawary, MD; Muayad Kadhim, MD; Michael G. Vitale, MD, MPH; John T. Smith, MD; Amer F. Samdani, MD; John M. Flynn, MD; Children's Spine Study Group*
- 14:03 - 14:05 **Paper 151: Choice of Anchors – Rib vs. Spine: Importance of Proximal Anchor Number**  
*Michael G. Vitale, MD, MPH; Hiroko Matsumoto, PhD; Nicholas Feinberg; Evan P Trupia, BS; Matthew B. Shirley; Sumeet Garg, MD; John M. Flynn, MD; Peter F. Sturm, MD, MBA; Francisco Javier Sanchez Perez-Gruoso, MD; David Price Royce, MD; David L. Skaggs, MD, MMM; Children's Spine Study Group; Growing Spine Study Group*
- 14:05 - 14:15 **Discussion**

14:15 – 14:30 **Walking Break & Exhibit Viewing**

ROOM: SALON 6

14:30 – 15:30 **Concurrent Sessions 9A-D: Abstract Session, Debate Series and Instructional Course Lectures**

**9A. Kyphosis, Congenital & Neuromuscular Deformity Abstracts**

ROOM: SALON 1-5

Moderators: *Jahangir K. Asghar, MD & Sigurd H. Berven, MD*

- 14:30 - 14:34 **Paper 152: Proximal Junctional Kyphosis in Scheuermann Kyphosis**  
*Alexander Gibson, FRCS; Darren F. Lui, FRCS; Jessica Osborn, MD; Haiming Yu, MD; Sean Molloy, FRCS (Orth) MSc*
- 14:34 - 14:38 **Paper 153: The Efficacy and Complications of Posterior-only Vertebral Column Resection (PVCR) for the Treatment of Severe Congenital Kyphoscoliosis**  
*Shengru Wang, MD; Jianguo Zhang, MD*
- 14:38 - 14:42 **Paper 154: Open versus Minimally Invasive Approach (MIS) in Placement of Pedicle Screws at the Upper-Instrumented Vertebra (UIV) and the Effect on the Incidence of Proximal Junctional Kyphosis (PJK): A Prospective Randomized Controlled Study**  
*Emily Kristine Miller, BA; Tina Raman, BS, MD, MS; Floreana Naef Kebaish, MD; Richard L Skolasky, ScD; Khaled M. Kebaish, MD, FRCSC*

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## Friday, July 15, 2016

- 14:42 - 14:49 **Discussion**
- 14:49 - 14:53 **Paper 155: Analysis of Patients with Cerebral Palsy Requiring Reoperation After Spinal Fusion: Associated Risk Factors and Impact on Quality of Life**  
*Amer F. Samdani, MD; James Stephen, MD; Giuseppe Orlando, MD; Joshua M. Pahys, MD; Randal R. Betz, MD; Peter O. Newton, MD; Firoz Miyajani, MD, FRCSC; Suken A. Shah, MD; Michelle Claire Marks, PT, MA; Burt Yaszay, MD; Patrick J. Cahill, MD; Paul D. Sponseller, MD, MBA*
- 14:53 - 14:57 **Paper 156: Are Severely Underweight Patients with Cerebral Palsy at a Higher Risk for Complications and Poorer Outcomes Following Posterior Spinal Fusion for Scoliosis?**  
*Joshua M. Pahys, MD; Amer F. Samdani, MD; Michael P. Kelly, MD, MS; Paul D. Sponseller, MD; Craig D. Steiner, MD; Peter O. Newton, MD; Suken A. Shah, MD; Tracey Bastrom, BS, MA; Harms Study Group; Patrick J. Cahill, MD*
- 14:57 - 15:01 **Paper 157: Minimally Invasive Surgery for Neuromuscular Scoliosis: Preliminary Results and Complications**  
*Laffi Miladi, MD; Mathilde Gaume, Fellow; Nejib Khouri, MD; Christophe Glorion, MD, PhD*
- 15:01 - 15:05 **Paper 158: Impact of Spinal Deformity and Surgery on Health-Related Quality of Life in Cerebral Palsy**  
*Patrick J. Cahill, MD; Unni Narayanan, FRCSC; Burt Yaszay, MD; Stefan Parent, MD, PhD; Jahangir K. Asghar, MD; Joshua M. Pahys, MD; Mark F. Abel, MD; Suken A. Shah, MD; Peter G. Gabos, MD; John M. Flynn, MD; Saba Pasha, PhD; Amer F. Samdani, MD; Peter O. Newton, MD; Harms Study Group; Paul D. Sponseller, MD, MBA*
- 15:05 - 15:12 **Discussion**
- 15:12 - 15:16 **Paper 159: Accuracy of Percutaneous Screws Inserted Under Intra-operative Cone-beam Computed Tomography and Navigation**  
*Robert Steven Lee, FRCS (Tr&Orth)*
- 15:16 - 15:20 **Paper 160: The Clinical Spectrum of PROMIS Physical Function Scores Over Time in Patients with Operative Lumbar Pathology**  
*Stephen Pehler, MD; Yue Zhang, PhD; William Ryan Spiker, MD; Brandon Douglas Lawrence, MD; Sukanta Maitra, MD; Darrel S. Brodke, MD*
- 15:20 - 15:24 **Paper 161: Surgical Correction of the Severe Rigid Pelvic Obliquity with PVCR in Neglected Congenital Scoliosis.**  
*Ozcan Kaya, MD; Selhan Karadereler, MD; Sinan Kahraman, MD; Bulent Guneri, MD; Gurkan Gumussuyu, MD; Gokhan Peker, MD; Kursad Aytakin; Tunay Sanli, MA; Meric Enercan, MD; Ufuk Talu, MD; Azmi Hamzaoglu, MD*
- 15:24 - 15:30 **Discussion**

### 9B. Debate Series 3

ROOM: SALON 7-10

Moderators: Todd J. Albert, MD & Michael Fehlings, MD, PhD, FRCSC

#### 14:30 - 14:54 **Debate 1: Cervical Deformity Correction Approach: Which is Better?**

*A/P: James S. Harrop, MD*

*Posterior: Vincent C. Traynelis, MD*



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14:54 - 15:30 **Debate 2: What Is the Optimal Approach for Single Level Radiculopathy/CSM?**

*Arthroplasty: Rick C. Sasso, MD*  
*Anterior Discectomy and Fusion: Tushar C. Patel, MD*  
*Laminoplasty: Lee H. Riley, MD*

## 9C. What Is New in Pediatric Deformity

ROOM: SALON 12-13

*Moderators: Kenneth MC Cheung, MD & John P. Dormans, MD*

14:30 - 14:40 **Brace Compliance and Efficacy: What Role Do Compliance Meters, Education and Counseling Provide?**

*Laurel C. Blakemore, MD*

14:40 - 14:50 **How Do We Use Spine Growth Data to Effectively Treat Early Onset Scoliosis?**

*James O. Sanders, MD*

14:50 - 15:00 **When to Fuse to the Pelvis in the Ambulatory Patient**

*Paul D. Sponseller, MD, MBA*

15:00 - 15:10 **Emerging Technologies: Growing Constructs and Beyond**

*Suken A. Shah, MD*

15:10 - 15:30 **Discussion**

## 9D. International Spine ICL: What are the Differences in the Approach to Adult Deformity Surgery?

ROOM: SHAW / LEDROIT PARK

*Moderators: Marinus De Kleuver, MD, PhD & Henry F.H. Halm, MD*

14:30 - 14:40 **Differing Approaches for Adult Spinal Deformity**

*Sebastien Charosky, MD*

14:40 - 14:50 **Are There Differences in Complication Rates for ASD Around the Globe?**

*Oheneba Boachie-Adjei, MD*

14:50 - 15:00 **Providing Safe and High Quality Surgical Care for ASD: How Can it Be Done Cost Effectively?**

*Robert Dunn, MMed FCS(SA) Orth*

15:00 - 15:10 **Taking Care of ASD Patients When Resource Allocation is Challenging: Is This the Future for all Surgeons?**

*Sean Molloy, FRCS (Orth) MSc*

15:10 - 15:30 **Discussion**

15:30 – 15:45 **Walking Break**

15:45 – 16:45 **Concurrent Sessions 10A-E: Instructional Course Lectures and Two-Minute Point Presentations**

## 10A. Pediatric Deformity: Common Challenges in Treatment and Correction

ROOM: SALON 7-10

*Moderators: B. Stephens Richards, III, MD & Daniel J. Sucato, MD, MS*

15:45 - 15:55 **How Does 3D Understanding Aid in Classifying AIS?**

*Carl-Eric Aubin, PhD, P.Eng*

15:55 - 16:05 **What Are the Most Reproducible Steps to Achieve Derotation and Deformity Correction?**

*Peter O. Newton, MD*

16:05 - 16:15 **Can We Really Save Levels With Anterior Surgery?**

*Henry F.H. Halm, MD*



# MEETING AGENDA

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

## Friday, July 15, 2016

16:15 - 16:25 **When Can the Rules of Level Selection Be Violated?**  
*Kenneth MC Cheung, MD*

16:25 - 16:45 **Discussion**

### 10B. Adult Deformity II: Goals and Complication Avoidance

ROOM: SALON 1-5

*Moderators: Christopher J. DeWald, MD & Christopher Hamill, MD*

15:45 - 15:55 **Defining the Goals in Approaching the Deformity?**  
*Ian J. Harding, FRCS(orth)*

15:55 - 16:05 **How to Ensure the Patient Will Tolerate a Major Operation: Considerations and Red Flags**  
*Christopher I. Shaffrey, MD*

16:05 - 16:15 **Perioperative Complications: Recognition and Solutions**  
*Sigurd H. Berven, MD*

16:15 - 16:25 **How Do We Assess and Optimize Patient Outcomes Following Complex Reconstructions?**  
*Hee-Kit Wong, MD*

16:25 - 16:45 **Discussion**

### 10C. Safety ICL

ROOM: SHAW / LEDROIT PARK

*Moderators: Lawrence G. Lenke, MD & Michael G. Vitale, MD, MPH*

15:45 - 15:55 **The Seattle Spine Team Approach: Applying Principles of LEAN and the Toyota Production System to Spine Surgery**  
*Rajiv K. Sethi, MD*

15:55 - 16:05 **Quality 101: PDCA, RCA, Six Sigma and LEAN- What Is all This and How Can it Be Applied to Spine Care?**  
*James O. Sanders, MD*

16:05 - 16:15 **Complex Spinal Deformity: How to Choose the Safest Operative Approach Both Pre-op and Intra-op, Including Staging When Appropriate**  
*David L. Skaggs, MD, MMM*

16:15 - 16:35 **Debate: Staggered or Simultaneous Spine Surgery**  
*I Never Stage Spine Surgery!: Serena S. Hu, MD*  
*I Always Stage!/: Praveen V. Mummaneni, MD*

16:35 - 16:45 **Discussion**

### 10D. Management of Junctional Failures

ROOM: SALON 12-13

*Moderators: John R. Dimar, II, MD & Michael K. Rosner, MD*

15:45 - 15:55 **Etiology and Treatment of Proximal Junctional Failures**  
*Christopher P. Ames, MD*

15:55 - 16:05 **What Can Be Done to Prevent Proximal Junctional Failures**  
*Morio Matsumoto, MD*

16:05 - 16:15 **LIV Selection in Long Adult Deformity Constructs: When Can One Reliably Stop Short of the Sacrum?**  
*Yong Qiu, MD*



# MEETING AGENDA

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

Friday, July 15, 2016

16:15 - 16:25 **When to Do VCR for PJK in Upper Thoracic Spine vs Extension into Cervical Spine**

*Ronald A. Lehman, Jr., MD*

16:25 - 16:45 **Discussion**

## 10E. Two-Minute Point Presentations

ROOM: CHINATOWN

*Moderators: Neel Anand, MD, Mch Orth & Amer F. Samdani, MD*

15:45 - 15:47 **Paper 162: Long-Term Results of Spine Stapling for AIS**

*Lawrence L. Haber, MD; Erika D Womack, PhD; M. Wade Shrader, MD; Takisha Robinson, BS*

15:47 - 15:49 **Paper 163: Spinal Surgery in Achondroplasia: Outcome Analysis and Risk Factors for Impending Neurologic Deficit**

*John Heydemann, MD; Oussama Abousamra, MD; Tyler Kreitz, MD; Kenneth J. Rogers, PhD; Colleen Ditro, RN; Suken A. Shah, MD; William Mackenzie, MD*

15:49 - 15:51 **Paper 164: Selection of Lowest Instrumented Vertebra for Thoracolumbar Kyphosis in Ankylosing Spondylitis**

*Guoquan Zheng; Yan Wang, MD; Zheng Wang, MD, PhD; XueSong Zhang, MD*

15:51 - 15:53 **Paper 165: Surgical versus Nonsurgical Treatment of Lumbar Degenerative Kyphosis**

*Jung Sub Lee, MD, PhD; Tae Sik Goh, MD; Jong Ki Shin, MD; Seung Min Son, MD*

15:53 - 15:55 **Paper 166: How Does Case Type, Length Of Stay, and Comorbidities Affect Medicare DRG Reimbursement for Minimally Invasive Surgery (MIS) for Deformity?**

*Pierce D. Nunley, MD; Richard G. Fessler, MD, PhD; Paul Park, MD; Joseph M. Zavatsky, MD; Gregory M. Mundis, Jr., MD; Juan S. Uribe, MD; Robert K. Eastlack, MD; Dean Chou, MD; Michael Y. Wang, MD; Neel Anand, MD, Mch Orth; Adam Kanter, MD; Vedat Deviren, MD; Praveen V. Mummaneni, MD; International Spine Study Group*

15:55 - 16:05 **Discussion**

16:05 - 16:07 **Paper 167: High Pelvic Incidence Predicts Alignment Failure in Patients Undergoing 3-Column Osteotomy**

*Gregory M. Mundis, Jr., MD; Virginie Lafage, PhD; Christopher P. Ames, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Frank J. Schwab, MD; Eric O. Klineberg, MD; Themistocles S. Protopsaltis, MD; Behrooz A. Akbarinia, MD; Bassel G. Diebo, MD; Han Jo Kim, MD; Vedat Deviren, MD; International Spine Study Group*

16:07 - 16:09 **Paper 168: National Trends for Primary and Revision Lumbar Disc Arthroplasty Throughout the United States from 2005-2013**

*Comron Saifi, MD; Alex Ha, MD; Alejandro Cazzulino, BA; Joseph Lawrence Laratta, MD; Charla R. Fischer, MD; Mark Weidenbaum, MD; Lawrence G. Lenke, MD; Ronald A. Lehman, Jr., MD*

16:09 - 16:11 **Paper 169: Timing of Preoperative Lumbar Corticosteroid Injection Does Not Affect Postoperative Infection Rate**

*Scott C. Wagner, MD; Jonathan Seavey, MD, MS; George Balazs, MD*

16:11 - 16:13 **Paper 170: Delayed Post-operative Foot Drop in Lumbar Spine Surgery: Natural History of Recovery, Correlation with Type of Surgery and Type of Pathology**

*Saumyajit Basu, MD; Sri Krishna Chaitanya Kondety, MS; Tarun Suri, MS; Amitava Biswas, MS; Sandeep Kesharwani, MS; Kiran Tapal, MS; Trinanjan Sarangi, MD*

16:13 - 16:15 **Paper 171: Inpatient Outcomes in Dialysis Dependent Patients Undergoing Elective Lumbar Surgery for Degenerative Lumbar Disease**

*Andrew Chung, DO; Norman Chutkan, MD; Joshua Hustedt, MD*

# MEETING AGENDA

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## Friday, July 15, 2016

- 16:15 - 16:25 Discussion
- 16:25 - 16:27 **Paper 172: Is Propionibacterium Acnes Becoming the Most Common Bacteria of Postoperative Infection Following Adolescent Idiopathic Scoliosis Surgery?**  
*Dave Nelles, MD; Calvin Kuo, MD; Todd Lincoln, BS, MD; Ravi Bains, MD*
- 16:27 - 16:29 **Paper 173: Utility of Supine Lateral Radiographs in the Assessment of Segmental Instability in Degenerative Lumbar Spondylolisthesis**  
*Foster Chen, MD; Woajin Cho, MD, PhD; Louis Amorosa, MD*
- 16:29 - 16:31 **Paper 174: National Trends for Primary and Revision Anterior and Lateral Lumbar Interbody Fusion Throughout the United States from 2004-2013**  
*Camron Saifi, MD; Alex Ha, MD; Alejandro Cazzulino, BA; Kola Jegede, MD; Charla R. Fischer, MD; Joseph Lawrence Laratta, MD; Yongjung Jay Kim, MD; Mark Weidenbaum, MD; Lawrence G. Lenke, MD; Ronald A. Lehman, Jr., MD*
- 16:31 - 16:33 **Paper 175: Is There a Correlation Between Gross Motor Function Classification System (GMFCS) Level and Scoliosis in Patients with Cerebral Palsy? A Systematic Review.**  
*Abdul Gaffar Dudhniwala, MRCS, FRCS (Orth); Lara E. McMillan, BS, Medical Student; Sashin Ahuja, FRCS*
- 16:33 - 16:35 **Paper 176: In Patients with Nonidiopathic Spinal Deformity, Risk of Surgical Site Infection can Range from 2.0% to 54.8%: Results of a Novel Risk Severity Score**  
*Jeanne Franzone, MD; Hiroko Matsumoto, PhD; WG Stuart Mackenzie; Michael Troy, BS; Kody K. Barrett, BA; Brendan Striano; Michael P. Glotzbecker, MD; John M. Flynn, MD; David L. Skaggs, MD, MMM; David Price Royce, MD; Michael G. Vitale, MD, MPH*
- 16:35 - 16:45 Discussion

16:45 – 17:00 **Walking Break**

16:45 – 17:00 **Membership Info Session**

ROOM: SALON 14

19:00 – 22:00 **\*Course Reception**

SMITHSONIAN NATIONAL ZOOLOGICAL PARK

*Please see page 5 for more information*

## Saturday, July 16, 2016

8:15 – 11:30 **Registration Open**

8:15 – 8:45 **Breakfast/Exhibits Closed**

ROOM: SALON 6

8:45 – 9:45 **Concurrent Sessions 11A-C: Instructional Course Lectures**

**11A. Management of Degenerative Cervical Myelopathy AOSpine and CSRS Guidelines: AOSpine North America and AOSpine International Special Symposia**

ROOM: SALON 7-10

*Moderators: Michael G. Fehlings, MD, PhD, FRCS & Rick C. Sasso, MD*

8:45 - 8:55 **Introduction and Presentation of Two Cases: Mild Cervical Myelopathy and Cervical Stenosis with Cord Compression but no Myelopathy**

*Michael G. Fehlings, MD, PhD, FRCS*



# MEETING AGENDA

† = Whitecloud Award Nominee – Best Clinical Paper  
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## Saturday, July 16, 2016

8:55 - 9:05 **Management of Cervical Cord Compression Without Cord Compression and Mild Degenerative Cervical Myelopathy**

*Brian K. Kwon, MD, PhD, FRCSC*

9:05 - 9:15 **Management of Moderate and Severe Degenerative Cervical Myelopathy**

*Vincent C. Traynelis, MD*

9:15 - 9:25 **Review of Methodology for Systematic Reviews and Guidelines**

*Lindsay Tetreault, PhD*

9:25 - 9:45 **Panel Discussion and Case Presentations**

### 11B. What is New in Lumbar Degenerative Surgery

ROOM: SALON 12-13

*Moderators: Jacob M. Buchowski, MD, MS & Jeffrey D. Coe, MD*

8:45 - 8:55 **Biomaterials for Interbody Cages**

*Paul A. Anderson, MD*

8:55 - 9:05 **Expandable Interbody Cages**

*Jeffrey D. Coe, MD*

9:05 - 9:15 **Cortical Screw Fixation**

*Mladen Djurasovic, MD*

9:15 - 9:25 **Spinal Alignment in Lumbar Degenerative Fusion**

*Jacob M. Buchowski, MD, MS*

9:25 - 9:45 **Discussion**

### 11C. Emerging Technologies in Spine Surgery

ROOM: SALON 1-5

*Moderators: Neel Anand, MD, Mch Orth & Ian J. Harding, BA, FRCS(Orth)*

8:45 - 8:55 **MIS Tumor Surgery: What Is New in Lumbar Degenerative Surgery**

*Peter S. Rose, MD*

8:55 - 9:05 **Posterior Sagittal Realignment From a Posterior-Only Route Without Major Osteotomies**

*Ronald A. Lehman, Jr., MD*

9:05 - 9:15 **Intra-op Factors That Help Limit Blood Loss During Major Spinal Reconstructions**

*Justin S. Smith, MD, PhD*

# MEETING AGENDA

† = Whitecloud Award Nominee – Best Clinical Paper  
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## Saturday, July 16, 2016

9:15 - 9:25 **Intra-op Navigation: Where We Are Now and Where We Are Headed?**  
*David W. Polly, Jr., MD*

9:25 - 9:45 **Discussion**

9:45 – 10:00 **Walking Break**

10:00 – 11:00 **Session 12: Debate Series**

### 12. Debate Series 4

ROOM: SALON 1-5

*Moderators: Ahmet Alanay, MD & J. Abbott Byrd, III, MD*

10:00 - 10:20 **LLIF is Superior to TLIF for Adult Degenerative Lumbar**  
*Pro: Praveen V. Mummaneni, MD*  
*Con: Tyler Koski, MD*

10:20 - 10:40 **TLIF is Always Needed for Degenerative Spondy Instrumented Fusions**  
*Pro: Jacob M. Buchowski, MD, MS*  
*Con: Jeffrey A. Goldstein, MD*

10:40 - 11:00 **Biologics are a Must for Long Adult Deformity Surgeries**  
*Pro: Steven D. Glassman, MD*  
*Con: Saumyajit Basu, MD*

11:00 – 11:30 **Walking Break & Lunch Buffet**

MEETING LEVEL 2 FOYER

11:30 – 13:00 **Session 13: Lunch with the Experts**

### 13. Lunch with the Experts: Top Pearls and Pitfalls I Have Learned in My Career

ROOM: SALON 1-5

*Moderators: Kamal N. Ibrahim, MD, FRCSC, MA & Ronald A. Lehman, Jr., MD*

#### Case Presenters

11:30 - 11:42 *Christopher I. Shaffrey, MD*  
11:48 - 12:00 *Oheneba Boachie-Adjei, MD*  
12:06 - 12:18 *Harry L. Shufflebarger, MD*  
12:24 - 12:36 *David W. Polly, Jr., MD*  
12:42 - 12:54 *John P. Kostuik, MD, FRCSC*

12:54 - 13:00 **Discussion**

13:00 **Adjourn**









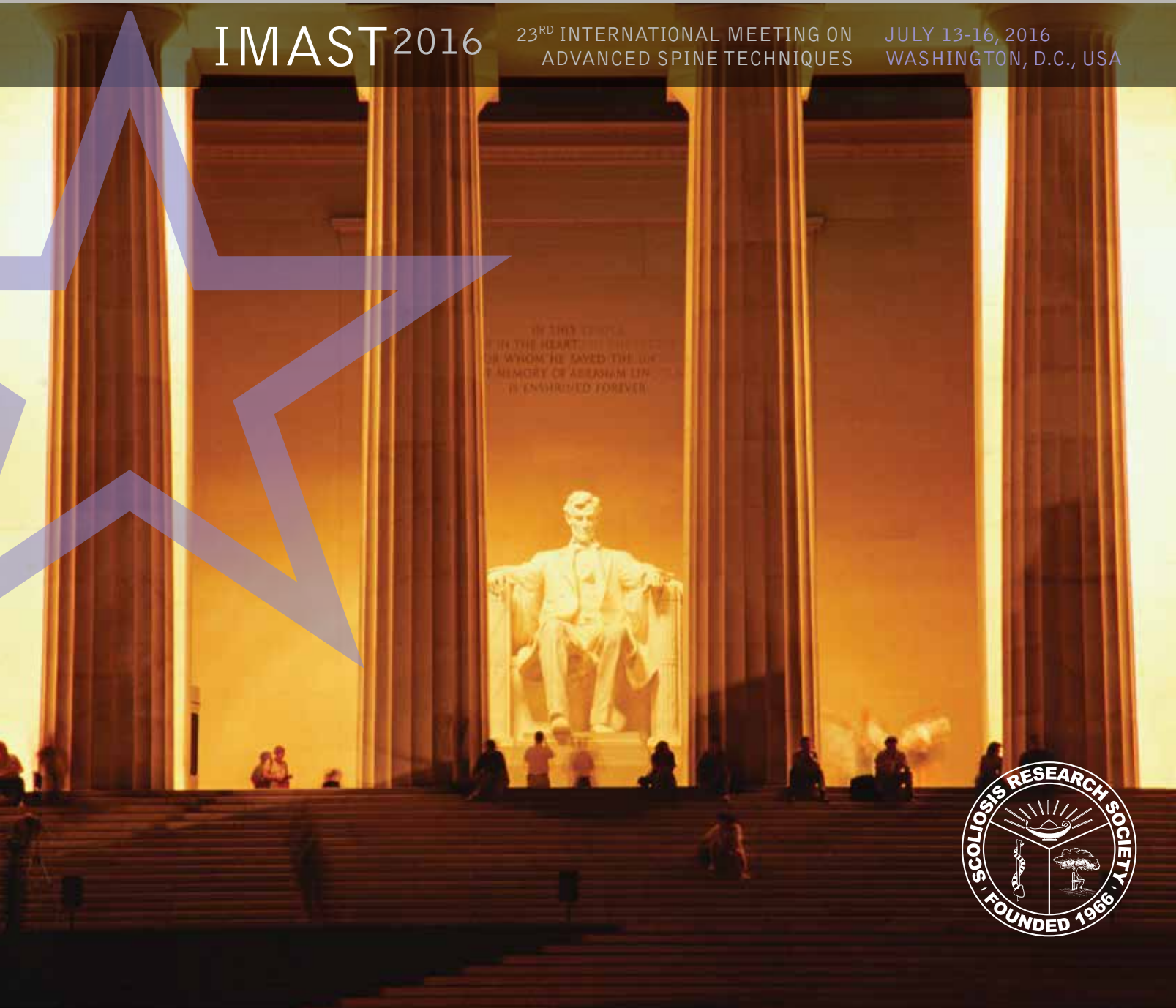


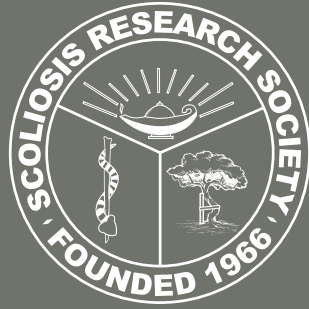
# PAPER ABSTRACTS

IMAST2016

23<sup>RD</sup> INTERNATIONAL MEETING ON  
ADVANCED SPINE TECHNIQUES

JULY 13-16, 2016  
WASHINGTON, D.C., USA





**The Scoliosis Research Society  
gratefully acknowledges NuVasive for  
their support of the Welcome Reception,  
Newsletter and Breakfasts.**



# PAPER ABSTRACTS

## 1. Surgical Planning of Anterior Vertebral Body Tethering in Pediatric Idiopathic Scoliosis

Nikita Cobetto, BS, MS; Carl-Eric Aubin, PhD, P.Eng.; Stefan Parent, MD, PhD  
Canada

### Summary

A finite element model of pediatric scoliosis integrating growth was developed for the numerical simulation of short and long-term effects of Anterior Vertebral Body Tethering (AVBT). The installation of AVBT and 2 years of vertebral growth were simulated for 33 patients. Simulated post-operative Cobb angles were on average  $\pm 4^\circ$  of that of the actual correction,  $\pm 5^\circ$  for kyphosis/lordosis angles, and  $\pm 4^\circ$  for apical axial rotation.

### Hypothesis

Surgical planning of anterior vertebral body tethering (AVBT) in pediatric idiopathic scoliosis potentially could be predicted using patient-specific finite element models (FEM).

### Design

Numeric planning and simulation of immediate and long-term effects of AVBT for 33 patients.

### Introduction

AVBT is a recently introduced fusionless compression-based approach for pediatric scoliotic patients presenting progressive curves. Surgical planning is mostly empirical and reported issues include over-correction (inversion of the side) of the curve and a lack of control on 3D correction. The objective was to develop a planning tool based on patient-specific FEM of pediatric scoliosis integrating growth to computationally assess the short and long-term 3D biomechanical effects of AVBT.

### Methods

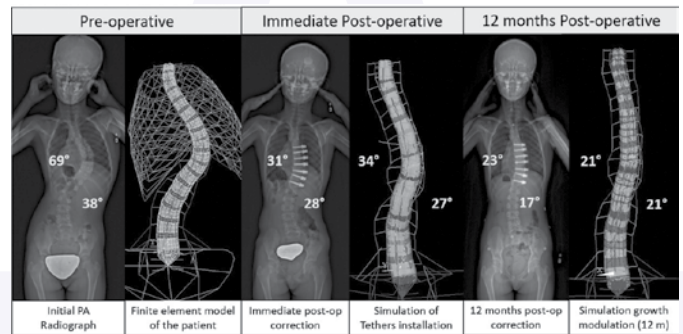
33 scoliotic patients instrumented with AVBT at our institution were used. The study was approved by our institutional ethical committee and each participant and their parents gave a written consent. An osseo-ligamentous FEM of the spine, rib cage and pelvis was generated using patient's 3D reconstruction obtained from calibrated bi-planar radiographs. For each case, we simulated a few scenarios of AVBT, and 2 years of vertebral growth and growth modulation due to gravitational loads and forces from the tethers. For the final scenario that was used for the surgery, simulated correction indices in the coronal, sagittal and transverse planes were computed and compared to actual patient's post-operative and 1 year follow-up data.

### Results

The simulated immediate post-operative Cobb angles were on average  $\pm 4^\circ$  of that of the actual correction, while it was  $\pm 5^\circ$  for kyphosis/lordosis angles, and  $\pm 4^\circ$  for apical axial rotation. For patients with 1 year follow-up, correction results were predicted at  $\pm 4^\circ$  for Cobb angles and  $\pm 3\%$  for T1-L5 height.

### Conclusion

A numeric model simulating the immediate and long term effects of AVBT was developed to study the 3D corrective effects.



1) Initial PA radiograph and FEM; 2) Immediate post-operative correction and simulation of AVBT immediate effect; 3) 1-year post-operative results and simulation of 1 year growth modulation (rib-cage and ligaments not shown for clarity)

## 2. Treatment of Severe Scoliosis: Role of Traction Halo vs Progressive Magnetic Temporary Bar for Correction and Fusion in Two Separate Times (An Innovative Technique)

Tiziana Gregg, MD; Elena Maredi, MD; Francesco Vommaro, MD; Stefano Giacomini, MD; Mario Di Silvestre, MD; Andrea Baioni, MD

Italy

### Summary

Classical surgical treatment for severe scoliosis has been characterized by a combined approach (anterior release and posterior fusion); pedicle screws have reaffirmed the role of posterior approach alone. The goals of scoliosis treatment are to stop curve progression, to correct the curve while achieving a balanced and solid fusion, and to minimize complications, especially the neurological ones.

### Hypothesis

Surgical treatment for severe scoliosis has been characterized by a combined approach and gradual distraction before final arthrodesis

### Design

Three female patients were treated for severe scoliosis using transient magnetic rods for internal distraction followed by magnetic rod removal and definitive PSF.

### Introduction

pedicle screws have reaffirmed the role of posterior approach.

### Methods

Three female patients were treated for severe scoliosis using transient magnetic rods for internal distraction followed by magnetic rod removal and definitive PSF.

MCGR: Case A: 12-year-old female with severe thoracic scoliosis of  $120^\circ$ . First Stage: release, pedicle screws T3-L4 with MCGR, then daily ultrasound guided lengthening for 3 weeks followed by second stage posterior arthrodesis and thoracoplasty.

Case B: 15-year-old, kyphoscoliosis of  $115^\circ$ . The same technique as in case A was performed.

Case C: 21-year-old female with Noonan syndrome. Thoracic kyphoscoliosis of  $130^\circ$ , The same technique as in case A was performed.



# PAPER ABSTRACTS

## Results

A: First : scoliosis decreased to 75°. After the second operation it was equal to 42° with a total correction of 65%. No neurological complication.

B: First : scoliosis decreased to 72°. After the second stage it was 45° with a total correction of 60%. No neurological complication.

C: First : scoliosis decreased to 80° (correction 38%). The patient showed reduced bone mineral density and developed respiratory distress: she was admitted to an Intensive Care unit. Last x-rays revealed a scoliosis and kyphosis correction in Cobb degrees equal to 59° (correction rate of 49%) and 43° (correction 48%), respectively.

Follow-up at two months showed scoliosis and kyphosis in Cobb degrees of 59° and 44°, respectively.

## Conclusion

The MGCR is a valid alternative when the use of halo is contraindicated in the presence of myeloradicular malformations or halo traction is not well tolerated by the patient or their family. Results are comparable in terms of correction and the psychological effect of MGCR elongation is favorable. All of the data are available in literature.

## 3. Selective Thoracic Fusion with Spontaneous Improvement of Lumbar Curve in Adolescent Idiopathic Scoliosis Patients

*Shyam Kishan, MD; Dennis Raymond Knapp, MD; Mark D. Rahm, MD; Karl E. Rathjen, MD; Virginie Lafage, PhD; Matthew E. Cunningham, MD, PhD; Oheneba Boachie-Adjei, MD; Hongda Bao, MD, PhD; Julie Lynn Reigrut, MS United States*

## Summary

20 cases utilizing the Enhanced Rigidity Spinal Beam System (ERSB) demonstrated that the restoration of thoracic kyphosis (TK) would benefit the spontaneous improvement of coronal lumbar curve in adolescent idiopathic scoliosis (AIS) patients who underwent Selective Thoracic Fusion (STF).

## Hypothesis

STF may benefit AIS patients with more mobile levels. Although a recent study with 30-year follow-up showed lumbar curves may be stable without fusion, a method to improve spontaneous correction can be pursued.

## Design

Multi-center retrospective review.

## Introduction

Since AIS is a three dimensional deformity, the correction of sagittal profile may impact the coronal curve. This study aims to investigate if pelvic parameters and restoration of TK would influence spontaneous improvement of lumbar curves in AIS patients.

## Methods

AIS patients with lower instrumented vertebra at L1 and above were reviewed. The radiographic parameters including TK, pelvic incidence (PI), pelvic tilt (PT), sacrum slope (SS), coronal lumbar (CL) and coronal thoracic (CT) Cobb angles were obtained pre-operatively and at 6-weeks. Pearson's correlation was performed between change in CL curve and restoration of sagittal parameters.

Patients with good (TK+) and failed (TK-) restoration (defined as post-op TK - pre-op TK  $\geq 0$ ) were compared in terms of CL curve improvement.

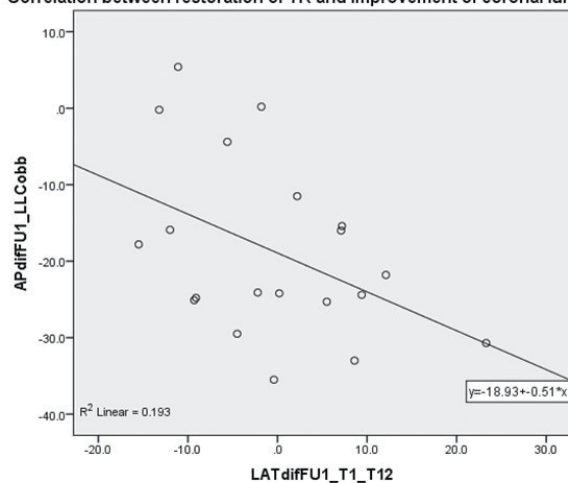
## Results

20 patients (mean age 15.7 yrs) with a mean CT Cobb angle of 62.2° were reviewed. Strong correlation was shown between change of TK and improvement of CL Cobb angle ( $r=0.440$ ,  $P=0.026$ ). No correlation was observed between change of CL Cobb angle and pelvic parameters. Both TK groups had similar pre-op and post-op major Cobb angles. However, significant difference was observed in CL Cobb angle improvement between two groups ( $P=0.024$ ) indicating that CT curve correction was less effective in spontaneous CL curve correction, than the restoration of thoracic kyphosis.

## Conclusion

Thoracic Kyphosis restoration in STF improves spontaneous lumbar curve correction. This effect appears to be more important than that of the coronal thoracic curve correction.

Correlation between restoration of TK and improvement of coronal lumbar curve



## 4. Comparison of The Risk of Spinal Cord Injury During Different Surgical Steps in Severe Thoracic Scoliosis Posterior Approach Vertebral Column Resection

*Yang Junlin, MD, PhD; Huang Zifang, MD, PhD China, People's Republic of*

## Summary

Posterior approach vertebral column resection (VCR) has been proved as a useful way to reach a significant spine deformity correction. However, risk of spinal cord injury due to VCR osteotomy cannot be ignored. To our best knowledge, there is no researches evaluating the risk of spinal cord injury during different steps of the operating procedure by analyzing changes in evoked potentials in different stages of posterior approach vertebral column resection (VCR) in severe thoracic scoliosis.

## Hypothesis

Through effective MIOM, the high-risk VCR osteotomy can be performed relatively safely.



# PAPER ABSTRACTS

## Design

We retrospectively reviewed the cases of 33 consecutive patients who had undergone VCR for severe thoracic scoliosis under combined monitoring of SSEP/MEP.

## Introduction

To evaluate the risk of spinal cord injury during different steps of the operating procedure by analyzing changes in evoked potentials in different stages of posterior approach vertebral column resection (VCR) in severe thoracic scoliosis.

## Methods

We retrospectively reviewed the cases of 33 consecutive patients who had undergone VCR for severe thoracic scoliosis under combined monitoring of SSEP/MEP from May 2008 through March 2012. Based on different steps of the operating procedure, monitoring data were collected and analyzed. Risk factors that induced this change were evaluated.

## Results

100% cases of our group obtained successful combined monitoring. The average Cobb angle of coronal plane major curve was corrected from 124.2° preoperatively to 61.9° postoperatively, with the average corrective rate of 50.2%. The average kyphotic angle was corrected from 101.6° preoperatively to 27.8° postoperatively, with the average corrective rate of 72.6%. 10 out of 33 cases had 14 changes in EPs totally, among which 1 occurred in screw insertion, 6 occurred in osteotomy, 6 occurred in closure and 1 occurred in correction. There were 11 positive SSEP findings and 11 positive MEP findings. In cases aforementioned, there were 4 cases whose SSEP/MEP changed during surgery had post-op positive neural abnormalities, including 3 transient neural injuries and 1 irreversible neurologic injury.

## Conclusion

Through effective MIOM, the high-risk VCR osteotomy can be performed relatively safely. This study showed that 85.7% of signal changes in neurological monitoring occurred when osteotomy and closure were performed, which indicated high risk of neural injury in these two steps.

## 5. Risk Factors for Revision Surgery Following Primary Adult Spinal Deformity Surgery in Patients 65 Years and Older

*Varun Puvanesarajah; Francis H. Shen, MD; Jourdan M. Cancienne, MD; Amit Jain, MD; Adam L. Shimer, BS, MD; Hamid Hassanzadeh, MD*

*United States*

## Summary

The elderly population is poorly studied with regards to revision surgery following adult spinal deformity (ASD) correction. The purpose of this study is to assess factors that modify the risk of revision surgery in elderly ASD patients. Obesity is a significant univariate predictor of one-year revision surgery. Osteoporosis and BMP use are associated with significantly increased and decreased, respectively, risks of revision surgery at five years postoperatively. Five years following surgery, it was estimated that the cohort had 68.8% survivorship.

## Hypothesis

Comorbid conditions are strong predictors of increased revision surgery in ASD patients.

## Design

Retrospective review of prospective multicenter Medicare database.

## Introduction

Surgical correction of ASD is a complex undertaking with high revision rates. The elderly population is poorly studied with regards to revision surgery, yet senior citizens constitute a rapidly expanding surgical demographic. The purpose of this study is to assess factors that modify the risk of revision surgery in elderly adult spinal deformity (ASD) patients.

## Methods

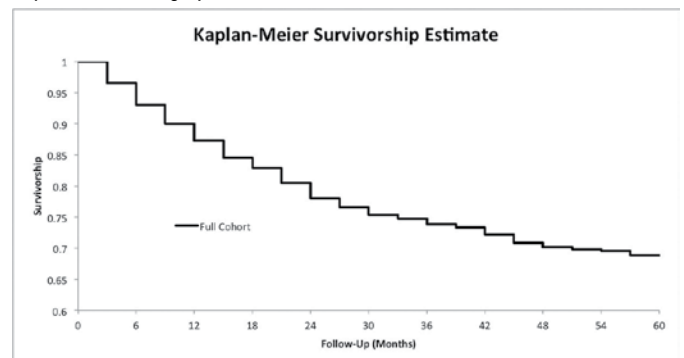
The PearlDiver database (2005-2012) was utilized to determine revision rates in elderly ASD patients treated with a primary thoracolumbar posterolateral fusion of eight or more levels. Analyzed risk factors included demographics, comorbid conditions, and surgical factors. Significant univariate predictors were further analyzed with multivariate analysis. Significance was set at  $p < 0.005$  for multiple comparisons.

## Results

In total, 2,293 elderly patients were identified. After 1 year, 241 patients (10.5%) were treated with revision surgery, while 424 (18.5%) had revision surgery within five years postoperatively. Multivariate analysis at five years of follow-up revealed that osteoporosis (OR 1.98, 95% CI 1.60 - 2.46,  $p < 0.0001$ ) and BMP use (OR 0.70, 95% CI 0.56 - 0.88,  $p = 0.002$ ) were significantly associated with increased and decreased revision risk, respectively. Smoking history trended towards significance (OR 1.37, 95% CI 1.10 - 1.70,  $p = 0.005$ ). Instrument failure was consistently the most commonly cited reason for revision. Five years following surgery, it was estimated that the cohort had 68.8% survivorship.

## Conclusion

For the elderly ASD patient, osteoporosis increases the risk of revision surgery, while BMP use decreases the risk of revision surgery. Other comorbidities were not found to be significant predictors of long-term revision rates. It is expected that within five years following the index procedure, over 30% of patients will require revision surgery.



Survivorship curve of all 2,293 cases included in this study



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## 6. Assessment of a Novel Adult Cervical Deformity (ACD) Frailty Index (FI) as a Component of Preoperative Risk Stratification

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United States*

### Summary

Complication rates following ACD have been associated with specific approaches and other surgical strategies. For this reason, adequate risk stratification of preoperative patients is necessary to assist with surgical planning and patient counseling. A deformity-specific frailty index (ACD-FI) was developed to assess frailty in this database. This frailty score was strongly associated with increased hospital length of stay and risk of major complications.

### Hypothesis

Increasing frailty will strongly correlate with complication rates following ACD surgery.

### Design

Retrospective review of a prospective, multicenter database

### Introduction

As patients become increasingly frail, they have been shown to be more vulnerable to adverse outcomes in general surgery. Following a validated model, we developed a novel ACD-FI and assessed the value of this index as a component of risk stratification.

### Methods

A frailty index was constructed using 40 variables contained in a multicenter adult cervical deformity database using a validated method from geriatric literature. The ACD-FI score was calculated as the average of all variables and used to stratify patients into 3 frailty cohorts:  $<0.2$  = not frail (NF),  $0.2-0.4$  = frail (F),  $>0.41$  = severely frail (SF). We then performed a multivariate logistic regression to determine the relationship between ASD-FI cohorts, incidence of major complications and hospital length of stay (LOS).

### Results

Of 61 patients with minimum one year follow up, the average ACD-FI was 0.26 (range 0-0.6). 17 patients were not frail, 34 were frail, and 10 were severely frail. The unadjusted odds ratio of having a major complication was 1.13 [0.34-3.8] and 2.75 [0.55-13.7] times higher for F (n=34) and SF (n=10) compared to NF (n=17) patients, but it was not significant ( $p>0.05$ ). After adjusting for important covariates such as operative time, the odds ratio of having a major complication was 15.2 [1.0-237.9] ( $p=0.052$ ) for F (n=34) and 53.8 [1.5-1882] ( $p<0.05$ ) for SF (n=10) compared to NF patients (n=17). The adjusted odds ratio of having a medical complication was 3.1 (not significant) for F and 44.9 [1.3-1559] ( $p<0.05$ ) for SF. Total surgical complications were not significantly correlated.

### Conclusion

Increasing frailty was strongly associated with increased risk of major complications and medical complications for ACD patients undergoing surgery. This indicates the value of the ACD-FI to improve the accuracy of preoperative risk stratification and allow for adequate patient counseling.

## 7. Primary vs Revision Adult Cervical Deformity: A Prospective Multicenter Study with 1-Year Follow-up

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Canada*

### Summary

Study on primary vs revision surgery in adult cervical deformity (ACD), looking at baseline patient characteristics, surgical parameters, complications, and health-related quality of life (HRQL) outcomes. Results show that both groups had similar complication rates. Revision patients have more disability at baseline, but both groups achieve similar HRQL improvements one-year post surgery.

### Hypothesis

Primary vs revision ACD patients differ in regards to their baseline characteristics, surgical parameters, and HRQL.

### Design

Prospective multicenter case series

### Introduction

There is little data in the current literature on the surgical treatment of adult cervical deformity (ACD), in particular revision surgery. This study looks at revision versus primary surgery in operative ACD patients.

### Methods

Surgically treated ACD patients who completed the one-year follow up visit were divided into two groups (primary vs revision). Baseline patient characteristics, surgical parameters, HRQL, and complications were assessed using t-tests and  $\chi^2$ , as appropriate.

### Results

61 patients met inclusion criteria: revision n=28, primary n=33. The two groups were similar in terms of gender distribution ( $p=0.9$ ), smoking ( $p=0.6$ ), Charlson Comorbidity Index ( $p=0.5$ ), or BMI ( $p=0.6$ ). In regards to surgical data, both groups were similar in regards to surgical time ( $p=0.1$ ), blood loss ( $p=0.4434$ ), use of traction ( $p=0.13$ ), and surgical approach ( $p=0.14$ ). Revision patients had a trend towards more 3-column osteotomies (15.2% vs 35.7%,  $p=0.06$ ) and were more likely to require admission to the ICU post surgery (89.3% vs 66.7%,  $p=0.036$ ). At baseline, revision patients had worse NDI scores (54.49 vs 45.34,  $p=0.0375$ ) and similar mJOA (13.43 vs 13.37  $p=0.93$ ) and NRS neck pain (6.89 vs 6.78,  $p=0.86$ ). At 1 year, both groups had similar improvements on the NDI ( $p=0.675$ ) and mJOA ( $p=0.2560$ ). Revision patients experiences less improvement on the NRS neck pain (1.69

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vs 3.375,  $p=0.036$ ). Revision and primary patients had similar rates of overall ( $p=0.12$ ) and major complications ( $p=0.19$ ).

## Conclusion

Our results show that at baseline, revision ACD patients have more disability as measured on the NDI score. Revision and primary patients achieve similar improvements at 1-year on the NDI and mJOA, but revision patients experience less improvement in neck pain. Revision patients showed a trend towards more 3-column osteotomies, and were more likely to require ICU admission. Complication rates were similar amongst both groups.

## 8. Location of Correction Within the Lumbar Spine Impacts Acute Adjacent Segment Kyphosis

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United States

## Summary

Surgical correction of adult spinal deformity (ASD) often involves modification of lumbar lordosis (LL) to restore appropriate sagittal alignment. However, large changes in LL are a risk factor for proximal junctional kyphosis (PJK). This study investigated the impact of cranial vs. caudal correction within the lumbar spine on PJK. Results showed that PJK patients had kyphotic changes in the L4-S1 segments and a restoration of the lumbar lordosis at more cranial levels (T12-L3).

## Hypothesis

Caudal vs. cranial correction of LL will significantly impact the occurrence of proximal junctional kyphosis (PJK).

## Design

Retrospective review of prospective multicenter database

## Introduction

Surgical correction of adult spinal deformity (ASD) often includes modification of lumbar lordosis (LL) to restore ideal sagittal alignment. However, corrections that include large changes in LL pose increased risk for developing PJK. Little is known about the impact of cranial vs caudal (i.e. upper lumbar vs lower lumbar segments) correction in the lumbar spine on the occurrence of PJK.

## Methods

Surgically treated ASD patients with early follow-up (6 wks) and fusion of the full lumbo-sacral spine were included. Radiographic parameters included classic spino-pelvic parameters (PI, PT, PI-LL, SVA) and segmental correction (Figure). Using Glatte's criteria, patients were stratified into PJK and noPJK, and propensity matched by age and regional lumbar correction (PI-LL).

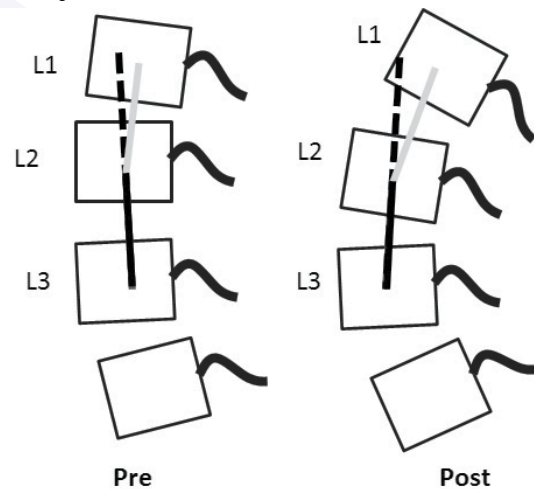
Radiographic parameters and segmental correction were compared between PJK and noPJK patient using independent t-tests.

## Results

348 out of 483 patients were included in the analysis after propensity matching (64yo, 76% F, 50% with PJK). There were no significant differences between PJK and noPJK patients in baseline, post-op, or change in alignment, with the exception of the TK and  $\Delta$ TK (due to the influence of PJK). PJK pts had a decrease in segmental lordosis at L4-L5-S1 ( $-0.4$  vs.  $1.6^\circ$ ,  $p=0.027$ ), and larger increases in segmental correction at cranial levels L1-L2-L3 ( $9.6$  vs.  $7.4^\circ$ ), T12-L1-L2 ( $7.3$  vs.  $5.3^\circ$ ), T11-T12-L1 ( $2.8$  vs.  $0.6^\circ$ ), all  $p<0.05$ .

## Conclusion

Though achievement of optimal sagittal alignment is the goal of realignment surgery, dramatic lumbar corrections appear to increase the risk of PJK. This study was the first to demonstrate that patients who developed PJK underwent kyphotic changes in the L4-S1 segments, as well as restoration of the lumbar lordosis at more cranial levels (T12-L3). These findings suggest that restoration of lordosis at lower lumbar levels may result in less risk of PJK. Further studies may expand upon this work by investigating rod contouring of the uppermost fused segments.



**Segmental correction:** Example: L3-L2-L1 correction:

[Angle between L3-L2 and L2-L1 (black versus light grey) post] minus [Angle between L3-L2 and L2-L1 pre]

If Negative = kyphotic progression and if Positive = lordotic progression

## 9. Incidence of Proximal Junctional Kyphosis in Patients with Adult Spinal Deformity Fused to the Pelvis: A ScolioRisk-1 Sub-analysis

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United States

## Summary

The aim was to investigate the incidence of proximal junction kyphosis (PJK) in adult spinal deformity patients fused to the pelvis, and to compare PJK rates in patients with long (UIV at or cranial to T8) vs. short (UIV caudal to T8)



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constructs. The overall incidence of PJK in our study was 23.7%, with 9.6% patients requiring revision for PJK. Further, there was no significant difference in PJK rate in long vs. short fusion constructs anchored at the pelvis.

### Hypothesis

In adult spinal deformity (ASD) patients fused to the pelvis, the incidence of proximal junctional kyphosis (PJK) would be significantly higher in short vs. long fusion constructs.

### Design

Secondary analysis of a prospective cohort

### Introduction

The aim of our study was to investigate the incidence of PJK in ASD patients fused to the pelvis, and to compare PJK rates in patients with long (defined as upper instrumented vertebrae "UIV" at or cranial to T8) vs. short (UIV caudal to T8) fusion constructs.

### Methods

198 (73% of 272) patients who had long or short fusions anchored to the pelvis were identified from the AOSpine-SRS ScolioRisk-1 prospective study. At 2 years, 148 (75%) patients had radiographic and 159 (80%) patients had clinical follow-up. Patients who required revision surgery for PJK were classified as having "symptomatic PJK." Patients who had a change from postoperative to a follow-up radiograph of  $>10^\circ$  in kyphosis between the UIV and two levels above, but did not require revision were classified as "radiographic PJK."

### Results

Over the 2-year follow-up, PJK was noted in 47 of 198 (23.7%) patients. Of all patients, 19 (9.6%) underwent a revision surgery for PJK. Of 133 patients who did not undergo revision for PJK and had follow-up radiographic data available, 28 (21.1%) had radiographic evidence of PJK. The long vs. short fusion groups did not differ significantly with respect to rates of overall PJK (23.5% vs. 24.1%,  $P=0.933$ ), symptomatic PJK (6.7% vs. 13.9%,  $P=0.092$ ) or radiographic PJK (25.3% vs. 14.8%,  $P=0.145$ ). Comparing health related quality of life outcomes in patients with radiographic PJK and those without PJK, there were no significant differences in: SF-36 physical component summary ( $P=0.986$  and  $P=0.714$ ), SF-36 mental component summary ( $P=0.705$  and  $P=0.952$ ), and SRS-22r total scores ( $P=0.993$  and  $P=0.322$ ) at baseline or at the 2-year follow-up, respectively.

### Conclusion

The overall incidence of PJK in severe ASD patients with fusion to the pelvis was 23.7% with 9.6% undergoing revision. There was no increased rate of PJK or revision for PJK in long vs. short fusion constructs anchored at the pelvis.

## 10. Microarray and Integrated Gene Network Analysis Identify Differential Genes Expression Profiles and Pathways of Bone Marrow Mesenchymal Stem Cells of Adolescent Idiopathic Scoliosis Patients

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China, People's Republic of*

### Summary

This study aims to explore the differential genetic expression profile, Go terms and KEGG pathways in bone marrow mesenchymal stem cells (BM-MSCs) of AIS and non-AIS controls. Microarray analysis and comprehensive bioinformatics analyses were used to identify differentially expressed genes of BM-MSCs from adolescent idiopathic scoliosis (AIS) patients compared with those from healthy individuals. 1,027 previously unrecognized genes were differential expressed in AIS MSCs, which may provide novel insight into the underlying etiological mechanisms of AIS and associated osteopenia.

### Hypothesis

Differential genes expression profiles of BM-MSCs might play a significant role, in not only the causal mechanism of osteopenia in AIS, but also the AIS initiation and development.

### Design

Microarray approach and integrated gene network analysis.

### Introduction

The pathogenesis of AIS and the accompanying generalized osteopenia remain unclear. Our previous study suggested increased proliferation ability and decreased osteogenic differentiation ability of BM-MSCs of AIS. Therefore, we hypothesized that that MSCs may play a significant role in the etiology and pathogenesis of AIS.

### Methods

In this study, microarray analysis was used to identify differentially expressed genes (DEGs) of BM-MSCs from AIS patients compared with those from healthy individuals. Comprehensive bioinformatics analyses were then used to enrich datasets for Gene Ontology and pathway. Based on the gene signal transduction network analysis of DEGs contained in significant pathways, 24 potential crucial genes were selected for validation by RT-PCR.

### Results

There are 1,027 previously unrecognized DEGs in BM-MSCs from AIS patients. Pathway analysis revealed dys-regulated MAPK signaling pathway; PI3K-Akt signaling pathway, Calcium signaling pathway, and Notch signaling pathway, all of which have been reported to play important role in regulating the osteogenic or adipogenic differentiation of MSCs. Furthermore, gene signal transduction networks analysis indicated that MAP2K, SMAD3, HOXC6, HSPA6, GTF2I, CREBBP, PIK3R2 and DUSP2 may play essential roles in AIS pathogenesis and accompanied osteopenia.

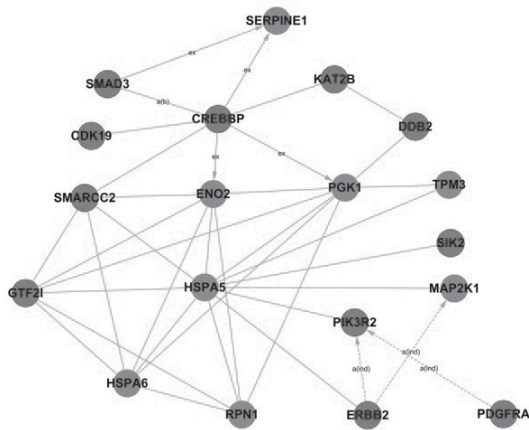
### Conclusion

This study reports the differential genes expression profiles of BM-MSCs from AIS patients and related potential pathways for the first time. These previously unrecognized genes and molecular pathways might play a significant role, in



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not only the causal mechanism of osteopenia in AIS, but also the AIS initiation and development.



Genes-genes interaction network of the 24 selected significant genes in AIS patients

## 11. Do Surgeons' Hands Get Re-Contaminated in Operations Longer Than Three Hours? A Pilot Study

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### Summary

Despite advances in surgical site infection (SSI) control, SSI surgical site infection (SSI) still cause complications especially in long operations (>3 hours). There is evidence that the efficacy of the scrubbing material fades away after three hours. Hence, it can be postulated that the scrubbed surgeon's hands may become a progressive source of contamination during surgery. The results of this study proved this hypothesis. Based on these findings rescrubbing at 4 hours is recommended.

### Hypothesis

Scrubbed surgeons' hands get recontaminated in operations lasting longer than three hours.

### Design

Prospective level II study

### Introduction

Surgical site infection (SSI) is a substantial cause of complications in patients. Different methods are being used to decrease SSI, however SSI can still cause complications especially in long operations (>3 hours). There is evidence that the efficacy of the scrubbing material fades away after three hours. Hence, it can be postulated that the scrubbed surgeon's hands may become a progressive source of contamination during surgery.

### Methods

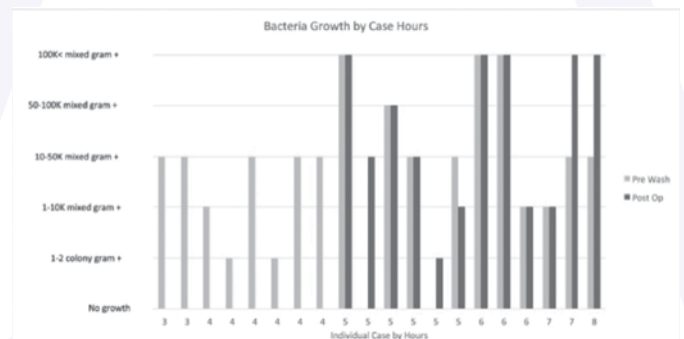
Three spine surgeons used the same scrubbing technique and material. Exclusion criteria included procedures less than three hours, and procedures that required changing of both sets of gloves. Twenty consecutive spine surgeries were included. Surgeons' hands were swabbed with sterile cotton tip applicators and 5 ml sterile Phosphate Buffered Saline at the following time points: Prior to hand scrubbing (pre-scrub), immediately following hand scrubbing (post-scrub) and immediately following surgery (post-operative).

### Results

Surgeries that were at least five hours had the post-operative colony count reach the same level or higher than the pre-scrub. The longer the operation, the higher the level of contamination post-operatively with a linear regression coefficient of 0.89 and  $p=0.005$ . None of the cases lasting 3-4 hours had colony growth post-operatively.

### Conclusion

Our results demonstrate that after four hours, a surgeon's hands starts recolonizing. Based on this pilot study, a larger clinical investigation to prove the necessity of rescrubbing at fourth hour post scrubbing is recommended.



## 12. Comprehensive Biomechanical Analysis of Three Lumbopelvic Reconstruction Techniques Following Total Sacrectomy - An In Vitro Human Cadaveric Model

*Bryan W. Cunningham, PhD; Mohamad Bydon, MD; Ashley A. Murgatroyd, BS; Kenneth Mullinix, BS; Ziya L. Gokaslan, MD United States*

### Summary

Using an in vitro cadaveric model, this investigation compared the multidirectional flexibility and anteroposterior shear properties at the lumbosacral and lumbopelvic junctions following 3 different lumbopelvic reconstruction techniques for total sacrectomy. Multidirectional flexibility testing demonstrated that Reconstruction 3, which incorporated four iliac screws and four rods, significantly or markedly reduced lumbopelvic segmental motion for all loading modes. Four bilateral iliac screws and four rods results in greater stabilization than two iliac screws and rods, with or without transverse iliac fixation.

### Hypothesis

A four iliac screw with four rod lumbopelvic reconstruction improves biomechanical stabilization for total sacrectomy reconstructions.



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## Design

In vitro cadaveric model.

## Introduction

Aggressive sacral tumors oftentimes require en bloc resection and lumbopelvic reconstruction. Using an in vitro cadaveric model, this study investigated 3 different methods of lumbopelvic reconstruction by multidirectional flexibility and axial compression testing, comparing range of motion and translation at the lumbosacral and lumbopelvic junctions.

## Methods

Eight human lumbopelvic specimens underwent biomechanical testing in flexion-extension, lateral bending, axial rotation ( $\pm 12.5\text{Nm}$ ) and axial compression. Following intact analysis, each specimen underwent total sacrectomy and reconstruction: Reconstruction 1 - segmental pedicular fixation (L3-L5) plus bilateral rods anchored with two iliac screws; Reconstruction 2 - addition of a trans-iliac rod; Reconstruction 3 - four rods and four iliac screws. For analysis, range of motion (ROM) and translations were normalized to the intact condition.

## Results

Multidirectional flexibility testing demonstrated that Reconstruction 3 significantly reduced flexibility in flexion-extension and axial rotation ( $p < 0.05$ ), and markedly reduced lateral bending ( $p > 0.05$ ). Axial compression testing did not demonstrate significant differences in segmental shear ( $\pm Y$  and  $\pm Z$  axes) across treatments ( $p > 0.05$ ). Linear regression analysis of BMD versus lumbopelvic ROM did not indicate a significant correlation for any reconstruction or loading mode ( $p > 0.05$ ).

## Conclusion

There is a definitive kinematic advantage of a bilateral four iliac screw with four rod reconstruction method over a bilateral rod and iliac screw construct with regard to lumbopelvic range of motion. The addition of a trans-iliac bar offered no biomechanical advantage, and there was no evidence that osteopenia affected range of motion outcomes for these instrumentation methods. Four screws and four rod fixation for total sacrectomy is clinically achievable and offers improved stabilization compared to conventional iliac screw configurations.

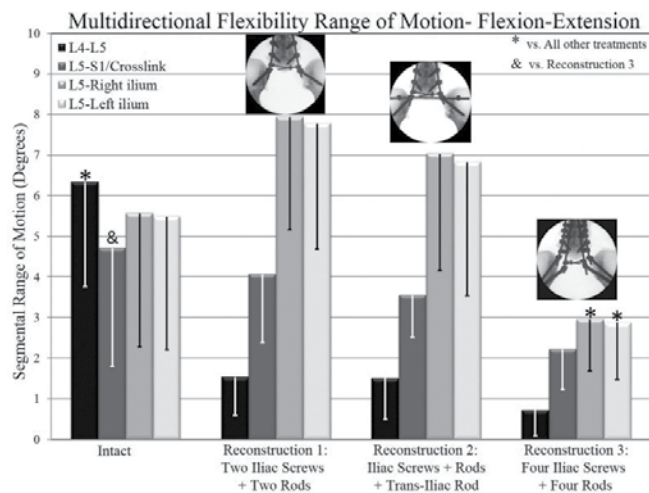


Figure 1

## 13. The Effect of Anti-Microbial Irrigations on Osteoblasts and Bone Formation: An in Vitro Comparison Of Vancomycin, Gentamicin and Povidone-Iodine.

Ashleigh Marie Philp; Matthew Peter Newton Ede, FRCS T&Q; Simon W. Jones, PhD United Kingdom

## Summary

Povidone-iodine (PVI), gentamicin and vancomycin have all been advocated to reduce infections in scoliosis surgery. These compounds are applied directly to the open wound prior to closure. We studied the effect of these solutions on osteoblasts and bone formation in vitro. We found that PVI was highly detrimental, whereas both gentamicin and vancomycin had very little adverse effect on the cells or their ability to form bone, even at doses far higher than anticipated in clinical practice.

## Hypothesis

PVI, vancomycin and gentamicin have varying magnitudes of effect on human osteoblasts and bone formation.

## Design

An in vitro study of the effect of anti-microbial solutions on human osteoblasts and bone nodule formation.

## Introduction

Success in scoliosis surgery is solid bony fusion without infection. Vancomycin, gentamicin and PVI have all been recommended as wound irrigants to reduce infection. Clinical studies describe a significant reduction in infection rates, however there is little work examining the effect of these solutions on osteoblasts and bone formation.

## Methods

Human osteoblasts were exposed to vancomycin (35 mM or 3.5 mM concentration), gentamicin (34 mM or 3.4 mM), 0.35% PVI or saline control. Proliferation was measured over the duration of 7 days by MTS assay. Metabolic function was determined by measuring oxygen consumption using a Seahorse Bioanalyser. Bone formation was quantified using Alizarin Red.

## Results

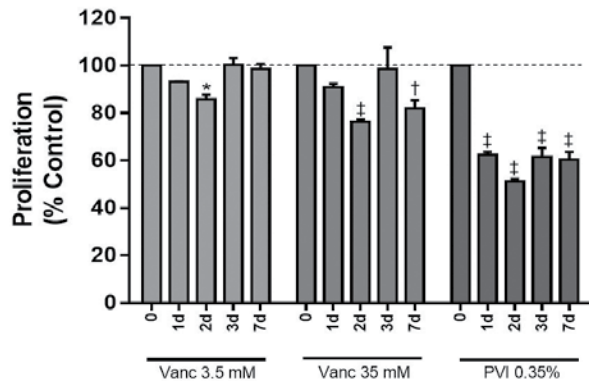
Compared to controls, gentamicin (3.4 mM) and vancomycin (3.5 mM) induced a transient 15-20% reduction in osteoblast proliferation, which recovered to control levels within 72 h. 0.35% PVI caused a sustained reduction in proliferation of 40-50% up to 7 days ( $P < 0.001$ ). PVI caused a 94% reduction in osteoblast metabolic rate ( $P < 0.001$ ) and a 24% reduction in bone nodule formation ( $P < 0.01$ ). Neither gentamicin nor vancomycin, at low or high dose, had any effect on metabolic rate, nor did they significantly affect the formation of bone nodules.

## Conclusion

Dilute PVI has a rapid and detrimental effect on human osteoblasts and bone formation. Conversely, gentamicin and vancomycin have a small and transient effect on proliferation and no effect on either metabolic function or bone formation, even at concentrations ten-times those expected in clinical practice. These findings support the Best Practice Guideline (2013) for using intrawound

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vancomycin powder in scoliosis surgery. We infer from our in vitro study that the additional risk of pseudarthrosis with vancomycin powder is negligible.



Osteoblast proliferation expressed as a percentage of control: low dose vancomycin; high dose vancomycin and PVI.

## 14. Correlations Between Quantitative T2 and T1ρ MRI Parameters and Mechanics and Biochemical Content in a Rabbit Intervertebral Disc Degeneration Model

Sarah Gullbrand, PhD; John Martin, PhD; Beth Ashinsky, MS; Lachlan Smith, PhD; Vincent Arlet, MD; Robert Mauck, PhD; Harvey Smith

United States

### Summary

Non-invasive imaging tools are needed to better assess the status of the IVD for longitudinal therapeutic trials of both DDD treatment and status of junctional levels after fusion. Here, in a rabbit degeneration model, quantitative MRI T2 and T1ρ are validated as markers for biomechanics and biochemistry.

### Hypothesis

Quantitative MRI parameters will correlate with IVD biochemical and biomechanical parameters.

### Design

In Vitro Rabbit Chemonucleolysis Model

### Introduction

Improved diagnostic measures for intervertebral disc (IVD) degeneration are necessary to enable early detection and treatment. Quantitative MRI parameters may serve as non-invasive diagnostic techniques to evaluate compositional and functional changes to the IVD.

### Methods

Rabbit lumbar spine motion segments (n=5/group) were injected with 100 μL of saline (control) or chymopapain at 3 U/mL, 15 U/mL or 100 U/mL. Following overnight digestion, T2 and T1ρ MRI series were obtained at 4.7T. Specimens were mechanically tested in tension-compression (20 cycles, +21N to -42N) and creep (10 minutes, -42N), to obtain the neutral zone (NZ) modulus, NZ range of motion (ROM), compressive modulus, compressive ROM, total ROM, creep moduli (S1, S2) and creep time constants (τ1, τ2). Nucleus

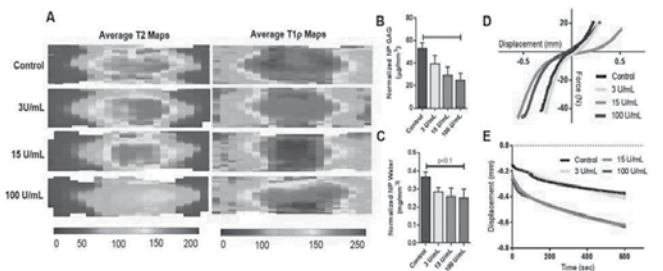
pulposus (NP) water and GAG contents were quantified and normalized to total NP volume. Stepwise multiple linear regression was performed to determine which parameters contributed most to changes in NP T2 and T1ρ values.

### Results

Chymopapain digest reduced NP T2, T1ρ, GAG and water content in a dose-dependent manner. Changes in IVD mechanical properties were also directly affected by increasing chymopapain dosage. Stepwise multiple linear regression yielded a model with GAG, compressive modulus, τ1 and τ2 as the variables that significantly (p=0.006) impacted T2 (r2=0.64). Stepwise multiple regression identified GAG and NZ modulus as variables contributing to T1ρ (p=0.08, r2=0.64).

### Conclusion

These results indicate that quantitative MRI can detect changes in the mechanical and biochemical properties of the IVD. T2 may be more sensitive to early stage degenerative changes than T1ρ.



(A) Time point average T2 and T1ρ maps of the rabbit IVD; NP (B) proteoglycan and (C) water content normalized to NP volume; Average (D) force-displacement curves and (E) creep curves

## 15. Location of Prophylactic Vertebral Cement Above Long-Instrumented Constructs Affects Junctional Endplate Stress: A Finite Element Model

Joseph M. Zavatsky, MD; David Charles Briski, BS

United States

### Summary

A finite element (FE) T6-pelvis osteoporotic spinal model was modified with screws/rods from T10-S1 and a tapered dose of vertebral cement in T10, T9, and T8. Endplate stress and ligamentous strain was analyzed for various cement configurations and compared to the gold standard of central placement. Stresses at the endplates of T8 and T9 reduced considerably with anteriorly placed cement. A decrease in maximal endplate stress translates to an increase in force required for endplate failure and possibly PJK.

### Hypothesis

Anterior placement of prophylactic vertebral cement reduces endplate stress.

### Design

Finite Element Analysis

### Introduction

PJK is not uncommon and can result in significant complication after spinal deformity surgery. Prophylactic vertebroplasty can reduce the rate of PJK,





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but optimal cement location or configuration has yet to be analyzed. Using a finite element (FE) model we analyzed various locations of a tapered dose of vertebral cement to see how it influences junctional endplate stress and ligamentous strain.

## Methods

A validated FE T6-pelvis osteoporotic spinal model was modified with screws/rods from T10-S1 and a tapered dose of vertebral cement in T10 (4cc), T9 (3cc), and T8 (2cc). Anterior, right lateral, left lateral, and staggered cement configurations were analyzed and compared to the gold standard of central placement. With the pelvis fixed, load was applied 10mm anterior to the center of T6 to simulate a flexion moment. Endplate stresses (T7-T10) and posterior ligamentous strain were recorded.

## Results

Anteriorly placed cement resulted in a 26% decrease in max superior endplate stress at T9, and a 21% decrease at T8, vs centrally located cement. Max superior and inferior endplate stress at T7 was similar for anterior vs central cement. Staggering the cement resulted in similar T7-T10 endplates stress and ligament strain vs centrally placed cement. Posterior ligamentous strain was reduced by 2% at the T8-T9 level with anterior placement.

## Conclusion

Anterior placement of prophylactic vertebral cement is advantageous when compared to the gold standard of centrally placed cement in this FE model. Stresses at the endplates of T8 and T9 reduced considerably with anteriorly placed cement. Posterior ligamentous strain was also reduced with anteriorly placed cement. However, staggering cement placement did not affect endplate stress or ligamentous strain. The effect of anterior cement placement may reduce endplate stress. A decrease in maximal endplate stress is beneficial, and translates to an increase in force required for endplate failure and possibly PJK.

## 16. What is the Optimal Vasopressor For Augmenting Cord Perfusion After Spinal Cord Injury?

Brian K. Kwon, MD, PhD, FRCSC; Kitty So, BS; Neda Manouchehri; Elena Okon, PhD; Katelyn Shortt, BS; Ana Gheorghie, BS; Femke Streijger, PhD Canada

## Summary

One of the only treatments available for acute spinal cord injury is the augmentation of blood pressure to support spinal cord perfusion. Two commonly used vasopressors are norepinephrine (NE) and phenylephrine (PE), although they differ in their basic pharmacologic properties. We used a porcine model of SCI to evaluate how these two vasopressors influenced spinal cord blood flow, oxygenation, pressure, and metabolism. With respect to improving blood flow and oxygenation, we observed a modest improvement with the use of norepinephrine.

## Hypothesis

Due to differing pharmacologic properties, norepinephrine (NE) and phenylephrine (PE) will have different effects on the spinal cord after injury.

## Design

In vivo experiment in a porcine model of SCI

## Introduction

Surgeons elevate mean arterial blood pressure (MAP) to support spinal cord perfusion in various settings, including acute traumatic SCI, intra-operative SCI, deformity correction, and cervical myelopathy decompression. NE and PE are commonly used to elevate MAP in these contexts, but whether one is better at restoring spinal cord blood flow (SCBF), oxygenation (tPO<sub>2</sub>), pressure, or metabolic responses within the injured spinal cord is unknown.

## Methods

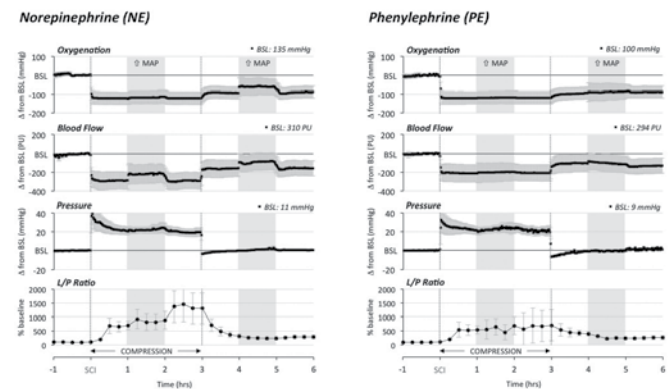
12 Yucatan minipigs underwent a contusion SCI at T10 and were randomized to either NE or PE for MAP elevation. Prior to injury, a combined SCBF/tPO<sub>2</sub> sensor, a pressure sensor, and a microdialysis probe were inserted into the spinal cord adjacent to T10. A weight drop contusion SCI was induced at T10. SCBF, tPO<sub>2</sub>, pressure, and metabolic responses were monitored for 3 hours during sustained compression and then 3 hours post-decompression. During each 3 hour period, NE or PE was used to elevate MAP by 20 mm Hg for 1 hour to measure responses inside the injured cord.

## Results

Following SCI with sustained compression, the SCBF and tPO<sub>2</sub> adjacent to the injury site plummeted and the lactate/pyruvate (L/P) ratio increased (indicative of downstream ischemia). During sustained compression, only NE was able to improve SCBF and, to a lesser extent, tPO<sub>2</sub>. PE had no effect on either. Following decompression, the SCBF and tPO<sub>2</sub> levels recovered partially; again only NE was able to improve SCBF and tPO<sub>2</sub>. Neither vasopressor however, had a significant effect on the L/P ratio.

## Conclusion

In this head-to-head comparison, we found that NE provided a better improvement in SCBF and oxygen within the injured spinal cord than PE. Whether one provides superior neurologic outcome is unknown, but given that clinicians can easily choose either drug for acute SCI, our data indicate that there is a physiologic rationale to opt for norepinephrine.



MAP elevation with NE vs PE for 1 hour (shaded region) before and after decompression

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## 17. The Posterior use of BMP-2 in Cervical Deformity Surgery Does Not Result in Increased Complications: A Prospective Multicenter Study

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United States

### Summary

The use of recombinant human bone morphogenetic protein-2 (rhBMP-2) posteriorly in cervical deformity (CD) surgery does not result in an increased incidence of complications compared to a control group who had surgery without BMP. In our multivariate analysis, BMP-2 use was associated with longer fusions and major operative complications, however, was not identified as an independent risk factor for increased complications.

### Hypothesis

BMP use in CD surgery does not substantially increase the rate of complications

### Design

Prospective cohort study

### Introduction

While BMP use is contraindicated in anterior cervical procedures, retrospective series' have shown its use to be safe in posterior procedures. The rate of complications following BMP use in the posterior cervical spine in a prospective series of adult cervical deformity patients has not been studied.

### Methods

CD pts undergoing surgery from 2013-2015 were enrolled in a prospective, multicenter database. CD was defined as: cervical kyphosis  $>10^\circ$ , cervical scoliosis  $>10^\circ$ , C2-7 SVA  $>4\text{cm}$  and/or chin-brow vertical angle  $>25^\circ$ . Pts were divided into those receiving rhBMP-2 (B) and no rhBMP-2 (NB). The relationship between complications and BMP use (total, dose per level) was evaluated using Pearson correlation and linear regression.

### Results

A total of 100 patients, including 47 patients in B group and 53 in NB group, met inclusion criteria. An average of 13.6mg of BMP was used per person with 1.5mg per level posteriorly only. Compared to NB group, pts in B were older ( $p=0.03$ ) and had longer prior fusions (6.0 vs. 2.5,  $p<0.01$ ). A history of surgery, CCI, EBL, operation time, fusion levels, surgical approach, posterior osteotomy and anterior corpectomy showed no difference between B and NB groups. The maintenance of radiographic parameters at 6-month follow-up was similar. No difference in terms of total complication incidence, total complications per person, major complications per person nor each specific complication were demonstrated between B and NB groups. Linear regression and Pearson correlation analysis did not reveal any strong  $r^2$ -values ( $r^2$  0.09, 0.08, 0.06) between the use of BMP and complications (major or operative).

### Conclusion

The posterior use of BMP was not directly associated with an increased incidence of complications in this prospective cohort of operative Adult Cervical Deformity patients. Its use was associated with longer fusions.

## 18. How Common is the Ponticulus Posticus? A CT Based Analysis of 3,000 Patients

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United States

### Summary

To date the prevalence of Ponticulus Posticus has not been evaluated in a large series. We evaluated 3000 cervical spine CTs of patients managed in the ER of a level I trauma center. We identified 655 (27.9%) patients with a ponticulus posticus. A novel classification system for ponticulus posticus is also introduced.

### Hypothesis

Ponticulus Posticus will be an uncommon finding in the emergency room patient.

### Design

Retrospective cohort study

### Introduction

The prevalence of ponticulus posticus (PP) or arcuate foramen is variable in the literature ranging from 7%-60%. Recognizing PP is important when placing C1 instrumentation. Our objective was to: establish the prevalence of PP and develop a classification system to describe PP.

### Methods

We evaluated cervical spine CT scans of patients in the emergency room of a level one trauma center from 1/1/2014 to 12/31/2014. The CT images were evaluated for the presence of PP and demographic data were collected: age, sex, race/ethnicity, and BMI. We also developed a classification system to standardize the way PP is described from CT scans.

### Results

3,000 patients underwent a cervical spine CT over the study period. 655 (27.9%) had PP present. The average age was 47.5 (7-100) with 360 (55%) males and 295 (45.0%) females; 468 (71.5%) were white, 160 (24.4%) black, 2 Asians (0.30%), 23 (3.5%) other, 1 Native-American (0.15%). 43 (6.6%) were of Hispanic ethnicity.

The following classification system based was developed (1st letter is right C1, 2nd letter is left C1): AA (no PP right or left side); BB (incomplete arch right & left side); CC (complete arch right & left side). Combinations can exist; BC (right incomplete arch; left complete arch).

The 655 patients with a PP were classified as: AB 6.87%; AC 8.39%; BA 4.58%; BB 17.25%; BC 18.17%; CA 6.26%; CB 13.6% and CC 24.9%

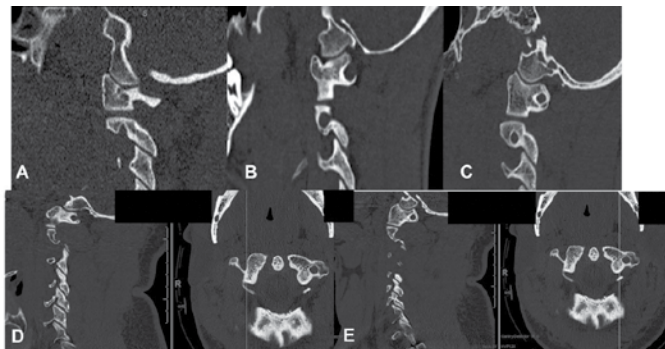
### Conclusion

We found a 27.9% prevalence of PP in 3000 patients undergoing a cervical spine CT. This is the largest series to date evaluating the prevalence of PP. The most common type of a PP was CC (complete arch left & right) comprising 24.9% of the patients. PP is a common anomaly that should be recognized



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preoperatively in order to avoid placement of C1 instrumentation in the PP and vertebral artery injury.



A. A classification, no ponticulus posticus; B. B Classification incomplete arch; C. C classification, complete arch. D. Right side CT of a 57y/o M demonstrating B classification; E. Left side CT of the same pt demonstrating C classification; he would be classified as BC.

### 19. Is There a Correlation Between Thoracolumbar Kyphosis Correction and Pulmonary Function Change in Ankylosing Spondylitis Patients after Pedicle Subtraction Osteotomy? A 2-Year Follow-up Analysis

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#### Summary

To date, no reports have been specifically published for investigating the correction between thoracolumbar kyphosis correction and the postoperative PFTs improvement in AS patients undergoing PSO.

#### Hypothesis

The correction of thoracolumbar kyphosis have a positive correlation with the postoperative PFTs improvement.

#### Design

A retrospective prospective clinical study.

#### Introduction

The objectives of this study were to measure the change in pulmonary function tests (PFTs) in ankylosing spondylitis (AS) patients with thoracolumbar kyphosis after pedicle subtraction osteotomy (PSO); and to investigate the correlation between the change of radiological parameters and PFTs improvement at 2-year follow-up.

#### Methods

A total of 30 AS patients undergoing PSO, were prospectively evaluated before and 2 years after surgery. PFTs included VC, FVC, FEV1 and FVC/FEV1. Radiographic parameters, including the global kyphosis (GK), thoracic kyphosis (TK), lumbar lordosis (LL), local kyphosis (LK), and angle of fusion levels (AFL), were recorded. Significant clinical pulmonary function improvement was defined as a 10% or more increase of percent predictive FEV1 value at 2 years postoperative.

#### Results

All of the preoperative pulmonary impairments were found to be restrictive. There was a significant clinical pulmonary function improvement in 25 patients (83.3%) at last follow-up. The FVC significantly increased by an average of 440 ml after surgery at 2-year follow-up ( $P < 0.05$ ). The percent-predicted FEV1 before PSO was  $71.2\% \pm 8.1\%$  and it was  $79.3\% \pm 6.4\%$  at 2-year follow-up ( $P < 0.05$ ). Additionally, the change in FVC was significantly correlated with the changes in GK ( $r = 0.326$ ,  $P = 0.031$ ), LL ( $r = 0.481$ ,  $P = 0.015$ ), and AFL ( $r = 0.457$ ,  $P = 0.001$ ).

#### Conclusion

The absolute and percent-predicted PFTs improved significantly after PSO at 2-year follow-up for AS patients with preoperative pulmonary dysfunction. Moreover, a significant pulmonary function improvement was related with thoracolumbar kyphosis correction.

### 20. National Administrative Databases in Adult Spinal Deformity Surgery – A Cautionary Tale

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United States

#### Summary

National Administrative Databases (NADs) have become a high volume source of publications in adult spinal deformity (ASD), utilizing billing codes as a surrogate for medical and surgical diagnoses, procedures and complications. These have become popular due to large patient volumes and no requirement for Institutional Review Board approval. NADs represent a different patient population to Physician Managed Database (PMD). NADs do not allow tracking of patients over time. Caution should be exercised in interpretation of data from NADs in ASD.

#### Hypothesis

National administrative databases (NABs), reliant on billing codes, do not provide comparable data to a physician-driven database for surgical outcomes in adult spinal deformity.

#### Design

Comparison between national administrative databases and a prospective multicenter physician managed database.

#### Introduction

National administrative databases (NADs) such as National Inpatient Sample (NIS) and National Surgical Quality Improvement Program (NSQIP) have provided large numbers of publications owing to their large sample size. These databases utilize billing codes rather than clinical inclusion criteria, and have not previously been validated against physician-managed databases (PMDs) in adult spinal deformity (ASD) surgery.

#### Methods

The NIS was searched for years 2002-2012 and NSQIP for years 2006-2013 using validated spinal deformity diagnostic codes. Procedural codes (ICD-9 and CPT) were then applied to each database. A multicenter PMD (PON), including

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years 2008-2015 was used for comparison. Databases were assessed for levels fused, osteotomies, decompressed levels, and invasiveness (a product of these parameters). Database comparisons were made in all patients, and also for patients with at least 5 level spinal fusions.

## Results

37,368 NIS patients, 1,291 NSQIP patients and 737 PON patients were identified. NADs showed an increased use of deformity billing codes over the study period (NIS doubled, 68x NSQIP,  $p < 0.001$ ), but remained stable in the PMD. Despite primary diagnosis of spinal deformity, surgical invasiveness was lower for all patients in the NIS (11.4-13.7) and NSQIP databases (6.4-12.7) compared to PON (27.5-32.3). When limited to  $\geq 5$  levels, invasiveness, levels fused, and use of 3-column osteotomies remained significantly higher in the PMD compared with NABs ( $p < 0.001$ ).

## Conclusion

Billing code databases NIS and NSQIP do not capture the same patient population, or detailed data granularity, as Physician Managed Databases in Adult Spinal Deformity. Physicians should remain cautious in interpreting conclusions drawn from these high-volume datasets.

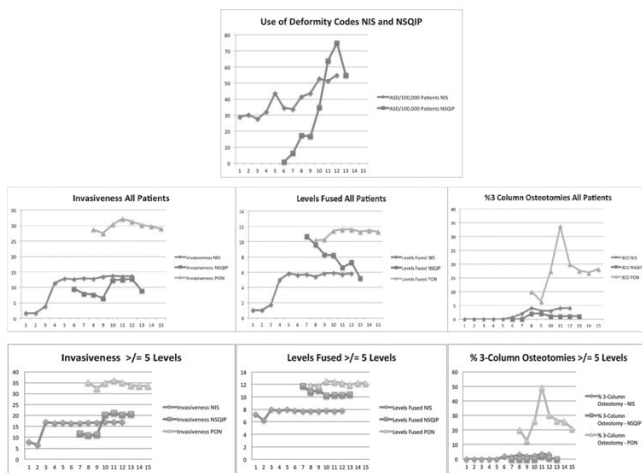


Figure 1: Trends in use of deformity codes in NIS and NSQIP databases. Note that despite the increased use of these codes, the levels fused and invasiveness was lower in NIS and NSQIP than in the Physician Managed Database (PON).

## 21. Outcomes and Complications of Sacropelvic Fixation Using the S2 Alar-Iliac (S2AI) Technique in Adult Spinal Deformity Patients Fused to the Sacrum: A Minimum Two-Year Follow-Up Study

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United States

### Summary

Patients undergoing long posterior spinal fusion (PSF) to the sacrum for adult spinal deformity (ASD) often require additional fixation into the ilium for increased stability and decreased implant related complications. We have previously described the S2 alar-iliac (S2AI) technique for sacropelvic fixation. Here, we report on our 2 yr follow up results, demonstrating a low rate of

technique-related complications and rare need for revision at two years of follow-up.

### Hypothesis

For long segment PSF, the S2AI technique has a lower rate of complications compared to other available techniques.

### Design

Retrospective review of prospective database.

### Introduction

The S2AI technique has been previously described by our group as an alternative method for sacropelvic fixation. It is performed using an entry point in the sacral ala, between the S1 and S2 dorsal foramina, directed into the ilium towards the anterior inferior iliac spine. We report our results at 2-year follow-up.

### Methods

In 263 consecutive ASD patients who underwent sacropelvic fixation with S2AI technique between 2006-13, 331 S2AI screws were placed in 170 patients (64.6%) who had complete 2-year radiographic and clinical follow-up (47.3  $\pm$  21.7 months).

### Results

The overall rate of revision for all reasons was 17.6%. Complications specific to the S2AI technique occurred in 2.1% (7) of screws placed in 2.9% (5) of patients: 3 (0.9%) broken screws (3 patients), of which 1 required revision, and 4 (1.2%) screws (2 patients) removed for persistent buttock pain. The reoperation rate specifically for S2AI screws was 1.8% (3). Radiographic screw loosening  $< 2$ mm was found for 10 screws (3.0%) in 10 patients (5.9%). The overall incidence of buttock pain at 2 years was 11.2% (19 patients). 3 patients (1.8%) had a pseudarthrosis at L5-S1. The overall rate of rod fracture was 4.2% (most commonly at the L4 level). There were 9 (5.3%) surgical site infections (7 superficial, 4.1%; 2 deep, 1.2%). There was significant improvement in SF-36 PCS, and SRS Function and Pain scores ( $P < 0.05$ ) between pre- and final follow-up.

### Conclusion

This is the largest series using the S2AI technique with a minimum 2-year follow-up showing a much lower rate of technique-related complications, and rate of revision, compared with other commonly used techniques.

Parameter	S2AI Group (N=170)
Age (yrs, mean [SD])	59.7 (12.4)
Female patients (%)	74
Active smokers (%)	7.3
Comorbidities (%)	38.6
Osteoporosis (%)	33
3CO (%)	41
2 <sup>nd</sup> stage ALIF (%)	42
# of levels fused (mean [SD])	9.9 (4)
LOS (days, mean [SD])	7.9 (4.5)

Patient and Surgical Characteristics





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## 22. Radiographic Outcome Differences in Growing Rod Constructs Using Tandem vs. Wedding Band Connectors

Matthew E. Oetgen, MD; Allison Matthews, MS; Yunfei Wang, PhD; Laurel C. Blakemore, MD; Anna M. McClung, RN, BSN; Jeff B. Pawelek; Paul D. Sponseller, MD; Francisco Javier Sanchez Perez-Gruoso, MD; Behrooz A. Akbarnia, MD; Growing Spine Study Group

United States

### Summary

No differences were found between use of tandem and wedding band connectors in GR constructs in regards to coronal curve correction and overall spine growth overtime; however, connector type may lead to differences in sagittal plane alignment overtime which should be considered when planning construct design.

### Hypothesis

Growing rod patients with wedding band connectors have an improved sagittal profile compared to those with tandem connectors.

### Design

Multi-center review of retrospective and prospective data

### Introduction

Treatment of early onset scoliosis (EOS) with growing rods (GR) has become common, but the optimal construct design of these spinal implants is debated. One basic construct design option is that of rod connector type, with the majority of constructs incorporating either tandem (T) or wedding band (WB) type connectors. The purpose of this study was to evaluate the radiographic outcomes between these two connector types.

### Methods

A multi-center database of GR patients was studied at the pre-op time point, immediate post-op time point, and pre-final time point. The pre-final time point was the most recent visit prior to final fusion. 209 patients were included: 152 in the T group and 57 in the WB group. Ethnicity, etiology, gender, major curve size, T1-S1 length, maximum kyphosis, PJK, and segmental kyphosis regions were assessed.

### Results

No statistical differences were found between the two groups in regards to age, ethnicity, etiology or gender. Statistical differences between the groups were found in the following variables: major curve size (pre-op T:74° vs. WB:80°, p=0.041; post-op T:39° vs. WB:49°, p=0.0002; pre-final T:40° vs. WB:50°, p=0.0009); T1-S1 length (pre-op T:264mm vs. WB:248mm, p=0.02; pre-final T:355mm vs. WB:336mm, p=0.04); T5-T12 kyphosis (post-op T:16° vs. WB:25°, p=0.003; pre-final T:24° vs. WB:36°, p=0.002); and PJK (pre-final T:10° vs. WB:6°, p=0.03). No statistical differences were found in the other variables and time points analyzed.

### Conclusion

Use of tandem connectors compared to WB did not appear to effect major curve correction, T1-S1 length, or max kyphosis over time. Despite this, there does appear to be segmental differences in the sagittal plane, with the tandem connector leading to less T5-T12 kyphosis and more PJK over time as compared

to WB. This may be due to an increased rigidity or a lordosing effect of the tandem connector situated in the T5-T12 region resulting in an increase in PJA to maintain overall kyphosis.

SRS 2016

Radiographic outcome differences in growing rod constructs using tandem vs. wedding band connectors – TABLE 1.

Variable	Pre-op	Post-op	Pre-Final	% Change	P-value
Major curve (°)-T	74	39	40	46%	Pre-op: 0.04 Post-op: 0.00018 Pre-Final: 0.00091
Major curve (°)-WB	80	49	50	37%	
T1-S1 (mm)-T	264	298	355	34%	Pre-op: 0.019 Post-op: 0.07 Pre-Final: 0.04
T1-S1 (mm)-WB	248	286	336	36%	
Max Kyphosis (°)-T	49	33	43		Pre-op: 0.26 Post-op: 0.13 Pre-Final: 0.72
Max Kyphosis (°)-WB	53	37	45		
PJK (°)-T	-3	6	10		Pre-op: 0.43 Post-op: 0.24 Pre-Final: 0.035
PJK (°)-WB	3	4	6		
Kyphosis T2-T5 (°)-T	12	14	21		Pre-op: 0.80 Post-op: 0.79 Pre-Final: 0.24
Kyphosis T2-T5 (°)-WB	15	14	18		
Kyphosis T5-T12 (°)-T	30	16	24		Pre-op: 0.32 Post-op: 0.003 Pre-Final: 0.002
Kyphosis T5-T12 (°)-WB	35	25	36		
Kyphosis T10-L2 (°)-T	15	5	11		Pre-op: 0.23 Post-op: 0.36 Pre-Final: 0.85
Kyphosis T10-L2 (°)-WB	20	5	13		

Table 1

## 23. Exercise Tolerance in Growing Rod “Graduates” - New Respiratory Functional Outcome Measure

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United States

### Summary

In a graded exercise test, 11 growing rod “graduates”<sup>1</sup> showed they were able to keep up with control group in every day walking velocity, despite worrisome PFT results.

### Hypothesis

EOS patients with impaired PFT results and other physical deformities would not be able to keep up with control group in strenuous physical activities.

### Design

Single-centered IRB-approved prospective study.

### Introduction

Functional outcomes for EOS patients who have undergone extensive treatment are assumed to be limited from respiratory impairment. PFTs are used as a primary outcome measure of respiratory capacity but are highly dependent on effort. We wished to evaluate exercise O<sub>2</sub> consumption as a new outcome measure to better characterize respiratory capacity.

### Methods

EOS patients completing growing-rod treatment with ≥1 year of no surgery (“graduates”<sup>1</sup>) underwent oxygen consumption (VO<sub>2</sub>) testing while walking at self-selected speed overground (OG) and submaximal graded exercise test on a treadmill (TM). Maximal VO<sub>2</sub> measured those who were able to reach 85% age predicted maximum heart rate (HR). Student t-tests compared EOS to

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20 controls (mean age 13). Patient reported outcomes EOSQ & SRS-30 were administered at time of testing to evaluate patients' assessments.

## Results

11 patients (4 congenital, 3 idiopathic, 2 syndromic, 2 NM), mean age 12.6 yr, completed OG testing. Mean %pred FVC=48.4%; EOS walked at the same speed as controls, but at higher VO<sub>2</sub> Cost (0.28ml/kg/m vs 0.22ml/kg/m; p<.001), and at higher HR (132 vs 117, p=.021). 9/11 completed the TM test protocol. EOS group consumed less VO<sub>2</sub> during final stage test (28.2ml/min vs controls 34.2ml/min; p=.035), with higher respiratory rate (50 vs 37, p=.005), lower tidal volume (.8 vs 1.5L, p=.001) and minute volume 36.2 vs 51.2 L/min, p<.003) than controls. EOS had lower pred. VO<sub>2</sub> max (37.8ml/min) compared to controls (44.6ml/min, n.s.).

Mean EOSQ and SRS30 scores were similar, 84.7 & 83.2%. Patients reported low level of difficulty in pulmonary (92%) and physical function (83.3%) on EOSQ. SRS30 showed low pain level (81.8%) and average function/activity, 76.6%.

## Conclusion

While PFT data suggests worrisome pulmonary compromise in EOS "graduates" (<50% pred), this study shows that these children keep up with their peers' walking speed and have the capacity to exercise, albeit with definite respiratory limitation.

**Table 1: Exercise Tolerance tests, N=11**

		EOS		Control		P
		mean	SD	mean	SD	
OG Walking	VO <sub>2</sub> Rate (ml/kg/min)	21.5	5.4	17.5	2.8	0.1074
	VO <sub>2</sub> Cost (ml/kg/m)	0.28	0.04	0.22	0.03	0.0001
	HR	132	29	117	22	0.0208
Velocity	Self-Selected (m/min)	76.4	14.2	79.9	5.9	0.0828
TM Final Stage	VO <sub>2</sub> Rate (ml/kg/min)	28.2	7.0	34.2	6.4	0.0352
	HR	164	20	174	5	0.2310
	Rf (breaths/min)	50.5	10.7	37.2	10.3	0.0050
	VT (L)	0.8	0.4	1.5	0.6	0.0010
	VE (L/min)	36.2	14.6	51.2	22.9	0.0026
Speed (mph)	2.8	0.4	3.6	0.3	0.0000	
VO <sub>2</sub> Max Predicted	VO <sub>2</sub> Pred Max	37.8	9.6	44.6	9.7	0.1314

**Table 2: EOSQ and SRS-30 Scores (%), N=11**

EOSQ		SRS-30	
Total	84.7	Total	83.2
General health	68.2	Function/activity	76.6
Pain/discomfort	73.9	Pain	81.8
Pulmonary function	92	Self-image/appearance	78.2
Transfer	81.8	Mental health	89.1
Physical function	83.3	Satisfaction	80.6
Daily living	78.4		
Fatigue/energy	76.1		
Emotion	79.5		
Parental impact	83.6		
Financial impact	97.7		
Satisfaction	78.4		

## 24. The Efficacy of Halo-Gravity Traction in the Treatment of Severe Spinal Deformity

Zhaomin Zheng, MD, PhD; Huafeng Wang; Hua Wang, PhD; Hui Liu, MD; Jianru Wang, MD

China, People's Republic of

### Summary

Halo-gravity traction (HGT) could achieve partial correction, and it may reduce the need for higher risk 3-column osteotomies, improve preoperative pulmonary function, and reduce neurologic complications.

### Hypothesis

HGT could improve preoperative nutritional status, pulmonary function, and gradual traction would also help reduce risk of neurologic compromise.

### Design

Retrospective analysis of a prospectively collected single-center database.

### Introduction

The treatment of severe spinal deformity is a surgical challenge. HGT has been reported to successfully assist in managing severe spinal deformity without significant complications.

### Methods

Thirty-three consecutive surgery patients underwent HGT. The Cobb angle of coronal major curve and the maximal sagittal kyphosis were 112.9° and 107.8° respectively. All patients underwent preoperative HGT 8 weeks at least, posterior instrumentation and fusion was performed. PFTs and health-related quality of life scores taken before and after treatment were compared.

### Results

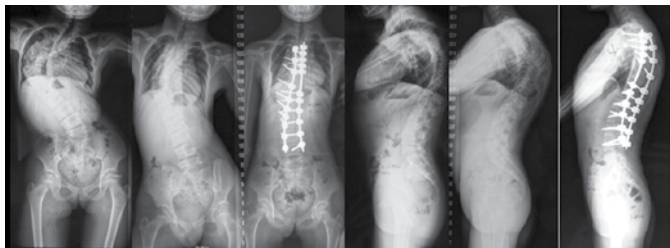
The average traction weight was 52.8% of body weight. Traction contribution to the average coronal major curve correct rate in 1 week, 4 weeks and the terminal were 17.9%, 4.7% and 25.0%, respectively. Traction contribution to the average sagittal maximal kyphosis correct rate in 1 week, 4 weeks and the terminal were 12.7%, 6.7% and 24.7%, respectively. The difference between the first and the final PFTs during the HGT averaged 6.0 ± 7.2% (p<0.001). In this series, there were only 2 patients who required a 3-column osteotomy for deformity correction. One patient experienced transient brachial plexus palsy which resolved completely at 3 month postoperatively. Two cases needed an increased requirement of postoperative ventilatory support at least 12 hours postoperative. No neurologic complication, death and respiratory failure occurred after surgery. Twenty-one cases were followed up over 12 months. At the final evaluation, there were no significant correction loss. The overall Scoliosis Research Society-22 questionnaire scores improved significantly.

### Conclusion

Partial correction was observed preoperatively with HGT, and it may reduce the need for higher risk 3-column osteotomies, improve preoperative pulmonary function, and reduce neurologic complications. However, whether traction could increase final correction was still unclear.



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Comparison of radiographs

## 25. Five or More Proximal Anchors, Including Upper End Vertebra, Protects Against Reoperation

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United States

### Summary

Increased number of anchors and instrumentation at or above the upper end vertebrae (UEV) of kyphosis were associated with decreased rates of revision surgery.

### Hypothesis

Number, type and placement of proximal anchors will impact the rate of revision surgery in growth friendly constructs.

### Design

Retrospective Multi-center enrollment

### Introduction

Proximal anchor pullout and junctional kyphosis are common causes necessitating revision surgery during growth friendly treatment of early onset scoliosis (EOS). Many options exist for proximal fixation and may impact the rate of these complications.

### Methods

Retrospective review of multicenter database of patients with growth friendly constructs for EOS. Inclusion criteria were patients with index instrumentation < 10 years of age and minimum of 2 years follow-up.

### Results

357 patients had the following constructs: growing rods with spine anchors=306; growing rods with rib anchors=16 and VEPTR=35. Preoperatively mean age was 5.9 years, Cobb angle was 76° (range 25 to 147), and kyphosis was 54° (range -28 to 119). Mean follow-up was 6.1 years. 21.6% (77/357) experienced anchor pullout. There was a significant trend toward lower anchor pullout rates with a higher number of proximal anchors ( $p=0.003$ ,  $r=0.157$ ), and 5 or more anchors were significantly associated with lower rates of anchor pullout ( $p=0.010$ ). Type of anchor (screw vs hook vs rib cradle) did not differ significantly in rate of anchor pullout ( $p=0.850$ ). Additionally, kyphosis data was available for 200 patients in the cohort. 23.5% (47/200) of patients required proximal extension of their construct after index surgery. On multivariate analysis, initial instrumentation below UEV of kyphosis was associated with higher rates of subsequent

proximal revision ( $p=0.021$ ), with patients who were instrumented at or above the UEV of kyphosis being revised proximally in 20.0% (26/130) vs 30% (21/70) for those below the UEV.

### Conclusion

Five or more anchors are associated with lower rates of anchor pullout. Proximal anchor placement at or above the UEV resulted in a statistically significant decrease in rates of proximal extension of the construct.

## 26. A Pilot Cadaveric Study of the Safety and Efficacy of Magnetic-Controlled Growing Rods after Exposure to Magnetic Resonance Imaging

Selina C. Poon, MD; Adam Graver, MD; Stephen F Wendolowski, BS; Rachel Claire Gecelter, BS; Yen Hsun Chen, BS, MD; Ryan Avey Nixon, MD; Jon-Paul DiMauro, MD; Terry D. Amaral, MD

United States

### Summary

A pilot cadaveric study was carried out to test the safety and efficacy of Magnetic-Controlled Growing Rods (MCGRs) for the treatment of early onset scoliosis (EOS). The results showed that the MCGR did not lengthen or shorten, the function of the rod remained intact and the structural integrity remained within manufacturer's limits.

### Hypothesis

The MCGRs are safe to have implanted during an MRI and maintain their functionality.

### Design

A pilot cadaveric study

### Introduction

Magnetic-Controlled Growing Rods (MCGRs) are a new and promising technology in the treatment of early onset scoliosis (EOS). A significant percentage of patients with EOS have additional intraspinal abnormalities that need to be monitored with Magnetic Resonance Imaging (MRI) over time. The safety and efficacy of MCGRs and MRIs have not been established and are therefore of limited use in this subset of EOS patients.

### Methods

Three fresh frozen cadaver torsos were utilized. MRI scanning of the specimens was performed after bilateral L5, S1 pedicle screws and T2, T3 hook implantation and after MCGR rod implantation. Data collected includes MCGR rod length, function and structural integrity before and after MRI scans. The length of the rods was measured before and after MRI scanning. The manual distractor was used to determine whether the lengthening and shortening mechanism remain intact pre- and post-MRI. Maximum distraction force generated by the rod was tested pre- and post-MRI.

### Results

There was no significant increase or decrease in length of MCGR after MRI scanning. MCGR's continued to function properly after MRI scanning. Structural integrity of the MCGR remained within manufacturer's tolerances after exposure to MRI.



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## Conclusion

MRI scans of EOS patients with intraspinal abnormalities may be necessary over the course of treatment. Because of safety concerns, this subset of patients with EOS has not benefited from this new technology. When implanted in human tissue in the recommended fashion, these growth rods do not post a significant risk to the patient with respect to hardware malfunction. These initial results show promise. Further in vivo study is warranted.

## 27. Effectiveness of Rib Osteotomies in Correction of Severe Spinal Deformity Treated with Halo Gravity Traction and Posterior Spinal Fusion

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### Summary

We examined 72 consecutive patients to assess the effect of convex and concave rib osteotomies during correction of severe spinal deformity with preoperative halo gravity traction and Posterior Spinal Fusion (PSF) and Segmental instrumentation (PSSI) and posterior column osteotomy (PCO). While rib osteotomies had no impact of deformity correction and complications it negatively impacted pulmonary function.

### Hypothesis

Concave and/or convex Rib osteotomies improve complex spine deformity correction

### Design

Historical Cohort Study

### Introduction

Concave rib osteotomies improve the flexibility of the spine and convex rib resections (Thoracoplasty) additionally improve the cosmetic appearance of the rib prominence on the convex side. For severely rotated deformities it becomes necessary to perform these rib procedures in order to fully expose the spine and perform posterior column osteotomies or VCR.

### Methods

72 patients (pts) operated consecutively were reviewed from a single center database, minimum 2 years follow up. A Cohort study of two groups was done: with and without Rib osteotomies. For comparison between the two groups Kruskal-Wallis test was used between Pre Op and 1st Follow-up (1st F-up) period. We evaluated surgical and radiological parameters.

### Results

Rib Osteotomy Group (RO) vs No Rib Osteotomy Group (NRO): 46 pts, 31/25 F/M vs 26 pts, 14/12 F/M. Surgical time (min): 305.70±92.13 vs 265.36±73.78 (p=0.069); No significant differences between groups were found for EBL(ml): 1778.77±741.269 vs 1638.80±756.82; PCO: 4.85±2.19 vs 4.79±1.47; 1st F-up "" Preop Major Cobb correction: 66.27±7.43 vs 67.03±8.45; minor Cobb: 39.65±16.23 vs 37.93±16.57; Kyphosis: 44.44±12.86 vs 46.66±11.36; Pre Op FVC (%): 56.28±34.10 vs 52.42±24.76 (p=0.829); Post Op FVC (%): 43.70±12.90 vs 59.92±15.67

(p=0.005); IOM changes: 28pts (59.6%) vs 13 (52%); Neurological Cord Injury: 1 pts vs 2 pts. Total Complications: 59.6% pts vs 56% pts. Complications presented in RO were: pleural tear (6) and postop respiratory depression (1) were treated successfully.

## Conclusion

Among patients undergoing complex spine deformity surgery with preoperative halo gravity traction and Posterior Spinal Fusion (PSF) and posterior column osteotomy (PCO). Surgical Time and EBL, Coronal major, Coronal minor and kyphosis Cobb Angle were similar whether a rib osteotomy procedure was done or not. Rib osteotomy group had a significant decrease in pulmonary function.

## 28. Minimal Invasive Surgical Technique in Adolescent Idiopathic Scoliosis Surgery

*Jae Hyuk Yang, MD, PhD; Dong-Gune Chang, MD; Suh Woo Seung, MD, PhD; Soo Hyun Kim, MD; Chang Hwa Ham, MD Korea*

### Summary

Authors developed Minimal Invasive Scoliosis Surgery Technique (MISS) performing screw fixation and reduction through 2~3 tubular retractors. It was applied to Adolescent Idiopathic Scoliosis (AIS) prospectively. Favorable radiological and clinical outcomes such as correction rate, coronal and sagittal balance, and SRS-22 score was obtained. Importantly, intraoperative bleeding, scar lengths, and postoperative hospital stay decreased without severe complications. However, long duration of operation, lack of long-term follow up, and small number cases are the shortfalls of this study. Therefore, continuous studies are needed.

### Hypothesis

Application of MISS technique in AIS can result in favorable radiological and clinical outcome.

### Design

Prospective case series study

### Introduction

The authors have developed MISS, performing the screw fixation and the derotation maneuver through two to three 2.5cm incisions using tubular retractors.

### Methods

22 AIS patients underwent MISS. 2 to 3 incisions of 2.5cm per a tubular retractor were made. Through the incision, tubular retractor for the screw insertion and bone grafting was placed. 10 to 12 screws were fixed through a tubular retractor. Two skin incisions were made in curves that needed less than 12 levels of fusion and three incisions for more than 12 levels. Free hand technique was used to insert all screws for less radiation exposures. Poly-cannulated screws were used to ease the rod assembly. Thoracoplasty was done through the same incisions. Spinal fusion was achieved at the facet joint using a bone-reamer and autologous bones or allogenic bone materials. Finally, derotation maneuver was applied. For the analysis of surgical outcomes, coronal factors, sagittal factors and SRS-22 scores were evaluated.



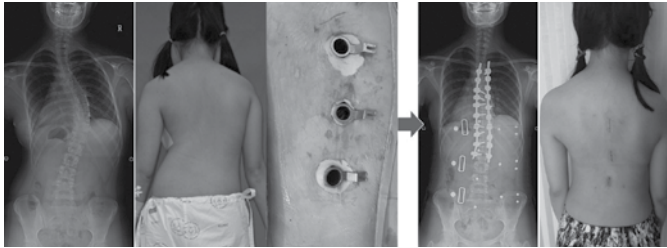
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## Results

Pre-operative Cobb angle was  $61^{\circ} \pm 10$ . The range of fusion level was 11 (9"–14) and the number of skin incisions were 3 (2"–3). The duration of operation was  $442 \pm 110$  min and the intraoperative bleeding was  $1195 \pm 475$  ml. Postoperative hospital stay was  $12 \pm 2$  days. The correction rate of Cobb angle was  $66 \pm 8\%$ . After the surgery, coronal and sagittal factors showed statistically significant improvements ( $p < 0.05$  in all factors). Total lengths of the scars were  $11 \pm 1$  cm (elongated by the retraction of the tubular retractor). None of them had shown any neurological complications. In 3 patients, chest tube was inserted for the hemothorax. However, no additional complications had encountered. Postoperatively, self-image and satisfaction score were significantly higher ( $p = 0.005$ ,  $< 0.001$ ).

## Conclusion

MISS in AIS showed an acceptable correction rate, short postoperative scar with higher satisfaction, less intraoperative bleeding. However, long duration of the operation and lack of long term follow ups are shortfalls. Therefore, continuous studies on MISS Technique are needed.



MISS technique

## 29. Learning Curve of Mini-Open Correction and Fusion for Adolescent Idiopathic Scoliosis (AIS) Correction: A Single Surgeon's 5 Year Experience

*Matthew J. Geck, MD; Devender Singh, PhD; Eric Truumees, MD; Dana Hawthorne, PA-C*

*United States*

### Summary

This study reports a single surgeon's learning curve over the course of 5 years for the treatment of adolescent idiopathic scoliosis (AIS) corrections using minimally-invasive surgery (MIS) technique.

### Hypothesis

There is a gradual learning curve of MIS for AIS Correction

### Design

Retrospective analysis

### Introduction

Although MIS offers a potentially less morbid treatment option for patients requiring stabilization of AIS, the procedure's learning curve has not been sufficiently established. We report a single surgeon's learning curve of MIS technique over the course of 5 years for the treatment of AIS corrections.

## Methods

39 consecutive patients undergoing MIS correction of AIS from 2010 to 2015 performed by a single surgeon at one institution were studied. Our cohort was divided into two groups: group I (first 20 patients) and group II (second 19 patients). Age, gender, operative time (OR), estimated blood loss (EBL), length of hospital stay (LOS), number of spinal levels treated, radiologic outcomes, complications, Oswestry Disability Index (ODI), Visual Analogue Scale (VAS) and Scoliosis Research Society-22r (SRS-22r) were evaluated. Surgical technique was uniform in all patients using two or three midline incisions. OR, EBL and LOS were normalized per spinal levels treated for analysis. A two-tailed Student t-test was used to assess for differences between the two groups ( $\alpha = 0.05$ ).

## Results

The surgeon's learning curve for MIS was achieved at 20th case (2 years). The demographics of the early 20 patients (group I) and later 19 patients (group II) were similar ( $p > 0.05$ ). There were significant statistical differences between the two groups in the mean normalized EBL, OR and LOS ( $p < 0.05$ ). The percent changes in the mean normalized EBL, OR and LOS between the two groups were 15.5%, 18.5% and 30.2%, respectively. At the final follow-up, there were no statistically significant differences in VAS, ODI and SRS-22r scores between the two groups ( $p > 0.05$ ). Mean loss of correction on follow-ups was less than  $5^{\circ}$  for both groups. The radiographic evaluation showed similar solid fusion rates in both groups.

## Conclusion

The technical proficiency in MIS for the treatment of AIS corrections was achieved after 20 cases. There were significant reductions in blood loss, operative time and length of hospital stay for patients treated in the later part.

## 30. Gabapentin Decreases Time to Meeting Physical Therapy Goals in Patients with Idiopathic Scoliosis Undergoing Posterior Spinal Fusion

*James Joseph Thomas, MD; Sumeet Garg, MD; Mark A. Erickson, MD, MMM; Nicole Michael, BA; Nikki Bloch, BA; Mindy Cohen, MD*

*United States*

### Summary

Time to achieve physical therapy (PT) goals for patients recovering from posterior spinal fusion surgery (PSF) to treat adolescent idiopathic scoliosis (AIS) was significantly less for patients who received perioperative gabapentin compared to those who did not.

### Hypothesis

Use of perioperative gabapentin will decrease time to attain PT goals.

### Design

Retrospective case-control study

### Introduction

Meeting PT goals is used as an outcome metric for patients recovering from PSF surgery to treat AIS. In July 2014, our institution adopted a protocol-based use of perioperative gabapentin as an adjunct for pain management in patients with AIS undergoing PSF. The aim of this study was to determine if gabapentin

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was associated with a quicker attainment of PT goals compared with a pre-protocol control cohort.

## Methods

After IRB approval, we retrospectively reviewed the charts of consecutive PSF patients treated under our gabapentin protocol and a historical control cohort of patients who did not receive gabapentin. Study patients were given a one-time dose of gabapentin by mouth preoperatively and a dose by mouth three times a day until discharge postoperatively. Doses were 300mg for patients >40kg and 200mg for patients 20-40kg. Groups were matched for age, sex, and weight ( $p=0.84$ ,  $p=0.13$ ,  $p=0.26$ ). Patient charts were reviewed to determine time to achieve PT goals and day of discharge. PT goals and discharge were scored as categorical variables. T-test for equality of means was performed for each PT goal and discharge. The PT goals assessed were:

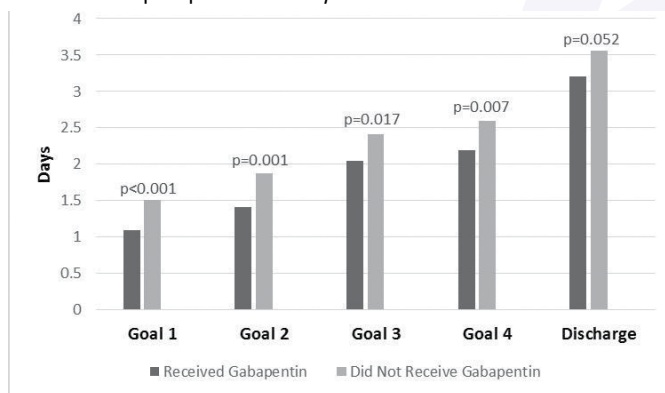
1. Logroll with minimal assistance
2. Side-lying to sitting and sitting to side-lying transitions with minimal assistance
3. Ambulating 250 feet with standby assistance
4. Ascending and descending at least 3 stairs with a railing with standby assistance

## Results

Each cohort was comprised of 54 patients. Groups included male and female patients with AIS between 10 and 18 years old. The average times for meeting each PT goal and discharge for patients receiving versus those not receiving gabapentin are shown in the graph below.

## Conclusion

The use of perioperative gabapentin is associated with a statistically significant decrease in time to completing PT goals. Institutions should consider adopting a protocol-based use of perioperative gabapentin for patients undergoing PSF for AIS to decrease postoperative recovery time.



## 31. Comparative Analysis of Radiological and Clinical Outcomes Between Minimal Invasive and Conventional Surgery in Adolescent Idiopathic Scoliosis

Jae Hyuk Yang, MD, PhD; Dong-Gune Chang, MD; Suh Woo Seung, MD, PhD; Tae Jin Lee, MD; Chang Hwa Ham, MD

Korea

### Summary

Comparative analysis study of conventional surgery with Minimal Invasive Surgery (MIS) in adolescent idiopathic scoliosis (AIS) was prospectively designed. In MIS group, through two to three 2.5cm-sized skin incisions, muscle sparing approach for the fixation and correction was done through tubular retractors only. On comparison, radiological and clinical outcomes were statistically equivalent between the two groups. Notably, intra-operative bleeding, postoperative hospital-stay, and scar lengths have improved in MIS group. However, prolonged duration of operation and lack of long-term follow-up were its shortfalls.

### Hypothesis

Scoliosis surgery using MIS technique in AIS results in equivalent radiological and clinical outcomes to the conventional surgery, with an outstanding cosmetic outcome in view of scars.

### Design

Non-randomized prospective comparative study.

### Introduction

MIS technique has been applied to various spine surgeries. However, its application on scoliosis surgery and comparative analysis on radiological and clinical outcomes has not been reported.

### Methods

48 patients who have undergone AIS correction surgery from 2013 to 2014 were enrolled. Patients who have undergone conventional surgery and MIS technique were identified as group A and B. In group A, the correction was performed through a long linear skin incision. In Group B, it was done through 2 to 3 skin incisions of 2.5cm. In group A, mono axial screw was used. In Group B, poly axial screw was used to ease the rod assembly. Derotation maneuver was applied to the rod in both groups. Postoperatively, radiological outcomes, coronal and sagittal factors, and clinical outcomes, SRS-22 scores, were assessed.

### Results

25 and 24 patients were identified in Group A and Group B, respectively. Preoperatively, homogeneity of the two groups were verified in terms of sex, age, BMI, Cobb's angle, Risser's stage, curve type (Lenke's classification) and flexibility, application of thoracoplasty, and fusion levels. Cobb's angle corrected in group A and B were 44.5° and 38.2° (correction rate 70.4% and 65.2%), respectively. Postoperatively, no statistical difference in coronal and sagittal factors, and the SRS-22 score were found between the 2 groups. However, group B showed statistically significant improvements in intra-operative bleeding, postoperative hospital stay, and scar length ( $p < 0.001$ ,  $0.001$ ,

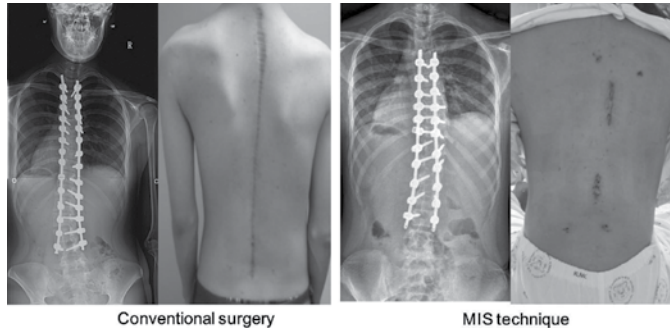


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0.001). The duration of the operation was significantly longer in group B. No difference in postoperative complications was observed.

## Conclusion

Application of the MIS technique in the AIS surgery shows favorable radiological and clinical outcome. However, there are no reports on long-term results. Therefore, continuous observation for possible additional complications is required.



Surgery case

## 32. Are Flexible Braces as Effective as Rigid Braces in Non-Operative Management of Adolescent Idiopathic Scoliosis?

Nanjundappa S. Harshavardhana, MD, MS; Vincent Arlet, MD

United Kingdom

## Summary

Bracing is superior to observation in non-operative treatment of adolescent idiopathic scoliosis (AIS). Rigid braces (RB) are perceived to be less patient-friendly with poorer compliance in-comparison to flexible braces (FB). We undertook a systematic review with meta-analysis of pooled data evaluating the success with bracing for AIS comparing RB vs. FB in an effort towards incorporating evidence-based recommendations. The overall success with bracing was 66.3 percent (RB:78.6; FB:53.5). The odds of success with RB in-comparison to FB was 3.2 (range: 1.6-6.2 & p=0.0007).

## Hypothesis

Are FB as effective as RB in orthotic management of AIS?

## Design

Systematic review with meta-analysis of studies comparing the success with bracing evaluating FB vs. RB.

## Introduction

Our objectives were to: i) Determine if FB were as therapeutically effective as RB when used for AIS and ii) Report the risk ratio with 95% confidence intervals(CI) of success with bracing for FB and RB to aid with evidence-based recommendations.

## Methods

A comprehensive search was undertaken in MEDLINE, EMBASE & Cochrane database for published full-text studies evaluating the results of FB & RB for AIS. The inclusion criteria: i) Level of evidence I-III studies involving AIS subjects with an average follow-up of at least 18 months and ii) Comparative studies that evaluated the success with bracing of FB vs. RB and reported change in Cobb angle at initiation of bracing and follow-up. We extracted data adhering

to the PRISMA guidelines. Information pertaining to the clinical outcomes were analysed using the comprehensive meta-analysis software (CMA-v3). We adhered to AMSTAR guidelines in reporting our results and risk ratio (RR) with 95%CI was calculated for reported success of FB and RB.

## Results

Four studies with pooled data of 175 patients (86FB & 89RB; 7M & 168F) met the inclusion criteria. The mean age at the initiation of bracing was 12.2±1.2y for FB and 12.4±1.1y for RB. There were two randomised controlled trials, two had adhered to the SRS bracing criteria and one study had followed the patients to maturity. The mean Cobb angle at the initiation of bracing was 25.2°±3.1° for FB and 28.7°±3.5° for RB. The brace-wise breakdown of success rate for each study is summarised in Table 1. RB outperformed FB and the RR was statistically significant on random effects model (RR=0.72 & 95%CI: 0.59 to 0.88; p=0.001). The forest plot for all four studies is illustrated in Figure 1.

## Conclusion

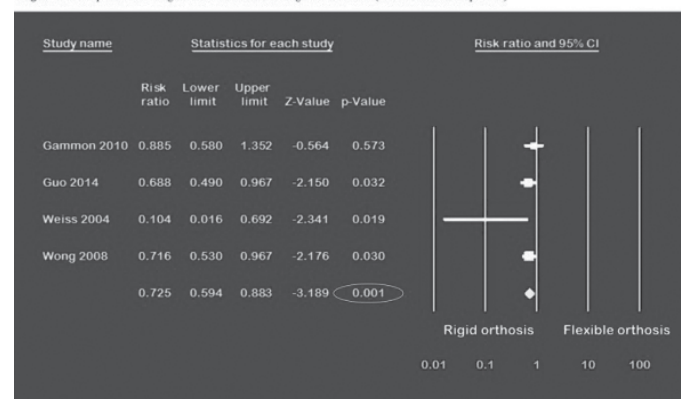
Though both FB and RB were effective in AIS, this meta-analysis found Rigid braces to be superior to their flexible counterparts. Based on the existing evidence, we recommend rigid braces (i.e. RB) to be the orthosis of choice in non-operative management of AIS.

Table 1: Summary of all comparative studies included in meta-analysis (Flexible vs. Rigid braces for Idiopathic scoliosis)

Sl No	Study name	LoE	SRS Criteria	No of Pts		Type of Brace		Success with bracing		Failure with bracing	
				Male	Female	Flexible	Rigid	Flexible	Rigid	Flexible	Rigid
1	Weiss 2004	III	No	0	27	12	15	1	12	11	3
2	Wong 2008	I	No	0	43	22	21	15	20	7	1
3	Gammton 2010	II	Yes	7	60	32	35	17	21	15	14
4	Guo 2014	I	Yes	0	38	20	18	13	17	7	1
				7	168	86	89	46	70	40	19
	<b>Total</b>	I-2 II-1 III-1	Yes: 2 No: 2	175		175		116		59	

Overall success with bracing: 66.3% (Flexible: 53.5% & Rigid: 78.6%); Odds ratio (OR) of success with RB is 3.20 (range: 1.62 – 6.20)

Figure 1: Forest plot summarising the result of Flexible vs. Rigid brace for AIS (n=4 studies and 175 patients)



Study Result & Forest plot



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## 33. Randomized Trial of Healing Therapy Effects on Pain and Anxiety in Adolescent Idiopathic Patients Undergoing Posterior Instrumentation

Natalie McNeil, BHSP, RMSKS, RT; Tracey Bastrom, MA; Carrie E. Bartley, MA; Burt Yaszay, MD; Peter O. Newton, MD

United States

### Summary

Energy healing (EH) is one of many therapies considered part of the diverse group of Complementary and Alternative Medicines (CAM). 50 patients were enrolled in a randomized fashion to receive EH vs standard care for posterior surgical correction of adolescent idiopathic scoliosis (AIS). The pre-operative anxiety and post-operative pain experienced by AIS patients appears to be abated by EH therapy. Offering this therapy may enhance the well-being of the patient and their overall experience in undergoing posterior correction for AIS.

### Hypothesis

Energy healing will result in reduced pain and anxiety in patients undergoing posterior surgical correction for adolescent idiopathic scoliosis (AIS) compared to controls.

### Design

Prospective randomized trial

### Introduction

Energy healing (EH) is one of many therapies considered part of the diverse group of Complementary and Alternative Medicines. Studies over the last decade have reported positive results of EH therapies in reducing anxiety and pain. The purpose of this study was to evaluate whether positive effects exist in patients receiving EH prior to and following posterior instrumentation for AIS.

### Methods

Patients were randomized into one of two groups; standard pre & post-operative care for surgery (controls) vs adding 3 sessions of EH. The first session was within 1 week pre-operative, the 2nd on day of surgery (post-operative), and the 3rd was prior to discharge. Outcomes included visual analog scale (VAS) for pain (0-10), VAS for anxiety (0-10), days until oral pain medication, and length of hospital stay. For the controls VAS was assessed once at each time point and assessed pre and post EH for the experimental group.

### Results

50 patients enrolled, 28 controls and 22 EH patients who were similar in age (mean 14 yrs  $p=0.5$ ). The controls had a median of 12 levels fused vs. 10.5 in the EH group ( $p=0.04$ ). Thoracic and lumbar Cobb was similar ( $p>0.05$ ). Overall VAS pain scores increased from pre to post-operative ( $p<0.001$ ) whereas the VAS anxiety scores decreased post-operative ( $p<0.001$ ). The control and pre EH assessments were statistically similar except for 1st post op pain ( $p<0.05$ , table). Significant decreases in all scores from pre to post EH assessment was noted for the EH group ( $p<0.05$ ). Both groups transitioned to oral pain management at a median of 2 days post op ( $p=0.11$ ). The median days to discharge was 4 in the controls and 3 in the EH group ( $p=0.067$ ).

### Conclusion

The pre-operative anxiety and post-operative pain experienced by AIS patients appears to be abated by EH therapy. Offering this therapy may enhance the well-being of patients and their overall experience in undergoing posterior correction for AIS.

Table: Median values for VAS pain and anxiety

		control	EH - pre	EH -post
Pre-Op	Pain*	1	2	0
	Anxiety*	4	2	2
1st Post	Pain ^	4	6	3
	Anxiety*	0	0	0
D/C	Pain*	4	5	1.75
	Anxiety*	1	0	0

\*significant difference between the pre and post healing, post healing and controls; ^ in addition to significant difference between the pre and post healing, post healing and controls, the control and pre-healing assessments were significantly different ( $p<0.05$ ).

## 34. Is High Implant Density in Lenke 1B & 1C Beneficial?

Bekir Eray Kilinc, MD; Dong-Phuong Tran, MS; Charles E. Johnston, MD; Chan-Hee Jo, PhD

United States

### Summary

Analysis of 120 AIS patients with Lenke 1B & 1C curve patterns shows those with higher implant density have larger preop curve magnitude and more correction, but longer surgical (OR) time and higher estimated blood loss (EBL). In a group of 60 patients matched for curve magnitude, high implant density achieved more coronal correction, hypokyphosis, OR time and EBL.

### Hypothesis

Patients with higher implant density have more implants, OR time, higher EBL, with more curve correction.

### Design

Single-centered IRB approved retrospective review.

### Introduction

Optimal implant density for management of AIS remains unknown. Our aim is to compare radiographic and surgical outcomes of patients with Lenke 1B&1C curve patterns.

### Methods

120 AIS patients Lenke 1B&1C treated with PSF were grouped by implant density: Low Density (LD)  $\leq 1.4$  and Higher Density (HD)  $>1.4$ . Matched subgroups (30 patients each) based on age, curve magnitude & BMI were created from LD and HD groups. Radiographic parameters were evaluated at preop, immediate postop (ipo), and 2yr f/u. SRS-30 was administered at preop and 2 yr f/u. Mann-Whitney test was performed on all patients and matched subgroup.



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## Results

Preop major curve of LD (n=82) and HD (n=38) groups were 59.1° vs 65.6° (p<.001); 26.3° vs 22.9° (p=.05) at ipo and 29.9° vs 19.8° (p<.001) at 2yr f/u. No differences in trunk shift and coronal balance postop (p=.69, p=.74). HD group had higher implant density (p<.001), blood loss (p=.02), number of implants (p<.001), levels fused (p=.002), and OR time (p<.001). Minimal differences were seen in the sagittal plane at ipo and 2 year f/u. However, HD were more hypokyphosis from preop to f/u (p<.001). No differences in any 5 categories of SRS-30 scores at preop and 2yr f/u. No differences in Risser grades and density and surgical outcomes.

Matched groups have similar preop major curve (p=.56), age (p=.53), and BMI (p=.92). There were differences with more OR time (p=.009), density (p<.001), and correction (p<.001) in HD patients at 2yr f/u. Similar to the cohort, minimal differences were seen in the sagittal plane at ipo and 2 year f/u. However, HD were more hypokyphosis from preop to f/u (p<.001). Again there were no differences in SRS-30 scores at preop and 2yr f/u and no differences in Risser grades and density and surgical outcomes.

## Conclusion

Low implant density fixation achieves less correction in Lenke 1B & 1C AIS patients but reduces blood loss, shortens OR time, thus theoretically reducing intraoperative radiation use, costs, and postop implant malposition while achieving similar outcomes as higher density constructs.

## 35. Initial and Long-Term Changes in 3D Position of Upper and Lower Instrumented Vertebrae following Surgery for Adolescent Idiopathic Scoliosis

*Dino Colo, MD; Suken A. Shah, MD; Julian D Rose, BS; Saba Pasha, PhD; Rene M. Castelein, MD, PhD*

Netherlands

## Summary

This three-dimensional study demonstrates that posterior spinal fusion (PSF) for adolescent idiopathic scoliosis (AIS) significantly changes the position in space in a dorsal direction of the upper (UIV) and lower (LIV) instrumented vertebra. This change remains constant over a 2 year follow up (FU) but higher (unfused) thoracic levels gradually compensate back in flexion to their original position, thus creating PJK.

## Hypothesis

The spine adjusts and compensates in the unfused, mobile segments following surgery for AIS.

## Design

Retrospective cohort analysis of prospectively collected data.

## Introduction

The importance of restoring a normal sagittal alignment in AIS surgery has been increasingly recognized. Recent data show that suboptimal reconstruction leads to an increase of adjacent degenerative disc disease and junctional kyphosis.

We hypothesize that the postoperative 3D UIV and LIV position determines the tendency of the spine to adjust in the remaining uninstrumented segments. The aim is to describe the 3D UIV/LIV position change following AIS surgery.

## Methods

Retrospective analysis of prospectively collected data on 19 AIS patients with EOS low-dose biplanar imaging pre- and postop following PSF with >2yr FU. All except one had all-pedicle screw constructs. The difference in A-P dimension (X-axis), left-right (L-R, Y-axis) and height (Z-axis) was determined using custom developed software with the sacrum as reference point in this free-standing position.

## Results

A total of 13 females and 6 males with a mean age of 14.6y at surgery were included. UIV was T2 (7), T3 (3), T4 (4), T5 (4), T10 (1), LIV was T12 (5), L1 (5), L3 (6), L4 (3). Mean preop Cobb angle of the major curve improved significantly from 69° to 22°. The mean change in AP direction of the UIV vs LIV was 2.2 vs 0.9cm posteriorly, L-R direction 1.5 to the left vs 1.0cm to the right and height 2.6 vs 0.5cm longer (all significant except height for LIV). This difference remained stable over 2-year FU. Sacral slope remained relatively unchanged. Over the course of FU, the higher thoracic uninstrumented levels gradually migrated back to their original position.

## Conclusion

This study shows that PSF for scoliosis significantly and consistently displaces the UIV posteriorly and cranially, but that the superadjacent levels gradually compensate back in flexion to their original position. This change of position remains stable over a 2yr FU. This mechanism provides an explanation for adjacent segment disease and junctional kyphosis.

## 36. Can Areal and Volumetric Bone Mineral Density (BMD) Predicts Risk of Surgery in Newly Diagnosed Girls with Adolescent Idiopathic Scoliosis (AIS)?

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## Summary

~30% of AIS girls were found to have osteopenic BMD status that could persist until skeletal maturity. The prognostic power of osteopenia on the risk of surgery, however, has never been reported. We investigated the prognostic value of osteopenia status (OST) at initial visit on risk of surgery through longitudinal follow-up. Results showed that AIS patients first presented with osteopenia measured either by areal BMD (aBMD) or volumetric BMD (vBMD) through HR-pQCT would have significantly higher risk of deterioration to the surgical level.

## Hypothesis

Newly diagnosed AIS patients with initial OST have higher risk of surgery

## Design

Longitudinal cohort study

## Introduction

Osteopenia was recognized as prognostic factor for curve progression in AIS girls, but the predictive power on risk of surgery has never been reported, especially HR-pQCT parameters. The objectives of this study were to investigate

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the prognostic power of OST at initial visit on surgical outcomes through longitudinal follow-up and to explore if the bone quality measured by HR-pQCT can provide additional predictive power in sub-group analysis.

### Methods

513 newly diagnosed AIS girls (mean age:  $13.1 \pm 1.1$ ) had initial Cobb angle  $\geq 10^\circ$  but  $\leq 40^\circ$  (i.e. not yet reached study outcome) were recruited and follow-up clinically until skeletal maturity (age  $\geq 15.5$  and post-menarche  $\geq 2$  years). Bilateral hips were measured by DXA at first visit and subgroup of 90 was also assessed by HR-pQCT at non-dominant distal radius. The study outcome was indication of surgery (Cobb angle  $\geq 45^\circ$  or had undergone surgery). Akaike Information Criterion (AIC) was used to evaluate prognostic value of OST. Classification and Regression Tree analysis (CART) was used to identify the optimal cut-off points of HR-pQCT parameters and the risk classification ability were further assessed by sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV).

### Results

At last, 55 patients were progressed and osteopenic AIS were more likely to progress to  $\geq 45^\circ$  (17.2% vs 7.6%) or undergone surgery (6.5% vs 2.0%). Cox proportional hazard model with OST had better overall performance than model without (AIC 533.13 vs 528.56) and improved the data fitness significantly ( $p=0.0104$ ). Osteopenic AIS had significantly higher risk (HR 2.24,  $p=0.011$ ) of surgery. In sub-group analysis, HR-pQCT had promising risk classification ability; cut-off  $< 570 \text{ mgHA/cm}^3$  of the cortical vBMD for patients with initial Cobb angle  $\geq 24^\circ$  had 42.9% sensitivity, 100% specificity, 100% PPV and 95.4% NPV.

### Conclusion

Results reinforced that AIS patients first presented with OST measured either by aBMD or vBMD would have significantly higher risk of deterioration to the surgical level.

### 37. Comparison of Bending vs Fulcrum vs Traction X-ray Under General Anesthesia (TrUGA) for the Assessment of the Curve Flexibility and Prediction of Correction in AIS

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### Summary

Traction x-ray under general anesthesia (TrUGA) reflects flexibility in main thoracic and thoracolumbar/lumbar curves  $> 65^\circ$  better than Fulcrum and Bending X-rays. TrUGA change the surgical plan in 57% of the patients with severe curves. TrUGA also better estimated the postop correction.

### Hypothesis

TrUGA which is performed under full muscle relaxation will show better flexibility in severe curves and may change the preoperative surgical plan.

### Design

Retrospective

### Introduction

Bending x-rays (BXR) are traditionally used for assessment of the curve flexibility in AIS. Fulcrum x-rays (F) and Traction x-ray under general anesthesia (TrUGA) have been promoted as alternatives to BXR. The aim of this study is to compare all 3 methods in AIS.

### Methods

80 (70F, 10M) patients with AIS who were operated by pedicle screw fixation and have had BXR, F and TrUGA were included in this study. Curves in standing and flexibility x-rays were measured and flexibility rates obtained by each method at proximal thoracic (PT), Main thoracic (MT) and Thoracolumbar/lumbar (TL/L) curves was compared. To evaluate the best method to predict the postsurgical correction, the agreement between the methods and postop results were examined by using Bland-Altman method.

### Results

Ave age was 14 (11-17) years and ave f/up was 38.7 (36-104) months. Lenke types (LT) were 21 LT1C, 8 LT2C, 20 LT3C, 7 LT4C, 15 LT5, 9 LT6. Curves were  $< 65^\circ$  in 47 patients and  $> 65^\circ$  in 33 patients. For curves  $< 65^\circ$ ; TrUGA demonstrated highest flexibility rate for PT and MT curves when compared to BXR ( $p < 0.001$ ) and F ( $p = 0.56$ ), and BXR demonstrated highest flexibility rate for TL/L curves when compared to TrUGA ( $p > 0.05$ ) and F ( $p = 0.003$ ). However, for curves  $> 65^\circ$ ; TrUGA demonstrated highest flexibility rate when compared to BXR and F for PT, MT and TL/L curves ( $p < 0.05$ ). TrUGA demonstrated better 95% limits of agreement with postop correction rates better than BXR and F for MT and TL/L curves  $> 65^\circ$ . In 19 (57%) of 33 pts with curves  $> 65^\circ$ , TrUGA eliminated posterior osteotomy indication.

### Conclusion

TrUGA showed better flexibility rates than BXR and F for PT and MT curves  $< 65^\circ$  and BXR showed better flexibility rates for TL/L curves  $< 65^\circ$ . However TrUGA demonstrated highest flexibility rate for all curves  $> 65^\circ$ . TrUGA showed better flexibility rates in severe curves and would be helpful in decision making whether deformity corrections needs an osteotomy or not.

### 38. Two Year Clinical and Radiographic Outcomes of Mini Open Correction and Fusion for Adolescent Idiopathic Scoliosis (AIS)

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United States

### Summary

This study reports deformity corrections and clinical outcomes of minimally invasive surgical (MIS) techniques for adolescent idiopathic scoliosis (AIS) reconstruction at 2 years follow-up at one institution.

### Hypothesis

MIS offers adequate correction and positive outcomes at 2 years follow-up.

### Design

Retrospective analysis of prospectively followed patients.





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## Introduction

Minimally invasive surgery (MIS) offers a potentially less morbid treatment option for patients requiring stabilization of AIS. This study is one of the first to report deformity correction and clinical outcomes at 2 years follow-up.

## Methods

42 consecutive patients undergoing MIS correction of AIS were reviewed. Age, operative time, estimated blood loss (EBL), length of hospital stay (LOS), Lenke curve, preoperative (pre-op) and postoperative (post-op) Cobb angles, Scoliosis Research Society-22r (SRS-22r), Oswestry Disability Index (ODI) and Visual Analogue Scale (VAS) were evaluated. Mean (standard deviations) were calculated. Surgical technique was uniform in all patients using two or three midline incisions. Matched pair t-tests were conducted for statistical significance ( $\alpha=0.05$ ).

## Results

Mean patient age was 17 years (11–47 yrs.). Mean body mass index (BMI) was 19.5 ( $\pm 2.6$ ). Curves were classified as: 20 Lenke 1A, 12 Lenke 1B, 3 Lenke 1C; 7 Lenke 5C. Mean flexibility index of the main curve was 55.4% ( $\pm 10.4\%$ ). Mean pre-op and 2 years follow-up Cobb angles were 55.4° ( $\pm 3.8^\circ$ ) and 13.3° ( $\pm 3.2^\circ$ ), respectively with a mean correction of 77% ( $\pm 9.8\%$ ). This difference was statistically significant ( $p < 0.001$ ). Mean loss of correction on follow-ups was less than 5°. Mean operative time was 318 minutes with mean EBL of 158 mls ( $\pm 73.4$  mls). Mean LOS was 3.4 days ( $\pm 1.3$  days). Pre-op mean VAS and ODI scores were 25 and 16.8, respectively; 12.5 and 8.0 at 2 years post-op which were statistically significantly improved ( $p < 0.001$ ). The mean SRS-22r score at 2 years was 4.66 ( $\pm 0.6$ ). The radiographic evaluation showed solid fusion rates in all patients at 2 years. .

## Conclusion

Our cohort's 2 years follow-up data demonstrates that MIS technique can achieve and maintain adequate deformity correction while preserving midline musculature. Additionally, the MIS approach is associated with positive patient reported outcomes at 2 year follow-up as indicated by VAS, ODI and SRS-22r scores.

## 39. The Impact of Obesity on Compensatory Mechanisms in Response to Progressive Sagittal Malalignment

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## Summary

Mechanisms for compensation in sagittal malalignment in obese patients presenting with spinal pathology are poorly understood. Given significant energy expenditure in these patients to maintain gravity line, understanding additional compensatory mechanisms in lower limbs is important for proper global deformity assessment. This study demonstrates differential lower-limb and pelvic recruitment in knee and hip extension, dependent on BMI, with increasing loss of lumbar lordosis to maintain a balanced gravity line.

## Hypothesis

Obesity impacts patients' ability to compensate for sagittal spinal malalignment.

## Design

Single center retrospective review.

## Introduction

Obesity's impact on standing sagittal alignment is poorly understood, notably with regards to the role of lower limbs. This study compares obese and non-obese patients (pts) with sagittal malalignment for differences in recruitment of pelvic and lower limb mechanisms.

## Methods

Inclusion: pts  $\geq 18$  yrs that underwent full body stereographic x-rays. Pts were categorized as non-obese (NO: BMI  $< 30$ ) and obese (OB: BMI  $\geq 30$ ). To eliminate confounding compensation factors, groups were propensity matched for age, gender and baseline pelvic incidence (PI), and then stratified into 3 categories of progressive PI-LL mismatch:  $< 10^\circ$ ,  $10^\circ$ - $20^\circ$ ,  $> 20^\circ$ . T-tests and linear regressions compared upper body (SVA, T1SPi) and lower limb (PS: pelvic shift; KA: knee flexion; AA: ankle flexion, SFA: sacrofemoral angle; GSA: global sagittal axis) parameters in groups.

## Results

554 pts (277 OB, 277 NO) were analyzed with the following mismatch distributions:  $< 10^\circ$ : n=367;  $10^\circ$ - $20^\circ$ : n=91;  $> 20^\circ$ : n=96. OB pts had higher baseline SVA, KA, PS and GSA compared to NO ( $p < 0.001$  all). Low PI-LL mismatch OB pts had greater SVA with lower SFA ( $142.22^\circ$  vs.  $156.66^\circ$ ,  $p=0.032$ ), higher KA ( $5.22^\circ$  vs.  $2.93^\circ$ ,  $p=0.004$ ) and PS ( $4.91$  vs.  $-5.20$  mm,  $p < 0.001$ ) compared to NO. With moderate PI-LL mismatch, OB pts similarly demonstrated greater SVA, KA, and PS, combined with significantly lower PT ( $23.69^\circ$  vs.  $27.14^\circ$ ,  $p=0.012$ ). Obese pts of highest ( $> 20^\circ$ ) PI-LL mismatch showed greatest forward malalignment (SVA, T1SPi) with significantly greater PS in response, and a concomitantly high GSA ( $12.86^\circ$  vs.  $9.67^\circ$ ,  $p=0.005$ ). Regression analysis for lower-limb compensation revealed that increasing BMI and PI-LL predicted KA ( $r^2=0.234$ ) and GSA ( $r^2=0.563$ ).

## Conclusion

With progressive sagittal malalignment, obese patients differentially recruit lower extremity compensatory mechanisms while non-obese preferentially recruit pelvic mechanisms. Obesity seems to limit the ability to compensate for malalignment through the pelvic retroversion.

		BMI Group		P-Value
		OB	NO	
PI-LL $< 10^\circ$	KA	5.22	2.93	0.004*
	AA	6.37	5.96	0.304
	PS	4.91	-5.20	$< 0.001^*$
	SFA	142.22	156.66	0.032*
	GSA	2.75	1.49	$< 0.001^*$
PI-LL $10^\circ$ - $20^\circ$	KA	10.42	4.00	$< 0.001^*$
	AA	7.75	6.56	0.132
	PS	36.58	13.29	$< 0.001^*$
	SFA	151.44	150.22	0.876
	GSA	7.25	3.90	$< 0.001^*$
PI-LL $> 20^\circ$	KA	15.02	11.83	0.095
	AA	8.24	8.63	0.686
	PS	75.12	47.35	0.001*
	SFA	154.88	152.10	0.151
	GSA	12.86	9.67	0.005*

Table: Lower-extremity alignment in obese (OB) and non-obese (NO) patients groups, stratified by increasing PI-LL (pelvic incidence minus lumbar lordosis mismatch) deformity. KA = Knee Angle, AA = Ankle Angle, SFA = Sacrofemoral Angle, GSA = Global Sagittal Axis.

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## 40. National Trends for Primary and Revision Posterior Lumbar Fusions throughout the United States

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### Summary

Given the increasing focus on health care utilization and value-based care, it is essential that the annual U.S. incidence of primary and revision posterior lumbar fusions is determined. Patient demographics and economic data associated with primary and revision lumbar fusions are also critical to optimizing health care utilization. We analyzed data from the National Inpatient Sample database to infer utilization trends of posterior lumbar fusions nation-wide.

### Hypothesis

We will be able to identify national utilization trends of primary and revision posterior lumbar fusions.

### Design

Retrospective database review

### Introduction

Given the increasing focus on health care utilization and value-based care, it is essential that the number of primary and revision posterior lumbar fusions per year throughout the United States are determined. Additionally patient demographics and economic data associated with primary and revision lumbar fusions are critical to understanding and improving health care utilization.

### Methods

The data utilized in this study was collected between 2011-2013 across 44 states from the National Inpatient Sample (NIS) database on patients who underwent either primary or revision posterior lumbar fusions. Demographic and economic data were obtained. The NIS database represents a 20% sample of discharges from U.S. hospitals, which is weighted to provide national estimates.

### Results

The total number of posterior lumbar fusion has decreased 19% from 127,916 in 2011 to 103,215 in 2013. The mean total cost of lumbar fusion decreased 12% from \$28,333 in 2011 to \$24,916 in 2013. The mean cost was \$27,170 per case over the three years. The mean LOS remained stable at 3.9 days. The mean routine discharge of 62% also remained steady. The number of revision procedures similarly declined 19% from 10,717 in 2011 to 8,610 in 2013. Hence the mean national revision burden, the ratio of revision procedures to the sum of primary and revision procedures, was 8%. The mean cost of revision posterior lumbar fusion was \$28,937. The mean LOS for patients undergoing revision posterior lumbar fusion was 4.0 days with routine discharge in 64% of those patients.

### Conclusion

Nationally, there was a progressive decline of both primary and revision posterior lumbar fusions by 19% over the study period as well as a decrease in total costs for primary posterior fusion surgeries by 12% between 2012 and

2013. The U.S. revision burden for posterior lumbar fusion increased from 7% in 2011 to 9% in 2013.



## 41. The Sexual Activity Question in the Oswestry Disability Index: An Analysis of Elderly Adult Spinal Deformity Patients

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### Summary

The inclusion of question #8 (sexual activity) in the Oswestry Disability Index (ODI) is controversial in the evaluation of adult spinal deformity (ASD) patients. This study compared ODI and SRS-22 scores between patients who answered the questions vs. not. Results revealed no difference and that ODI sex score is correlated to total ODI score, other ODI question scores, and SRS-22 domains, indicating that ODI sex score is not necessary for QOL evaluation.

### Hypothesis

The question regarding sexual activity in the ODI is not relevant for older ASD patients.

### Design

Retrospective review of prospective multicenter ASD database

### Introduction

The inclusion of question #8 (sexual activity) in the Oswestry Disability Index (ODI) is controversial in the evaluation of ASD patients. Moreover, this question is often omitted by patients and deleted in versions of the ODI in different languages.

### Methods

Inclusion criteria were surgical treated ASD patients > 50 years with baseline and post-operative QOL outcomes including ODI and SRS-22. Pearson correlations were performed to examine relationships between ODI Q#8, the remaining ODI questions, and SRS-22 domains.

### Results

Of the 42 patients enrolled (mean age 65.2 years), 31 (74%) completed Q#8, while 11 (26%) omitted it. These two groups did not differ in age (66.6 vs. 64.7,  $p=0.404$ ). Moreover, at baseline, post-op and 1 yr FU, these two groups were similar in all other ODI question scores, ODI total score, each domain of the SRS-22, and the total SRS-22 total score. Q#8 correlated strongly with the total ODI score at baseline, post-op and 1 yr FU, Q#3, 5, 7,



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9 at baseline; Q#1, 6, 7, 9 at post-op; and Q#1, 3, 5, 6, 10 at 1 yr FU. ODI Q#8 also correlated to the total SRS-22 score and all SRS-22 domains at baseline and 1y post-op.

### Conclusion

Among ASD patients older than 50, 26.2% omitted the sex question of the ODI. However, ODI sex score is significantly correlated to total ODI score, other ODI question scores, and SRS-22 domains, indicating that ODI sex score is not necessary for QOL evaluation.

### 42. Horizontal Leveling of L4 and L5 in Long Fusions to the Pelvis Results in Improved Coronal Balance

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Canada

### Summary

Coronal curve correction in the face of a tilted L4 can lead to coronal imbalance towards the convexity of the main curve. Patients who had received good correction (>40%) on long fusions to the pelvis for AIS were reviewed and measured for L4 tilt, L5 tilt and coronal balance (coronal C7-CSVL). Patients in the unbalanced group had significantly higher tilts compared to those in the balanced group. L4 and L5 tilt were both positively correlated with increased imbalance.

### Hypothesis

In long fusions to the pelvis with good correction, horizontal leveling of the L4 and L5 vertebrae can result in improved coronal balance.

### Design

Retrospective Analysis

### Introduction

In lumbar scoliosis the fractional lumbosacral curve can often be stiffer than the main curve and is usually the main site of neural compression. Leveling L4 and L5 in the coronal plane during the correction can provide foraminal decompression and a balanced platform for which to correct the main curve. Curve correction in the face of a tilted L4 can lead to coronal imbalance towards the convexity of the main curve.

### Methods

The radiographs of 36 adult coronal deformity patients treated with fusions to the pelvis were retrospectively reviewed. Pre and postoperative coronal Cobb angles were measured to determine correction. Patients were classified as balanced (<3cm) or imbalanced (>3cm) based on the distance between the C7 coronal plumb line and the Central Sacral Vertebral Line.

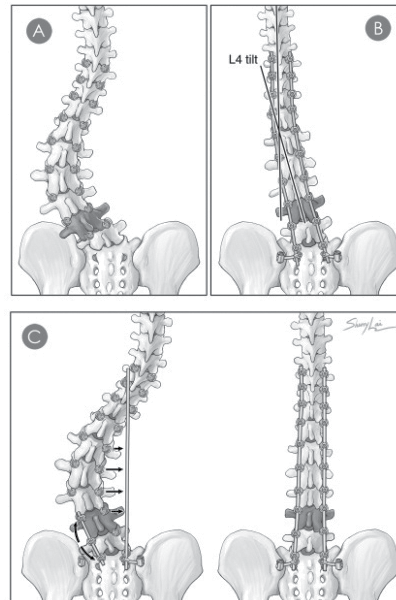
### Results

20 patients were balanced and 16 were imbalanced postoperatively in the coronal plane. The average global coronal correction was 31.1° (16.9-64.8) and all patients had good corrections of their deformity (> 40%). Coronal balance was 1.28 cm from center in the balanced group compared to 4.90 cm in the unbalanced group (P<0.001). L4 and L5 tilt were 8.1 and 5.6 degrees in the balanced group and 18.5 and 13.2 degrees in the imbalanced

group (P<0.001 for both). Correlational analysis was performed to determine the relationship between the distal vertebral angles and the magnitude of coronal imbalance. Both L4 and L5 tilt were positively correlated with coronal imbalance (r=0.75 and 0.54 respectively, P<0.001) There were no differences in demographics or coronal plane correction between groups.

### Conclusion

In long spinal fusions with good correction, leveling L4 and L5 leads to better coronal balance following surgery. The magnitudes of L4 and L5 tilt were positively correlated with the magnitude of coronal imbalance. Leveling L4 in the coronal plane should be a goal of surgery when correction of the main curve is desired in adult coronal plane deformities fused to the sacrum and pelvis.



### 43. Perioperative and Intraoperative Predictors of ICU Length of Stay in Adult Spinal Deformity Surgery

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Canada

### Summary

The records of 102 consecutive patients who underwent elective spinal fusion and were admitted to the ICU were stratified based on ICU length of stay (LOS), short stay (SS <3 days) and long stay (LS) ≥3 days. Multivariate analysis demonstrated that cumulative ICU fluid balance on day 2 and pleural tears were both independent predictors of ICU LOS. Alternatives to fluid should be considered when attempting to maintain a target postoperative blood pressure to protect spinal cord perfusion.

### Hypothesis

Positive postoperative fluid balance and greater use of opioids postoperatively will increase the ICU length of stay in patients undergoing elective spinal fusion.

### Design

Retrospective case series

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## Introduction

The increasing complexity of spinal fusion surgeries has increased the need for postoperative care in the ICU. The management of patients during and immediately following surgery can impact their postoperative course. Certain intraoperative and perioperative factors may influence clinical outcomes

## Methods

The records of 102 consecutive patients who underwent elective spinal fusion and were admitted to the ICU were retrospectively reviewed. Demographic, intraoperative and perioperative data was collected. Postoperative fluid balance was calculated following day 1 and day 2 in the ICU. Intraoperative and postoperative complications were recorded. Patients were stratified based on ICU length of stay (LOS). Short stay group (SS) consisted of patients with a <3 day ICU LOS. Long stay (LS) group consisted of patients with an ICU LOS  $\geq 3$  days. Statistical tests were performed to determine factors that contribute to ICU LOS

## Results

The cumulative ICU fluid balance on day 2 in the ICU was significantly greater in the LS group compared to the SS group (4.0 [2.0-6.7] vs. 2.3L [0.4-4.0] median [25th-75th percentile],  $P=0.006$ ). The frequency of pleural tears was significantly greater the LS group compared to the SS group (19.3% vs. 4.8%,  $P=0.03$ ). There was no difference in demographics, anesthetic time, intraoperative fluid balance, osteotomies, blood loss or opioid use between groups. Multivariate analysis demonstrated that cumulative ICU fluid balance on day 2 and pleural tears were both independent predictors of ICU LOS (adjusted OR 1.27 [95% CI 1.081-1.482] and 5.73 [1.081-30.327], respectively

## Conclusion

Postoperative day 2 cumulative ICU fluid balance is an independent predictor of increased ICU LOS following spinal fusion. Alternatives to fluid should be considered when attempting to maintain a target postoperative blood pressure to protect spinal cord perfusion. Intraoperative pleural tears are also a strong predictor of prolonged ICU stay

## 44. A Japanese Nationwide Multicenter Survey on Perioperative Complications of Corrective Fusion Surgery for Adult Spinal Deformity

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*Japan*

## Summary

We surveyed 1192 patients aged over 20 years old who underwent corrective fusion at 18 different institutions in Japan. Their demographics, diagnoses, comorbidities, surgical data, and perioperative complications were investigated. 49% of patients were 65 years of age and older, and they had higher incidence of perioperative complications than those younger than 65 years.

## Hypothesis

The older age impacts on the pathologies and incidence of perioperative complications in adult spinal deformity surgery (ASD).

## Design

A retrospective, multicenter survey

## Introduction

Japan is a super-aged society, in which 25 % of its population is 65 or older. ASD has become a serious problem which negatively impacts on health status and QOL of the elderly. Recently, corrective fusion surgery for ASD has become more common. We aimed to clarify the characteristics of ASD in the elderly population, focusing on pathoetiology and perioperative complications.

## Methods

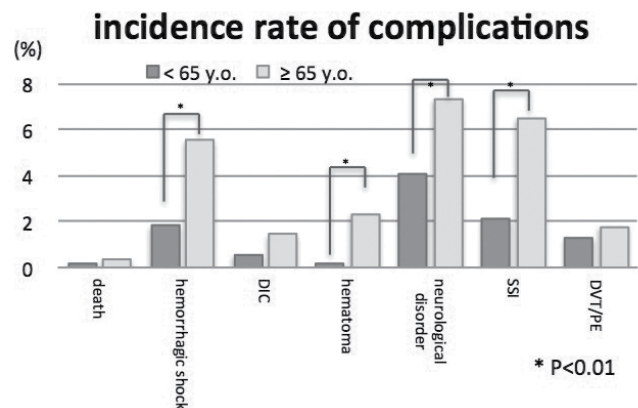
Data retrospectively collected from 18 scoliosis centers across Japan affiliated to Japanese Scoliosis Society were investigated (n = 1192; 227 men; 965 women; mean age, 57.7 years; range, 20-92 years). All patients aged over 20 years who underwent corrective fusion surgery for ASD from 2011 to 2013 were included in this study. We evaluated the diagnoses, surgical data, and perioperative complications using the database, and compared between patients  $\geq 65$  years and those under 65.

## Results

49% of the whole patients were 65 years and older. Etiopathology of deformity was idiopathic (<65y 43%,  $\geq 65y$  0.9%), de novo (<65y 29%,  $\geq 65y$  53%), and vertebral fracture (<65y 3%,  $\geq 65y$  23%). Iatrogenic deformity and reoperation were only 4%. Mean surgical time and estimated blood loss were 376 min and 1710 g, with no significant difference between over and under 65. Perioperative complications were neurological deficits (<65y 4.0%,  $\geq 65y$  7.4%), hemorrhagic shock (<65y 1.8%,  $\geq 65y$  5.5%), and surgical site infection (SSI) (<65y 2.1%,  $\geq 65y$  6.7%). Thus, complications were significantly more frequent in patients aged  $\geq 65$  years than those <65, with hemorrhagic shock, hematoma, neurological deficits, and SSI, heart failure being the most frequent.

## Conclusion

The elderly ASD patients had more deformities due to degeneration and vertebral fracture as etiopathology and they suffered from peri- and postoperative complications significantly more frequently than younger patients. Endeavor to reduce perioperative complications is necessary especially for the elderly ASD patients increasing in the aging society.





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## 45. Dynamic Posterior Stabilization Without Fusion in Degenerative Lumbar Scoliosis of Elderly Patients (Over 75 Years): Is it Effective ?

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Italy

### Summary

In elderly patients with degenerative lumbar scoliosis posterior instrumented fusion can cause an high incidence of complications. In degenerative lumbar scoliosis, dynamic stabilization resulted a safe procedure at mid-term follow-up in elderly patient over 75 years old. This non-fusion stabilization procedure appeared satisfying in these patients being less aggressive than instrumented fusion and less invasive with shorter operation time.

### Hypothesis

The use of dynamic stabilization has been used to reduce such adverse effects.

### Design

Retrospective study

### Introduction

In elderly patients with degenerative lumbar scoliosis posterior instrumented fusion can cause an high incidence of complications.

### Methods

A total of 36 consecutive patients (22 females, 14 males) with a mean age of 80.3 years (range, 75 to 83) operated on between 2008 and 2012 at our Department were included in the study. All cases were over 75 years old and received a dynamic posterior instrumentation for a degenerative lumbar scoliosis without sagittal imbalance. 7 cases presented additional mild degenerative spondylolisthesis. No patient had a previous surgery. All patients complained of back pain and leg pain while walking: 20 patients who had diffuse paresthesia at one or both legs, additionally.

### Results

At an average follow-up of 4.2 years (range, 3.1 to 6.0) all cases were reviewed. The average scoliosis Cobb angle before surgery was 20.1° (range, 12°-35°); this was corrected to 8.5° (range, 5°-10°) at the last control. The average number of levels instrumented was 4.8 + 2.4 (range, 5 to 7) and laminectomy was extended for 4.3 + 2.1 levels on average (range, 4 to 7). The mean preoperative VAS was 6.1 for low back pain and 6.7 for back pain and decreased to 3.5 and 3.9 respectively at follow-up. There was a significant increase at last visit of preoperative SF-36 scores of 7 items together (PF,RP,BP,MH,SF,V,GH): it was from 35 to 58 (65%) ( $r=0.41$ ,  $p<0.002$ ). There was also a significant increase in the ODI from 48.4 to 24.9, which represents an improvement of 83% ( $p<0.001$ ). There were no neurological complications. No instrumentation failure was observed in any patient. One patient (3.8%) required revision surgery for extension of the dynamic fixation for junctional degeneration.

### Conclusion

In degenerative lumbar scoliosis, dynamic stabilization resulted a safe procedure at mid-term follow-up in elderly patient over 75 years old. This non-fusion

stabilization procedure appeared satisfying in these patients being less aggressive than instrumented fusion and less invasive with shorter operation time.

## 46. Comparison of Posterior Spinal Fusion with Anterior-Posterior Spinal Fusion using MIS-ALIF for Adult Spinal Deformity with Global Sagittal Malalignment

*Tsuyoshi Sakuma, MD, PhD; Toshiaki Kotani, MD, PhD; Tsutomu Akazawa, MD, PhD; Shohei Minami, MD, PhD*

Japan

### Summary

This study was designed to determine whether anterior-posterior spinal fusion (APSF) using MIS-ALIF was more effective for improving sagittal alignment and less operative blood loss than posterior only spinal fusion (PSF). Result of this study, APSF group was significantly improved postoperative pelvic incidence minus LL and pelvic tilt than PSF group. Operative blood was smaller in APSF group. APSF with MIS-ALIF was associated with good radiographic outcomes and less invasive surgery compared with conventional PSF.

### Hypothesis

APSF with MIS-ALIF was associated with good radiographic outcomes and less invasive surgery compared with conventional PSF.

### Design

Retrospective Study

### Introduction

Conventional reconstruction surgery for adult spinal deformity (ASD) with global sagittal malalignment is associated with high morbidity and risk of complications. A minimally invasive anterior lumbar interbody fusion (MIS-ALIF) has been recently promoted for anterior column reconstruction with the hope of decreasing surgical invasion. The objective of this retrospectively study was to evaluate the radiographic and surgical outcomes of patients with ASD undergoing anterior-posterior spinal fusion (APSF) using the MIS-ALIF and to compare with posterior spinal fusion (PSF) including cases with three-column spinal osteotomy.

### Methods

A total of 51 patients with ASD and global sagittal malalignment who underwent APSF or PSF since 2012 were enrolled; 28 underwent APSF (mean age 70.0 years; 4 men and 24 women) and 23 underwent PSF (mean age 61.7 years; 2 men and 21 women). PSF cases were included in 9 cases with three-column spinal osteotomy (6 cases were pedicle subtraction osteotomy and 3 cases were vertebral column resection). Cobb angle, lumbar lordosis (LL), pelvic incidence minus LL (PI-LL), pelvic tilt (PT), and sagittal vertical axis (SVA) were evaluated.

### Results

Preoperative clinical dates were comparable between the two groups. Intragroup analysis showed that the APSF and PSF significantly improved Cobb angle, PI-LL, PT, and SVA. APSF significantly improved postoperative PI-LL and PT (-0.3°, 18.9°) compared with the PSF group (14.7°, 25.1°). Mean operative time was similar. Operative blood loss was less for APSF (1219.3mL) than PSF (1465.3mL), but the difference was not significant.

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## Conclusion

APSF with MIS-ALIF was associated with good radiographic outcomes and associated with less blood loss compared with conventional PSF.

## 47. Clinical and Radiographic Risk Factor for Knee-spine Syndrome in 535 Elderly Volunteers: Retrospective TOEI Study

*Sho Kobayashi, MD, PhD; Daisuke Togawa, MD; Tomohiko Hasegawa, MD, PhD; Yu Yamato, MD, PhD; Shin Oe, MD; Tomohiro Banno, MD; Yuki Mihara, MD; Yukihiro Matsuyama, MD, PhD*

*Japan*

## Summary

Clinical and radiographic analysis of 243 knee-spine syndrome revealed SVA was an independent risk factor of knee-spine syndrome in 535 elderly volunteers.

## Hypothesis

Sagittal imbalance of the spine is a risk factor of knee-spine syndrome (KSS) in elderly cohort.

## Design

In this retrospective case-control study, we enrolled consecutive elderly volunteers. All patients were evaluated for pain and standing radiographic parameters. We analyzed the characteristics and risk factors of the sagittal profile of the spine in KSS.

## Introduction

Knee OA and lumbar spondylosis are major public health issues because they cause chronic pain and disability.

KSS in the elderly is a clinically significant problem with unique therapeutic, and societal challenges. We sought to define the incidence and risks factors for KSS in an elderly population.

## Methods

A total of 535 volunteers with age of more than 65 years were participated in this IRB approved study in Toei town. There were 216 males and 319 females with average age of 76. Lateral whole spine and lower extremities X-rays were taken in neutral standing position. KSS was defined as knee and low back pain (LBP) and a Kellgren-Lawrence grade of 2 or higher. A univariate analysis was used to identify associations between risk factors and the incidence of KSS. Predictors included demographic information, Radiographic parameters included Sacral Slope (SS), Pelvic Tilt (PT), Pelvic Incidence (PI), Lumbar Lordosis (LL), Thoracic Kyphosis (TK), and Sagittal Vertical Axis (SVA). A multivariate logistic regression analysis was used in an attempt to identify independent risk factors for KSS. A  $p < 0.05$  was considered significant.

## Results

KSS were found in 243 (45%). In the univariate analysis, 3 variables emerged: the PT, PI-LL and SVA ( $P < 0.05$ ). But there was no significant differences with age, body mass index and vertebral wedging. In the multivariate logistic regression, the best fit was achieved with the model that included SVA (Odds ratio: 1.06; 95% CI 1.01-1.12,  $P < 0.05$ ).

## Conclusion

Data from this large case-control study confirm that the incidence of KSS in the elderly was high. Sagittal imbalance of the spine was independently associated with higher risk for KSS.

## 48. Fundamental Differences and Changes in Pelvic Parameters Depending on Age, Gender, and Race

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*United States*

## Summary

Pelvic parameters are fundamentally different depending on age, gender, and race. Pelvic incidence, which was thought to be static, showed increase with aging. Spinal reconstructions that extend to the pelvis should take these differences into consideration for optimal outcome.

## Hypothesis

There are significant differences in pelvic parameters amongst different demographics.

## Design

Retrospective cohort study.

## Introduction

Pelvic parameters and sagittal balance correlate with health related quality of life and are important for patient assessment and surgical planning. Age, gender, and race are three unalterable patient factors that may influence pelvic morphology.

## Methods

We included consecutive patients who presented for low back pain between 2010-2014 and had lateral standing radiographs with both femoral heads and L1-S1 visible. Patients presenting for traumatic injury were excluded. We measured pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS), and compared amongst races with one-way ANOVA, between genders with t-test, and correlated with all ages.

## Results

We investigated 1278 patients consisting of 1235 adults (>18 years), 781 women, 454 men, 357 Caucasians, 281 African Americans, and 258 Hispanics. 896 patients had a recorded race. Women had a statistically greater PI ( $53.11^\circ$  vs.  $51.07^\circ$ ,  $p < 0.005$ ) and SS ( $39.17^\circ$  vs.  $37.69^\circ$ ,  $p < 0.006$ ). Hispanics had a statistically smaller PT than both African Americans ( $12.76^\circ$  vs.  $14.91^\circ$ ,  $p = 0.002$ ) and Caucasians ( $12.76^\circ$  vs.  $16.00^\circ$ ,  $p < 0.0001$ ). Caucasians had a statistically smaller SS than both African Americans ( $36.91^\circ$  vs.  $40.40^\circ$ ,  $p < 0.0001$ ) and Hispanics ( $36.91^\circ$  vs.  $39.63^\circ$ ,  $p < 0.0003$ ). African Americans had a statistically greater PI than Hispanics ( $54.50^\circ$  vs.  $52.08^\circ$ ,  $p = 0.02$ ). There was a statistically significant correlation between increasing PT ( $p < 0.0001$ ), decreasing SS ( $p < 0.0001$ ), and increasing PI ( $p = 0.001$ ) with increasing age (fig. 1).



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## Conclusion

Pelvic parameters were different between genders, races, and age. Pelvic incidence, which was traditionally thought to be constant, increased with aging. These findings are important for patient assessment and preoperative planning to obtain optimal sagittal balance.

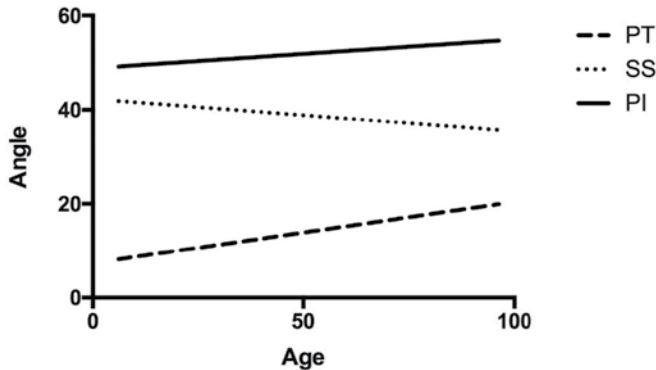


Figure 1. Linear regressions for age versus PI, PT, and SS.

## 49. Comparison of Active and Passive Correction of AIS using Vertebral Staples versus Tethers: A Medium Term Follow-up Study

John T. Braun, MD

United States

### Summary

Active and passive curve correction were evaluated in AIS patients treated with vertebral staples versus tethers. Our previous study with short term follow-up (SRS 2012) demonstrated greater active and passive curve correction with tethers versus staples. This current study with medium term follow-up confirmed greater active and passive correction with tethers versus staples but also demonstrated greater curve control over time with tethers.

### Hypothesis

Our hypothesis was that vertebral tethers would allow greater active and passive correction of AIS curves than staples and better curve control over time.

### Design

Retrospective review of consecutive patients (2009-10).

### Introduction

Fusionless scoliosis surgery using vertebral staples or tethers represents a novel treatment option that has been employed to treat AIS patients with moderate curves not amenable to bracing and at high risk for progression to fusion surgery. Our previous study (SRS 2012) reported short term follow-up on a cohort of AIS patients treated with vertebral staples versus tethers. This study reports medium term follow-up on the same cohort.

### Methods

Nine consecutive AIS patients were treated with staples or tethers for thoracic curves  $>30^\circ$  in the setting of significant skeletal immaturity. All patients had a risk of progression of 90% or greater by 2 of 3 risk assessment methods

(Lonstein and Carlson, Sanders, Scoliscore). Cobb angles pre-op, post-op and final were compared.

## Results

Nine female AIS patients with 14 curves (9T, 5L) underwent endoscopic stapling or tethering. The 4 stapled thoracic curves actively corrected from  $34.5^\circ$  pre-op to  $31.3^\circ$  post-op. Progression rather than passive correction was demonstrated over time with final curves reaching  $53.5^\circ$  at 31.5 months ( $p < 0.01$ ). Two stapled patients underwent definitive fusion for curves of  $55^\circ$  and  $66^\circ$ . The 5 tethered thoracic curves actively corrected from  $36.6^\circ$  pre-op to  $21.4^\circ$  post-op ( $p < 0.001$ ). Additional passive correction of  $1.4^\circ$  over time was demonstrated with final curves remaining stable at  $20^\circ$  at 32.2 months. One tethered patient underwent definitive fusion for distal decompression in the lumbar spine. Treated lumbar curves also fared better with tethers ( $27.3^\circ$  pre-op to  $-1.7^\circ$  post-op to  $9^\circ$  final) than staples ( $28^\circ$  to  $12.5^\circ$  to  $26^\circ$ ).

## Conclusion

Both active correction at surgery and passive correction over time with growth are important in the fusionless treatment of AIS. Vertebral tethers demonstrated significantly greater active ( $15.2^\circ$  vs  $3.2^\circ$ ) and passive ( $1.4^\circ$  vs  $-22.2^\circ$ ) correction when compared to staples and resulted in better curve control over time.

## 50. Preservation of Spine Motion in the Surgical Treatment of AIS Patients using an Innovative Apical Fusion Technique: A 2 Year Follow-up Study

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United States

### Summary

Two year + results from a prospective multi-center study on 21 AIS patients treated with a novel surgical approach with short segment apical correction, minimal fusion and preservation of spinal motion

### Hypothesis

Limited correction of AIS using an innovative implant design, permanently fusing fewer segments will preserve spinal motion

### Design

A prospective multi-center study.

### Introduction

Traditional surgical treatments for moderate to severe AIS realign the curves with instrumentation spanning a large number of segments. The risk of developing adjacent segment disease suggests that limiting fusion levels may have long term benefits.

### Methods

21 consecutive female AIS patients (Lenke 1A/1B) treated at 4 institutions with a novel Heim joint pedicle screw and L shaped screw rod-connection construct allowing for flexibility and maintenance of mobility. Arthrodesis



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was limited to the short apical curve with translational and de-rotational forces applied. Instrumentation spanned fused and unfused segments with motion of unfused segments maintained. Concave rods removed at maturity. Radiographic data collected pre and post-op as well as post-removal.

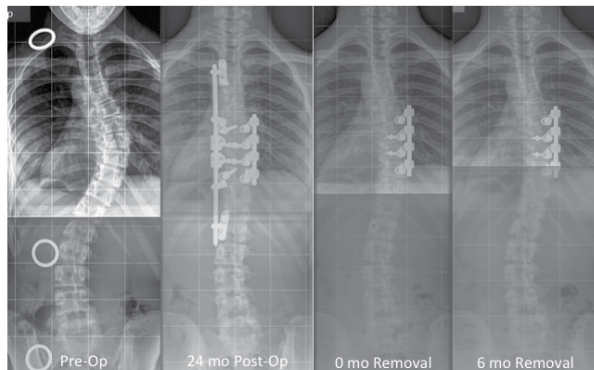
## Results

At the time of this abstract, all 21 patients were beyond 2Y post-op. Average age at surgery was 14.2 years (11-17Y). A mean of 10.5 ( $\pm 1$ ) levels per patient were stabilized. Only 5.0 ( $\pm 0.5$ ) levels (48%) were fused. Cobb angle improved from 56 ( $\pm 8.0$ ) $^\circ$  to 20.8 ( $\pm 7.8$ ) $^\circ$  at 1Y and 21.9 ( $\pm 9.5$ ) $^\circ$  at 2Y post-op, a 62.2% ( $\pm 15.9$ %) and 60.1% ( $\pm 18.7$ %) improvement at 1 and 2Y respectively. In levels instrumented but not fused, motion was 26 ( $\pm 6$ ) $^\circ$  pre-op compared to 10 ( $\pm 4$ ) $^\circ$  at 1Y post-op demonstrating 38% maintenance of mobility in non-fused segments at 1Y. There were no screw or rod failures reported. Alignment after concave rod and Heim screw removal measured 31.2 ( $\pm 7.8$ ) $^\circ$  at time of removal.

## Conclusion

This novel technique corrected deformity profile in AIS patients and maintained mobility of non-fused segments with a lower implant density and spared 52% of the spanned area from fusion.

### AP Standing X-Rays



Outcome result- UK patient

## 51. Selection of the Lowest Instrumented Vertebra in Lenke 1B Curve

*Hong Zhang, MD; Daniel J. Sucato, MD, MS; B. Stephens Richards, III, MD, United States*

### Summary

The lowest instrumented vertebra (LIV) was retrospectively investigated in 50 Lenke 1B curves treated with posterior approach using all posterior pedicle screw constructs. We demonstrated that choosing the last substantially touched vertebra in which the CSVL passed through the pedicle of the vertebra as the LIV achieved similar radiographic outcomes when compared to selecting the stable vertebra as LIV. The distal adding-on had been noted in three of four cases (75%) when selecting the last barely touched vertebra as LIV.

## Hypothesis

Specific criteria for the selection of the lowest instrumented vertebra (LIV) in Lenke 1B curves have not been established.

## Design

A retrospective study investigated the optimal criteria for selection of the lowest instrumented vertebra in Lenke 1B curves.

## Introduction

The purpose of the study was to evaluate the postoperative radiographic results in Lenke 1B curves in an effort to determine optimal criteria for LIV selection.

## Methods

Fifty patients with Lenke 1B curves treated with posterior spine fusion using all pedicle screw constructs from a single institution were retrospectively reviewed. Preoperative and latest follow-up radiographs were used. Follow-up averaged 32.9 months (24-62 months). Three groups were established based on where the center sacral vertical line (CSVL) on the preoperative radiograph touched the LIV. LBTV (Last Barely Touched Vertebra): the CSVL "barely touched" the corner of the LIV. LSTV (Last Substantially Touched Vertebra): the CSVL passed through the pedicle of the LIV. SV (Stable Vertebra): the CSVL passed between the pedicles of the LIV. Parameters evaluated on the latest follow-up radiographs included the percentage thoracic curve correction, percentage lumbar curve spontaneous correction, coronal balance (C7 distance from CSVL), thoracic trunk shift (TTS), LIV position relative to the CSVL, and coronal angulation of the disc below LIV (LIV-DISC).

## Results

Of 50 cases, the distribution was LBTV: 8% (4 of 50), LSTV: 30% (15 of 50), and SV: 62% (31 of 50). When LSTV was compared to SV, there were no statistically significant differences in the percent thoracic (55% vs. 63%) or lumbar (46% vs. 53%) curve correction, coronal balance (left 8.4 mm vs. left 5.6 mm), TTS (left 24.8 mm vs. left 23.6 mm), and LIV-CSVL distance (right 8.4 mm vs. right 12 mm). However, three of the four cases in LBTV demonstrated notable distal adding-on to the curve accompanied by  $>5^\circ$  increase in LIV-DISC angulation.

## Conclusion

Selecting the last "substantially touched" vertebra as the LIV in Lenke 1B curves will achieve similar radiographic outcomes when compared to selecting the stable vertebra as LIV. Selecting the last "barely touched" vertebra will not achieve acceptable results.

## 52. Comparison of Severe and Rigid Scoliosis Treated by Anterior Release and Posterior Fusion with and without Internal Distraction

*Chunguang Zhou, MD, PhD  
China, People's Republic of*

### Summary

The results of patients with severe and rigid scoliosis who were treated by anterior release and posterior fusion with and without internal distraction were compared.



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## Hypothesis

Internal distraction can improve the correction rate of severe and rigid scoliosis

## Design

Retrospective review of prospectively collected data from a single academic center.

## Introduction

Internal Distraction has been applied to treat severe and rigid scoliosis, and satisfactory results were reported. However, there is no report about comparison of severe and rigid scoliosis treated by anterior release and posterior fusion with and without internal distraction

## Methods

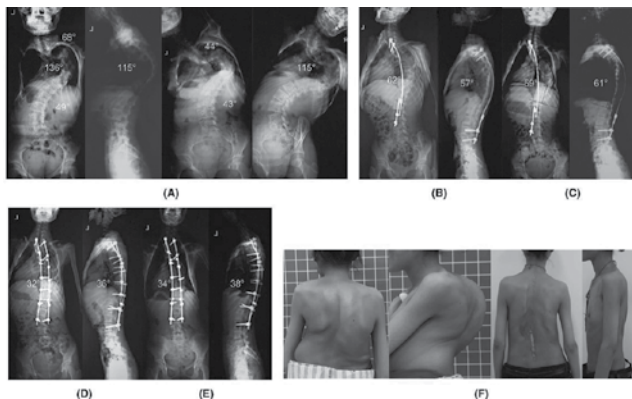
Data of 40 cases with severe and rigid scoliosis who had surgery were retrospectively analyzed. They were divided into two groups according to whether internal distraction was applied: traditional group and internal distraction group. There were 4 males and 16 females in traditional group with an average age of  $17.2 \pm 2.6$ , and 5 males and 15 females in internal distraction group with an average age of  $17.5 \pm 2.8$ . Operation time, estimated blood loss, Cobb angle of major curve, kyphosis angle, coronal trunk shift, and sagittal vertical axis were compared between two groups.

## Results

The follow-up duration averaged  $28.1 \pm 5.7$  months. There was no difference in operation time and estimated blood loss between two groups. There was no difference in preoperative Cobb angle of major curve between two groups, but after surgery and at final follow-up, Cobb angle of major curve in traditional group was much bigger than that of internal distraction group. The correction rate of major curve in internal distraction group averaged 73.7%, which was much better than that of traditional group (49.8%). Before and after surgery and at final follow-up, there was no difference in kyphosis angle, coronal trunk shift, and sagittal vertical axis between two groups.

## Conclusion

Internal distraction improved the correction rate of severe and rigid scoliosis, but not increased operation time, estimated blood loss, and complication rate.



A Preoperative X-ray film. B X-ray film taken after the first distraction. C X-ray film taken after second distraction. D X-ray film taken after posterior spinal fusion. E X-ray film taken 2 years after surgery. F Pre- and postoperative clinical photographs show the marked clinical correction.

## 53. Clinical Outcome of Idiopathic Scoliosis Surgery: Is There a Difference Between Young Adult Patients and Adolescent Patients?

*William Francis Lavelle, MD; Xiaobang Hu, PhD; Swamy Kurra, MD; Isador H. Lieberman, MD, MBA, FRCSC*

*United States*

## Summary

56 consecutive young adult and adolescent patients who underwent surgery for idiopathic scoliosis by two spine surgeons were reviewed. We found that young adult patients tend to have more levels fused, relatively higher peri-operative complication rate and relatively longer hospital stay. They also have lower percentage correction of their main coronal curve and relatively higher rate of additional surgery at mean 21 months follow up.

## Hypothesis

Young adult and adolescent idiopathic scoliosis patients have similar surgical outcome

## Design

Retrospective comparative study

## Introduction

The surgical outcome of adolescent idiopathic scoliosis patients has been well studied. However, few studies have examined the surgical outcome of young adult patients with idiopathic scoliosis.

## Methods

Data were retrospectively reviewed from consecutive young adult (19 - 30 years old) and adolescent (11 - 18 years old) idiopathic scoliosis patients who have undergone correction surgery between 2010 and 2014. Peri-operative and post-operative complications (including additional surgery) were reviewed. Radiographic measurements were obtained.

## Results

There were 27 young adult and 29 adolescent patients. The patients' gender, BMI, and follow up interval were not statistically different. The average pre-operative main coronal curve was  $53^\circ$  in young adult and  $57^\circ$  in adolescent patients ( $p > 0.05$ ). There were more levels fused in young adult patients (10.6 vs 8.9,  $p = 0.02$ ). Intra-operative blood loss was significantly higher in young adult patients (872 ml vs 564 ml,  $p = 0.02$ ). The length of surgery was not different between these two groups (344 min vs 377 min,  $p > 0.05$ ). Two young adult patients (7.4%) and 0 adolescent patients (0%) had peri-operative complications ( $p = 0.14$ ). Young adult patients had relatively longer hospital stay (5.8 vs 4.9 days,  $p = 0.11$ ). At mean 21 months (range 6 - 46 months) follow up, the patients in both groups had significant correction of their main coronal curve ( $21^\circ$  vs  $53^\circ$  in young adult patients,  $p < 0.001$ ;  $19^\circ$  vs  $57^\circ$  in adolescent patients,  $p < 0.001$ ). Young adult patients had lower percentage correction of their curves (61% vs 68%,  $p = 0.03$ ). Three young adult (11.1%) and 0 adolescent patients (0%) had additional surgery ( $p = 0.07$ ).

## Conclusion

Comparing with adolescent patients, young adult patients who underwent idiopathic scoliosis surgery tend to have more levels fused, relatively higher

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peri-operative complication rate and relatively longer hospital stay. They also have lower percentage correction of their main coronal curve and relatively higher rate of additional surgery.

## 54. Fusion Decision-making of Lumbar Curves in Lenke C Modifiers

*Hong Zhang, MD; Daniel J. Sucato, MD, MS; B. Stephens Richards, III, MD; Linfeng Wang, MD*

*United States*

### Summary

The decision to proceed with a lumbar fusion for Lenke 1-4C and 6C can be difficult. One hundred and nineteen AIS patients with C-modifier curves were identified and reviewed. We demonstrated that the distance (lumbar-gap, LG) between the center sacral vertical line and the concave margin of the apical vertebra of the lumbar curve is important for this process. Fusion of the lumbar curve is almost a certainty when the LG is >20mm and never fused with a LG<10mm.

### Hypothesis

The distance (lumbar gap, LG) between the center sacral vertical line (CSVL) and the concave margin of the apical vertebra of the lumbar curve is an important criteria for the decision to proceed with a lumbar fusion in Lenke C-modifier curves.

### Design

A retrospective study was to determine which Lenke C-modifier curves require fusion of the lumbar curve.

### Introduction

In surgical AIS patients whose deformities include lumbar curves, the decision to include the lumbar curve in the fusion remains controversial.

### Methods

One hundred and nineteen AIS patients with Lenke 1-4C and 6C curves were identified from a single institution. All cases were divided into 4 groups based on the LG: LG≤10mm (n=38); LG=11-15mm (n=23); LG=16-20mm (n=17); and LG ≥21mm (n=41). Two experienced scoliosis surgeons reviewed these patients' preop PA, lateral and bending radiographs and clinical photographs. The surgeons were then asked to determine whether the lumbar curve for each patient should be included in the fusion. The surgeons were not provided any of the LG information noted above. The surgeons' preop decision-making was then compared to the actual postop fusion levels performed within each of the 4 groups. The radiographic outcomes of a minimum 2 years follow-up were reviewed in each group.

### Results

The mean patient age was 13.4 years old. The decisions of each surgeon to include the lumbar curve in the fusion were as follows: 0% and 7% in LG≤10mm; 22% and 30% in LG=11-15mm; 47% and 29% in LG=16-20mm; 90% and 93% in LG ≥21mm (p<0.0001). The actual incidence of lumbar fusion was 2%, 52%, 77%, and 100% in each of the groups respectively (p<0.0001). Postop follow-up averaged 31.9 months (24-123 months). For the cases in which the lumbar curve was not fused, the thoracic curve

correction and the lumbar spontaneous correction rates were 50% and 42% in LG≤10mm, 41% and 33% in LG=11-15mm, and 48% and 40% in LG=16-20mm respectively.

### Conclusion

With a LG>20 mm, fusion of the lumbar curve is almost a certainty. When <10 mm, the lumbar curve is almost never fused. The decision to proceed with a lumbar fusion in the patients with the LG between 11 and 20 mm remains dependent on additional clinical factors and radiographic interpretation.

## 55. LEAN Process Mapping to Improve the Value of Spinal Fusion for Idiopathic Scoliosis

*Matthew E. Oetgen, MD; Benjamin D. Martin, MD; Shannon M. Kelly, MD; Sophie Pestieau, MD; Karen Thomson, MD*

*United States*

### Summary

In an attempt to improve the value of posterior spinal fusion (PSF), a LEAN process mapping was undertaken to develop a standardized care pathway. Using this LEAN process mapping process we successfully developed a care pathway demonstrating increased value of care for PSF in AIS, showing decrease use of ICU, decreased need for transfusion, improved pain scores, and decreased overall hospital charges.

### Hypothesis

The value of PSF for AIS can be improved by developing a standardized care pathway using a LEAN process mapping analysis.

### Design

Cohort Study

### Introduction

AIS has been shown to be among the 5 most expensive pediatric conditions in the US. This condition will be subject to scrutiny in the future as value-based payment becomes ubiquitous. Value in medicine is defined as quality of care divided by cost of care over time. To improve the value of PSF a LEAN process mapping was used to develop a standardized care pathway.

### Methods

From 10/15 - 03/16 a LEAN process mapping analysis was completed producing a standardized care pathway for patients undergoing PSF for AIS. Representatives from all departments interacting with patients met to develop a process map and identify areas of care variation. Working groups addressed the pre, intra, post-op, and post-discharge time points, and a standardized pathway was developed according to evidence-based literature or consensus opinion where definitive literature was absent. The new pathway was instituted in 03/2015. Variables of care, quality, and cost were compared between 2 groups: pre-surgical home (pre-SH) defined as one year prior to implementation and post-surgical home (post-SH) defined as six months post-implementation.

### Results

143 cases were included, 116 in pre-SH group and 27 in post-SH group. Baseline data were similar between groups. Quality comparisons are shown in Table 1. Post-SH group showed a significant decrease in LOS, ICU admission,



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and peri-operative transfusion rate. There was a decrease in post-op opioid use, although only statistically significant on POD 3. Post-SH non-implant hospital charges decreased by 10% ( $p=0.003$ ) and total hospital charges decreased by 9% ( $p=0.006$ ).

## Conclusion

A LEAN process mapping analysis is effective at developing a standardized PSF care pathway. Our process resulted in increased value for this procedure with a significant increase in quality (decreased LOS, transfusions, and ICU use) and a decrease in cost of care. Previous studies have decreased LOS with pathways focused on rapid discharge, our process focuses on decreased care variability to improve overall care value.

Variable	Pre-SH	Post SH	p value
Asthma (% of pts)	17.5	14.8	0.77
Obesity (% of pts)	20	7	0.17
Total OR Time (mean, hrs)	6.4	6.3	0.14
Use of ICU (%)	100	37	<0.001
Peri-op Blood Transfusion (% pts receiving)	37.5	11	0.024
Opioid use POD 1 (mean, mg/kg/day)	42.3	38.3	0.93
Opioid use POD 2 (mean, mg/kg/day)	40.8	36	0.52
Opioid use POD 3 (mean, mg/kg/day)	28.8	11.9	<0.001
Length of Stay (days)	5.2	3.6	<0.001

Table 1

## 56. The Change of Cervical Spine Alignment Along with Aging in Asymptomatic Population

Chen Yiwei; Zhong Junlong; Zhimin Pan, MD; Zhou Song, PhD; Chen Jiangwei, PhD; Kai Cao, MD, PhD

China, People's Republic of

### Summary

Asymptomatic population in four groups according to different age were accessed the change of cervical spine alignment. Linear regression indicated that thoracic inlet angle (TIA) and neck tilt (NT) were positively correlated with aging.

### Hypothesis

Cervical spine alignment changes along with aging in asymptomatic population.

### Design

A cross-sectional study.

### Introduction

Previous studies demonstrated the influence of lumbar and thoracic spine on cervical spine alignment, but few has reported the cervical spine alignment change along with aging in asymptomatic population.

### Methods

Asymptomatic population were divided into four groups according to different age (Group A:  $\leq 20$  years; Group B: 21-40 years; Group C: 41-60 years; Group D:  $\geq 61$  years). Each group was composed of 25 subjects. The following parameters were measured: C0-1 Cobb angle, C1-2 Cobb angle, C2-7 Cobb angle, C1-7 SVA, C2-7 SVA, center of gravity-C7 SVA (CG-C7 SVA), TIA, NT, cervical tilt, cranial tilt, T1 slope (TS), TS-CL. ANOVA statistical method was used to analyze the differences among four groups, then linear regression analysis was performed to analyze correlation of the cervical spine alignment with the aging.

## Results

C1-7 SVA, C2-7 SVA, CG-C7 SVA, TIA, NT and cranial tilt were found statistically different among four groups ( $P<0.01$ ). From Group A to Group D, the mean C1-7 SVA were 30.7mm, 26.0mm, 21.8mm and 36.9mm, the mean C2-7 SVA were 18.7mm, 14.7mm, 11.9mm and 24.7mm, the mean CG-C7 SVA were 19.6mm, 16.6mm, 9.4mm and 26.7mm. The mean TIA were 66.8°, 69.4°, 67.4° and 76.9°, the mean NT were 39.4°, 43.8°, 44.2° and 48.2°, the mean cranial tilt were 5.7°, 4.8°, 3.2° and 9.5°. Further linear regression indicated that TIA ( $r=0.319$ ;  $P<0.01$ ) and NT ( $r=0.279$ ;  $P<0.01$ ) were positively correlated with aging (Fig.1).

## Conclusion

TIA and NT increase along with aging in asymptomatic population.

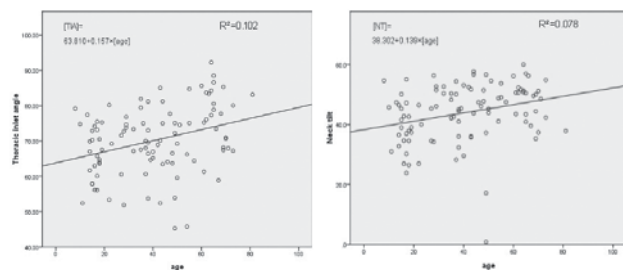


Fig.1 The correlation of TIA and NT with aging

## 57. Can Surgery for Adolescent Idiopathic Scoliosis be an Allogeneic Blood Transfusion Free Event?

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### Summary

Allogeneic transfusions in AIS surgery are associated with increased risk and cost. The need for transfusion in AIS surgery has been correlated with prolonged surgical time and intraoperative blood loss. The development of an experienced comprehensive spine team along with the use of time saving and blood sparing technologies has allowed us to eliminate the need for allogeneic transfusions after AIS surgery.

### Hypothesis

Development of an experienced and efficient spine team will decrease the need for allogeneic transfusion for AIS surgery.

### Design

Retrospective database review of 486 consecutive AIS patients (Level II).

### Introduction

Allogeneic transfusion rates during or after AIS surgery are reported to range from 0-55%. Transfusions are associated with significant risk and cost. Transfusions may be related to surgical time, surgeon experience, reduction technique, imaging methods, anesthesia, pharmacologic intervention, and technologies to reduce intra-op blood loss. The aim of this study was to look at a single institution 10-year surgical experience with a dedicated spine team in treating AIS to identify factors that may eliminate the need for allogeneic transfusions.



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## Methods

This is an IRB approved review of a single surgeon (JTS) surgical experience over a 10-year period treating AIS using the Intermountain Data Warehouse.

## Results

486 AIS surgical cases were reviewed between 2006-2015. In 2006, we established a dedicated spine team for all cases. Over the study period, operative times steady declined from 192 minutes to 152 min. Total intravenous anesthesia, somatosensory evoked potentials, and trans-cranial motor evoked potentials were utilized in all cases. Surgical technique included reduced density screw constructs (0.75/level). No systemic anti-fibrinolytic agents were given, but topical gel-foam/thrombin was used. Fluoroscopy with free hand pedicle screw placement technique was used. Following the introduction in 2008 of a dynamic pedicle finder and irrigated bi-polar cautery, we observed a reduction in intraoperative blood loss and since then, no allogeneic blood products have been given for AIS surgery. Surgical costs have remained flat.

## Conclusion

Allogeneic blood transfusion in AIS surgery has been associated with operative times >6 hours and blood volume loss >30%. The use of an experienced dedicated spine team including anesthesia, surgical technicians, nurses, imaging, neuro-monitoring, along with time saving and blood sparing technologies can shorten surgical time and reduce blood loss eliminating the need for allogeneic blood for most AIS surgery.

## 58. Thromboembolic Disease in Adult Spinal Deformity Surgery: Incidence and Risk Factors in 737 Patients

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## Summary

The overall incidence of thromboembolic disease (VTE) in patients (pts) undergoing adult spinal deformity (ASD) surgery was 4.3% [Deep Vein Thrombosis (DVT) 1.9% and Pulmonary Embolus (PE) 2.4%]. Pts with VTE had a significantly higher rate of mortality (6.3% vs. 0.7%) and a longer length of stay (10d vs. 7d). Osteoporosis, a lack of physical labor pre-operatively and an anterior/posterior surgical approach were independent predictors of VTE. These findings suggest future studies are necessary for developing effective VTE prevention.

## Hypothesis

Define the incidence of and risk factors for VTE in ASD surgery

## Design

Retrospective Matched Cohort Study

## Introduction

The incidence and risk factors for VTE have not been clearly defined in pts undergoing ASD surgery.

## Methods

ASD pts with VTE [DVT and/or PE] were identified in a prospective, multicenter database. Complications, revision and mortality rate were examined. Patient demographics, operative details, radiographic and clinical outcomes were compared and risk factors were identified. Multivariate binary regression model was used to identify predictors of VTE.

## Results

The incidence of VTE was 4.3% (32/737; DVT 14, 1.9%; PE 18, 2.4%). Compared to pts w/o VTE (n=705), VTE pts were of similar age, BMI, Charlson comorbidity index, ASA scores and %age of smokers. VTE commonly occurred with excessive blood loss >4L (50%), and infection cases 28%. Pts with VTE had greater sagittal deformity based on the SRS-Schwab SVA modifier (95 vs 55 mm, p<0.01) and underwent larger SVA corrections. VTE had a lower baseline SF36-PCS (27 vs 31), more pts not performing physical labor at baseline (40 vs 20%), osteoporosis (29% vs 15%) and liver disease (6.5% vs 1.4%), [all p<0.05]. No differences were noted in OR time, blood loss and frequency of antifibrinolytic use [VTE 48.4% (50%TXA, 50% Amicar) vs 51.6%], however, VTE was associated with a combined anterior/posterior approach (45 vs 25%) and longer length of stay (10 vs 7d), [all p<0.05]. Peri-operative complications (89.7 vs 33%), revision rates (25 vs 8%) and mortality (6.3% vs 0.7%) were significantly higher in VTE [all p<0.05]. In our multivariate analysis, osteoporosis (OR 2.68), lack of physical labor at baseline (OR 3.0) and combined surgical approach (OR 2.17) were independent predictors of VTE (r<sup>2</sup>=0.11, AUC: 0.74, p<0.05).

## Conclusion

The incidence of VTE in ASD is 4.3% with a DVT rate of 1.9% and rate of PE of 2.4%. Osteoporosis, a lack of physical labor pre-operatively and an anterior/posterior surgical approach were independent predictors of VTE. Pts with VTE had a higher mortality rate compared to non-VTE patients.

## 59. Early Postoperative Surgical Site Infections in the Scoli-Risk 1 Cohort of Complex Spinal Deformity Patients Still Allowed For Improved Health Related Quality of Life Outcomes at 2 Year Follow-Up

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*United States*

## Summary

The aim of our study was to investigate the incidence and impact of early postoperative surgical site infection on 2-year patient reported outcomes after surgical treatment for adult spinal deformity. We found an infection rate of 5.9% in the first 6 months after surgery. Further, occurrence of infection had no detrimental impact on 2-year health-related quality of life outcomes in adult spinal deformity patients.





# PAPER ABSTRACTS

## Hypothesis

Patients with surgical site infection (SSI) have significantly worse 2-year health related quality of life outcomes compared to patients without infection (no-SSI).

## Design

Sub-analysis of a prospective cohort

## Introduction

The aim was to investigate the incidence and impact of early postoperative SSI on 2-year patient reported outcomes after surgical treatment for adult spinal deformity (ASD).

## Methods

272 patients who underwent surgical treatment of severe ASD were identified from the AOSpine-SRS ScolioRisk-1 prospective study database. Early postoperative SSI was defined as having a SSI within the first 6 months after surgery. Patients presenting with a SSI after the first 6 months (n=3) were excluded from the analysis. Health-related quality of life outcomes comparing SSI to no-SSI groups were performed at baseline and at 2-year follow-up.

## Results

16 of 269 (5.9%) patients developed early postoperative SSI. There was a significant difference between SSI and no-SSI groups with respect to age at surgery (62.6 vs. 56.6 years,  $P=0.026$ ). There were no significant differences for female gender (25.0% vs. 32.4%,  $P=0.538$ ), race ( $P=1.000$ ), and history of smoking (18.8% vs. 9.2%,  $P=0.195$ ). There were no significant differences between the SSI and the no-SSI groups in the SF-36 physical component summary (PCS) ( $P=0.160$ ,  $P=0.161$ ), SF-36 mental component summary (MCS) ( $P=0.645$ ,  $P=0.077$ ), and the SRS-22r total scores ( $P=0.428$ ,  $P=0.176$ ) at baseline and at 2-year follow-up, respectively. Further, there was no significant difference between SSI and no-SSI groups in the mean improvement from baseline to the 2-year follow-up in SF-36 PCS (5.9 vs. 6.2,  $P=0.901$ ), SF-36 MCS (4.1 vs. 4.3,  $P=0.969$ ), or the SRS-22r total score (0.8 vs. 0.8,  $P=0.895$ ).

## Conclusion

The rate of early postoperative SSI after surgical treatment of patients with severe ASD is 5.9%. Based on the results, it appears that the occurrence of infection may not have a detrimental impact on 2-year health-related quality of life outcomes in ASD patients. However, future studies with larger infection cohorts are needed.

## 60. Consumptive and Dilutional Coagulopathies: The Next Treatable Bleeding Disorder in Scoliosis Patients?

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## Summary

In addition to hyperfibrinolysis, massive blood loss in PSF is also associated with a coagulopathy linked to hemodilution and/or consumption of coagulation factors. As antifibrinolytics have decreased the need for blood transfusion,

protocols designed to manage hemodilution and/or coagulation factor loss may also reduce blood loss and need for allogeneic transfusion in patients undergoing PSF.

## Hypothesis

A hemodilutional or consumptive coagulopathy associates with allogeneic blood transfusion following posterior spinal fusion (PSF) for scoliosis.

## Design

IRB-approved, single institution, retrospective review of prospectively collected data on children undergoing PSF for scoliosis of any etiology.

## Introduction

Antifibrinolytics in PSF have reduced blood loss and transfusion by 50%. However, children undergoing PSF continue to experience large blood volume loss and can still require blood transfusion. In addition to hyperfibrinolysis, massive blood loss is associated with a coagulopathy caused by a consumption (loss of coagulation factors) or dilution from administration of IV fluids. The purpose of this study was to determine if patients undergoing PSF developed a consumptive or dilutional coagulopathy.

## Methods

Demographic and operative data was collected, and hematologic laboratory data was gathered pre-, intra-, and post-operatively on children undergoing PSF >6 levels (n=103). The total volume (mL) of non-blood product (colloid+crystalloid) and blood (autologous+allogeneic) given to each child during and after surgery was collected and normalized to weight (kg). Overall transfusion rate and factors associated with the need for allogeneic blood transfusion were determined. All patients received antifibrinolytics.

## Results

45% (46/103) of patients received allogeneic blood during their hospital course. Neuromuscular scoliosis had the highest rate of allogeneic blood transfusion [72%, 18/26]. The following factors were significantly associated with the total volume of blood transfused per kg: neuromuscular etiology ( $p<0.02$ ); administration of either non-blood products ( $p<0.002$ ) or plasma ( $p<0.001$ ); intra-operative fibrinogen loss ( $p<0.007$ ); intra-operative prothrombin time (PT,  $p<0.02$ ).

## Conclusion

Rates of blood transfusion during PSF for scoliosis associate with hemodilution (crystalloid+colloid administered) and consumption of coagulation factors (fibrinogen loss+elevated PT). These data suggest that protocols designed to manage hemodilution and/or coagulation factor loss may potentially reduce blood loss and need for blood transfusion in patients undergoing PSF.

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## 61. The Effect of Vancomycin Powder on the Rates of Infection and Pseudarthrosis in Lumbar Spine Surgery: A Retrospective Analysis of 453 Patients

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### Summary

Vancomycin powder is effective in reducing surgical site infections; however, basic science research suggest it may effect osteoblast function and thus fusion rates. Our retrospective study aims to examine the revision rates due to pseudarthrosis between lumbar fusion patients before and after the use of routine use of vancomycin powder out our institution. The results suggest there is no significance in pseudarthrosis rates with the routine use of vancomycin powder in lumbar fusion surgery.

### Hypothesis

Vancomycin Powder does not effect pseudarthrosis rates in lumbar fusion

### Design

A retrospective chart review including all patients undergoing lumbar fusion with at least 2 years of clinical follow up

### Introduction

Surgical site infection (SSI) represents a major complication in spine surgery. The application of topical vancomycin powder has been shown to effectively reduce SSI's. Recent in vitro studies have suggested that topical application of lyophilized vancomycin has an inhibitory effect on osteoblast proliferation and differentiation that may adversely affect fusion rates. The primary purpose of this study was to examine our institution's overall revision rate for pseudarthrosis before and after the routine use of vancomycin powder in patients undergoing lumbar spinal fusion. Our secondary goal was to determine the infection rate prior to and after the initiation of vancomycin powder into the wound.

### Methods

The pre-vancomycin group (1/2007 - 12/2008) were compared to the vancomycin group (1/1/2012 - 12/31/2013) for development of a SSI requiring debridement, return to OR for revision of the prior surgery and data including number of levels fused, use of bone morphogenetic protein (BMP), and use of inter-body grafts was recorded.

### Results

A total of 232 patients were identified in the pre-vancomycin group with mean followup of 1.5 years and 221 in the vancomycin group with mean followup of 2 years. Overall deep infection rate was 9/232 (3.9%) in the pre-vancomycin group and 4/221 (1.8%) in the vancomycin group. There was a significant difference in the use of interbody grafts ( $p < 0.001$ ) and BMP use in the pre-vancomycin group ( $p < 0.001$ ). However, no significant difference was noted in the mean levels fused or revision rates due to pseudarthrosis between the two groups.

### Conclusion

The use of topical vancomycin powder did not significantly alter our fusion or revision rates despite significantly less use of inter-body grafts and BMP in our Vancomycin cohort. Further in vivo and in vitro studies are necessary to fully elucidate the role of vancomycin powder in the maturation of a fusion.

	Used Vanco N=221	Didn't use Vanco N=232	P-value	Test used
BMP used, n(%)	53(24.0%)	118(50.9%)	<0.001	Chi-square
DBX used, n(%)	149(67.4%)	71(30.6%)	<0.001	Chi-square
Interbody used, n(%)	52(23.5%)	94(40.5%)	<0.001	Chi-square
Revision, n(%)	84 (38.0%)	85(36.6%)	0.763	Chi-square
Levels fused, median(interquartile range)	3(2-5)	3(2-4)	0.145	Wilcoxon rank-sum
Follow-up Days, median(interquartile range)	557(271-789)	741(316-1629)	<0.001	Wilcoxon rank-sum
Age, mean(std)	63(15)	56(19)	<0.001	T test
Revision rate	8(3.6%)	11(4.7%)	0.552	Chi-square
Deep infection rate	4(1.8%)	9(3.9%)	0.187	Chi-square

Pre-Vancomycin vs Vancomycin

## 62. Nasal Swab Screening for Staphylococcus aureus in Spinal Deformity Patients Treated with Growing Rods

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### Summary

The use of Staphylococcus aureus (SA) nasal swab screening in GR patients identified 9 patients (26.5% of cohort) in whom the prophylactic antibiotics could be altered to permit appropriate SA coverage.

### Hypothesis

The use of pre-operative screening for Staphylococcus aureus (SA) for all growing spine procedures would permit alteration of prophylactic antibiotics to cover the identified resistances.

### Design

a retrospective review.

### Introduction

Surgical site infections (SSI) are one of the most concerning complications in patients treated with growing rods (GR).

### Methods

All patients were identified who had SA screening during the course of GR treatment. 34 patients (23 neuromuscular (NMS), 4 congenital, 4 idiopathic scoliosis (IS), and 3 syndromic) were identified who had 111 preoperative screenings (79 lengthenings, 23 insertions, 6 revisions, and 3 conversions to posterior spinal fusions (PSF)). Mean age at GR insertion was 5.5 years (2 to 11 years).

### Results

There were 11 methicillin-resistant Staphylococcus aureus (MRSA) "+" screenings in 6 patients (5NMS, 1 IS): 3 in 3 patients prior to GR insertion and 8 in 3 patients (all 3 were negative at GR insertion screening) at subsequent



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surgeries. Antibiotic sensitivities are listed below. There were 23 methicillin-sensitive *Staphylococcus aureus* (MSSA) "+" screenings in 12 patients (7 NMS, 2 congenital, 2 IS, 1 syndromic): 2 in 2 patients prior to GR insertion and 21 in 10 patients at subsequent surgeries (18 lengthenings, 3 revisions). Overall, 13 patients (3 MRSA +10 MSSA) were initially negative but screened positive for the first time at a subsequent surgery (12 lengthenings, 1 GR to PSF). All patients (n=5) with positive screenings prior to GR insertion were in patients with NMS (3 MRSA, 2 MSSA). Based on sensitivities, 9 patients demonstrated SA resistance to cefazolin (8 MRSA and 1 MSSA) and 6 to clindamycin (5 MRSA and 1 MSSA). Hence, if cefazolin was routinely used for all patients 26.5% of patients (9/34) would have been inadequately covered at some point during their GR treatment; Clindamycin, 17.7% (6/34).

## Conclusion

The use of SA nasal swab screening in GR patients identified 9 patients (26.5%) whose prophylactic antibiotics (cefazolin to clindamycin or vancomycin) could be altered to permit appropriate SA coverage.

	Resistant to cefazolin	Resistant to clindamycin	Resistant to vancomycin
MRSA (9/11 patients)	8/9 (89%)	5/9 (56%)	0/9 (0%)
MSSA (23/23 patients)	1/23 (4%)	1/23 (4%)	0/23 (0%)

## 63. Examining the Anti-Biofilm and Osteoconductive Properties of a PEEK-Silver Zeolite Composite in Spine

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### Summary

Polyether ether ketone (PEEK), a common spine biomaterial demonstrates intrinsic inertness and hydrophobic properties, thereby resulting in an inherent susceptibility to bacterial infections and reduced fusion capacity within the intervertebral space due to fibrous encapsulation. PEEK-Silver Zeolite is a polymer-ceramic composite that has received CE approval, and is known to have infection resistive and osteoblast stimulative effects due to silver ions and ceramic zeolite particles respectively

### Hypothesis

PEEK-Silver Zeolite composite possesses antibiofilm and osteoconductive effects due to silver ions and ceramic zeolite particles respectively.

### Design

Flow Cell Biofilm Bioreactor Assay (Modified ASTM E2647). *S.aureus* (ATCC 6538) biofilm quantification was done using a Flow cell Bioreactor Model under low shear and continuous flow conditions.

Critical Sized Rabbit femoral Defect Model:

A critical sized rabbit femoral defect model was utilized to evaluate in vivo osteoconductive properties of PEEK-Silver Zeolite (Group A) and PEEK-Zeolite (Group B) implants in comparison to PEEK (Group C) at 12 weeks.

## Introduction

PEEK's poor osteointegration and inherent susceptibility to infections led to the development of a novel PEEK composite with attractive material properties that overcome both these shortcomings.

## Methods

Flow Cell Biofilm Bioreactor Assay:

Growth conditions as detailed in ASTM E2647 at 37°C were used to grow an initial inoculum dosage of  $1.5 \times 10^4$  cfu's onto PEEK Silver Zeolite coupons (dia=12.5mm) after 48 hrs. The quantification of biofilm/cm<sup>2</sup> was done via colony count technique.

Invivo critical sized rabbit femoral defect model:

Each animal had one dumbbell shaped implant in each leg and no animal had two of the same group. A single unicortical hole (4.5mm diameter X 6mm deep) was created into the lateral distal femoral metaphysis. Upon explantation, all implants were imaged using micro-CT and un-decalcified histology (H&E and Goldner's Tri-Chrome staining) for new bone formation

## Results

Flow Cell Biofilm Bioreactor Assay (Modified ASTM E2647):

After 48 hrs, PEEK-Silver Zeolite was found to be an active anti-biofilm surface while PEEK was susceptible to colonization.

Invivo critical sized rabbit femoral defect model:

Micro CT images demonstrated increased bone growth in test groups relative to PEEK controls-which showed little to no sign of osseointegration at the bone-implant interface. Final results will also include histology and histomorphometric data on bone growth at the bone-implant surface.

## Conclusion

PEEK-Silver Zeolite demonstrates enhanced osteoconduction and anti-biofilm activity relative to PEEK; thereby allowing for a novel orthopedic biomaterial with improved characteristics.

## 64. Medical Complications in 3,519 Surgically Treated Elderly Patients with Adult Spinal Deformity: Comparison of Multicenter Surgeon Maintained vs. Medicare Claims Database

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### Summary

The aim of our study was to report the incidence of major medical complications in elderly patients with adult spinal deformity (ASD). A secondarily goal was to compare the rates reported by a prospective multicenter surgeon-maintained database vs. the Medicare claims database. We found that surgeon maintained databases reported similar complication rates as the Medicare claims database for most major medical complications.

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Multicenter surgeon-maintained databases provide substantially greater granularity regarding deformity characteristics and surgical details.

### Hypothesis

The rate of major complications vary significantly between multicenter surgeon-maintained versus payor-reported claims database

### Design

Retrospective

### Introduction

The aim of our study was to report the incidence of major medical complications in elderly patients with adult spinal deformity (ASD) over 2-year follow-up after surgery. A secondary goal was to compare the rates reported by a multicenter surgeon-maintained database (SMD) vs. the Medicare claims database (MCC).

### Methods

The SMD database was queried to identify surgically treated ASD patients  $\geq 65$  years eligible for 2-year follow-up (N=153) from 2008-2015. Validated commercially available software was used to query MCC data using appropriate ICD-9 codes for ASD patients  $\geq 65$  years who underwent  $>8$  level fusion (N=3,366) from 2005-2012. Cumulative rates of major medical complications in 2-year after surgery were identified. Bonferroni correction was used to set significance at  $P < 0.006$ .

### Results

The SMD provided significantly greater granularity with respect to deformity characteristics and surgical details (levels fused, osteotomies), while the MCC was limited to corresponding ICD-9 code descriptions. At 2-year follow-up, there were no significant differences between the MCC vs. the SMD databases with respect to the reported cumulative rates of: MI (3.1% vs. 2.0%,  $P=0.44$ ), CHF (2.3% vs. 1.3%,  $P=0.41$ ), cardiac arrest (1.5% vs. 0%,  $P=0.13$ ), DVT (7.7% vs. 2.6%,  $P=0.02$ ), or PE (4.7% vs. 2.0%,  $P=0.12$ ). The reported rates of pneumonia (11.3% vs. 2.0%,  $P < 0.001$ ), stroke (6.1% vs. 0%,  $P=0.005$ ), and acute renal failure (11.5% vs. 1.3%,  $P < 0.001$ ) were significantly higher in the MCC database. There was no significant difference in the 2-year mortality rates between MCC vs. SMD (1.7% vs. 3.3%,  $P=0.16$ ).

### Conclusion

The surgeon-maintained database reports similar complication rates as the Medicare claims database for most major medical complications. Medicare claims database lacks the granularity regarding deformity characteristics and surgical details, which are needed for risk factor identification.

## 65. Morbidity of Adult Spinal Deformity Surgery in Elderly Has Declined Over Time

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### Summary

Scoliosis incidence rises with increasing age, however intervention for elderly patients remains variable. In a cohort of 19,659 ASD patients from 2003-2012, surgical incidence in elderly ( $>75$  years) patients increased over 50%. Concurrently, surgical complexity increased while complication rates decreased. An age threshold could not be established because types of surgeries changed after age 70.

### Hypothesis

There is an age threshold in adult spinal deformity (ASD) at which surgical risk becomes heightened.

### Design

Retrospective review.

### Introduction

ASD prevalence increases in elderly populations, with age previously demonstrated as an independent risk factor for developing surgical complications. However, fusion of the lumbar spine is frequently avoided in older patients for fear of increased complication rates.

### Methods

Inclusion criteria: age  $>40$ , primary diagnosis ASD. Inclusion in complication estimates: fusion or decompression performed. Surgical incidence (by invasiveness: levels fused/decompressed/interbody, osteotomies, and revision) and complications were measured using ANOVA t-tests and trend analysis (1) as trends on elderly (ages 75+) years 2003-12 and (2) between age categories (40-54, 55-59, 60-64; 80-84, 85+) to establish an age threshold (all years aggregate).

### Results

In analyzing trends on elderly patients, surgical invasiveness increased significantly from 2.2 in 2003 to 9.3 in 2012 ( $p < 0.001$ ), CCI increased from 0.77 to 1.44 ( $p < 0.001$ ), and surgical correction (fusion or decompression) rates increased from 56.3% to 88.8% ( $p < 0.001$ ). Over the same interval, elderly patients undergoing fusion or decompression displayed overall reduction in complications (excluding anemia) - from 26.7% to 8.6% ( $p < 0.001$ ). Specifically, surgical complication decreased from 11.7% to 0.7% ( $p < 0.001$ ) and respiratory complications decreased from 6.7% to 1.4% ( $p = 0.004$ ). When all aged patients were included for threshold determination, surgical invasiveness score began decreasing in the 65-69 cohort (table 1). Complication rates did not change after age 55 ( $p = 0.777$ ).

### Conclusion

Despite increased utilization of operation in ASD on the elderly population, and more advanced surgeries being performed, morbidity of ASD corrective surgery has diminished in this population.





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	40-54	55-59	60-64	65-69	70-74	75-79	80-84	85+	Overall	P-val (linear)
Number patients	7383	2120	2374	2540	2172	1721	848	411	19569	
CCI	0.813	1.05	1.17	1.25	1.31	1.24	1.21	1.10	1.05	<0.001
Invasiveness score	10.4	10.4	10.3	10.4	10.0	9.1	7.0	3.2	9.9	0.001
Operative treatment (%)	94.3	95.1	95.4	94.6	94.2	89.5	73.6	38.2	92.0	<0.001
Avg. levels fused	5.3	4.8	4.7	4.7	4.7	4.5	4.3	4.1	4.9	<0.001
Avg. levels decompressed	0.48	0.71	0.69	0.70	0.69	0.63	0.50	0.31	0.60	<0.001
Three CO (%)	3.0	3.8	3.2	3.3	2.7	2.5	1.3	0.5	2.9	<0.001

Table 1. Surgical invasiveness by age categories.

## 66. Impact of New Motor Deficit on Early HRQOL After Adult Spinal Deformity Surgery: Subanalysis of 272 Patients from Scolio Risk 1 Prospective Study

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### Summary

An ambispective, multi-center observational study (Scolio-Risk-1) was completed to determine the impact of neural injury on Health-related Quality of Life scores (HRQOLs). 31.9% of patients suffered any ASIA lower extremity motor score (LEMS) worsening during the first 2 years after surgery. Within 3 subcategories of LEMS change ( $\geq 2$  points worsening, 1 pt worsening to no change, or LEMS improvement), ODI, SRS, SF-36 mental, and SF-36 physical scores worsened with LEMS worsening at 6 weeks, 6 months, and 2 years.

### Hypothesis

After correction of adult spinal deformity, new motor deficits (defined by LEMS worsening) will lead to worsened HRQOL scores.

### Design

International, multi-center, ambispective, longitudinal observational cohort

### Introduction

The Scolio Risk 1 study defined the risk of new LEMS worsening in correction of severe spinal deformities at 30.6% within the first 6 months. The purpose of this analysis is to define the impact of new LEMS deficit on HRQOL metrics and recovery of those measures after surgery in the first 2 years.

### Methods

Patients aged 18 or above with a diagnosis of adult spinal deformity were eligible for enrollment at 15 sites worldwide. Other inclusion criteria included major Cobb  $>80$  degrees, C7-L2 curve apex, and any patient undergoing 3 column osteotomy. ASIA scores and standard HRQOL scores were recorded pre-op, 6 weeks and 6 months, and 2 years.

### Results

272 complex adult spinal deformity (ASD) patients enrolled, with 183 female (67%) and 89 male (33%) patients. Mean age was 56.9 years (SD 15.3). 30.6% of patients suffered a worsening of LEMS within the first 6 months

post-surgery. HRQOL scores worsened as LEMS worsened. Compared to pre-op baseline, HRQOL changes at 6 wks to 2 yrs for motor-worse pts were: ODI (+12.4 at 6 wks to -4.7 at 2 yrs), SF-36 physical (-4.5 to +2.3), SRS-22 (0 to +0.4). HRQOL changes for motor-neutral pts were: ODI (+0.6 to -12.1), SF-36 physical (-1.6 to +5.9), and SRS-22 (+0.4 to +0.7). For motor-improved pts, HRQOL changes were: ODI (-0. to -16.3), SF-36 physical (+1.0 to +7.0), SRS-22 (0.5 to 0.9). Table 1 shows complete HRQOL change data.

### Conclusion

In the subgroup of patients who developed a new lower extremity motor deficit after adult spinal deformity surgery, total HRQOLs and HRQOL changes were negatively impacted. Patients with 2 or more points of LEMS worsening had the worst HRQOL changes. However, even these patients showed overall improvement in ODI,

SF-36 physical and SRS total scores at 6 months and 2 years compared to pre-op baseline.

Severity of motor deficit versus change in HRQOL

			Change in LEM Score from baseline		
			Decrease of $\geq 2$ pt in LEMS	No significant change in LEMS (decrease of 2-0)	Increase in LEMS
Oswestry disability index change from baseline	6 weeks	n	25	175	39
		Mean (sd)	12.4 (17.5)	0.6 (20.0)	-0.6 (19.6)
	6 months	n	11	177	49
		Mean (sd)	-7.3 (14.3)	-9.5 (18.5)	-13.7 (16.6)
	24 months	n	9	157	33
		Mean (sd)	-4.7 (19.7)	-12.1 (16.5)	-16.3 (18.7)
SF-36 Physical Component Summary Score change from baseline	6 weeks	n	22	165	39
		Mean (sd)	-4.5 (9.1)	-1.6 (11.0)	1.0 (8.9)
	6 months	n	8	174	49
		Mean (sd)	0.8 (7.4)	2.7 (9.6)	6.1 (7.5)
	24 months	n	8	148	34
		Mean (sd)	2.3 (8.9)	5.9 (10.4)	7.0 (9.2)
SF-36 Mental Component Summary Score change from baseline	6 weeks	n	22	165	39
		Mean (sd)	-1.7 (13.7)	1.7 (13.3)	0.6 (12.6)
	6 months	n	8	174	49
		Mean (sd)	-1.9 (16.5)	3.9 (13.3)	5.7 (13.0)
	24 months	n	8	148	34
		Mean (sd)	-1.5 (12.8)	3.1 (11.5)	7.6 (12.0)
SRS-22r change from baseline	6 weeks	n	19	154	35
		Mean (sd)	-0.0 (0.5)	0.4 (0.6)	0.5 (0.6)
	6 months	n	7	157	43
		Mean (sd)	0.3 (0.7)	0.7 (0.7)	0.8 (0.6)
	24 months	n	8	136	29
		Mean (sd)	0.4 (0.6)	0.7 (0.6)	0.9 (0.6)

## 67. Osteoporosis Increases Radiographic Failure After Transforaminal Lumbar Interbody Fusion

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United States

### Summary

We reviewed patients over 50-years old undergoing instrumented TLIF. Using CT Hounsfield Unit (HU) measurements of the instrumented vertebral body, patients were stratified as either osteoporotic or non-osteoporotic. Twenty-five patients were designated as osteoporotic, versus 103 patients without osteoporosis. We found increased rates of cage subsidence, iatrogenic fracture and overall radiographic complications in osteoporotic patients. However, these radiographic complications did not predispose osteoporotic patients to an increased risk of surgical revision or worse clinical outcomes.

### Hypothesis

Patients with osteoporosis will have inferior clinical outcomes compared to non-osteoporotic patients



# PAPER ABSTRACTS

## Design

Retrospective analysis

## Introduction

Osteoporosis is an important risk factor for suboptimal outcomes following lumbar fusion surgery. We set out to compare clinical outcomes after TLIF in patients with and without osteoporosis.

## Methods

We reviewed patients over 50-years old undergoing instrumented TLIF from July 2004 to June 2014, with minimum six-month post-operative radiographs and computed tomography (CT) scans for evaluation. Using CT Hounsfield Unit (HU) measurements at the instrumented level, patients were stratified as osteoporotic or non-osteoporotic. Radiographs and CT scans were evaluated for evidence of implant subsidence, migration, interbody fusion, iatrogenic fracture or loosening of posterior pedicle screw fixation. Medical records were reviewed for post-operative symptoms.

## Results

We identified 128 patients, and excluded 40 patients who did not have at least 6 month follow up CT imaging. Twenty-five of patients were designated as osteoporotic based on postoperative CT HU measurements, versus 103 patients without osteoporosis. Overall, 18 osteoporotic patients and 70 non-osteoporotic patients were included in the final data analysis. Patients had a mean 35.8±27.9 month radiographic follow up. We found significantly higher rates of subsidence (72.2% vs 45.7%, p=0.05) and iatrogenic fractures (16.7% vs 1.4%, p=0.03) in the osteoporotic group. In addition, the osteoporotic patients had significantly higher radiographic complication rates compared to non-osteoporotic patients (77.8% vs 48.6%, p=0.03). There was no difference between groups for revision surgery (16.6% vs 14.3%, p>0.05) or post-operative symptoms (44.4% v 50.0%, p>0.05).

## Conclusion

Our study demonstrated significantly increased rates of cage subsidence, iatrogenic fracture and overall radiographic complications in osteoporotic patients. However, these radiographic complications did not predispose osteoporotic patients to an increased risk of surgical revision or worse clinical outcomes. Prospective studies are needed to further evaluate lumbar fusion surgery in the osteoporotic patient.

## 68. Psychological Burden of Spinal Deformity: A Comparative Analysis With Three Disabling Chronic Diseases

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## Summary

The psychological burden of adult spinal deformity (ASD) in relation to other disease states is not fully quantified. This study compares the prevalence of psychological disorders in ASD vs. 3 other chronic diseases using the National Inpatient Sample (NIS). More than 1 in every 3 ASD patients (36.5%) had at least one psychological disorder. This prevalence was higher than patients with lung cancer, diabetes and cardiac diseases.

## Hypothesis

Psychological burden of spinal deformity is higher than other chronic diseases.

## Design

Retrospective review of the National Inpatient Sample (NIS): 2000-2012.

## Introduction

Psychological status is an important factor in the evaluation, treatment and prognosis of disabling chronic conditions. The psychological burden (PB) of adult spinal deformity (ASD) in relation to other disease states remains unclear.

## Methods

ICD-9 coding identified 4 diagnoses: idiopathic, degenerative scoliosis with >4 levels fused (ASD), cardiac disease (CD), diabetes (DM), lung cancer (LC). Based on Diagnostic and Statistical Manual of Mental Disorders (DSM-5), PB was defined as incidence of any of the following disorders: Depressive, Anxiety, Obsessive-Compulsive, Stress, Somatic symptoms, Sexual Dysfunction, Substance Abuse, Delirium, Personality. PB was compared between the diagnoses with sub-analyses in age groups.

## Results

4,194,073 pts: ASD=17,537 (0.4%), CD=2,675,767 (63.8%), DM=1,137,435 (27.1%), LC=363,334 (8.7%). ASD had highest incidence of psychological disorders (ASD=36.5%, LC=33.3%, DM=28.3%, CD=24.3%, p<0.001). The highest prevalence of PB was observed in 55-74 y/o (61.7% of all PB) vs. 25-40 (6.2%) and 75+ (12.2%), p=0.001. The most prevalent disorders in ASD were: depression, substance abuse disorders, sleep disorders, anxiety, and delirium, respectively (Figure). Among other diagnosis, ASD had the highest prevalence of depression, sleep disorders, anxiety disorders, and delirium. However, ASD was third in substance abuse (Figure). Depression, anxiety and sleep disorders were mostly prevalent between 55-75 y/o; however, +75 y/o and 41-54 y/o brackets had the second highest prevalence of patients with delirium (27.9% of all delirium pts) and substance abuse (29.8%), respectively.

## Conclusion

Among 4 debilitating chronic diseases, operative ASD patients displayed the highest psychological burden: more than 1 in every 3 ASD patients (36.5%) had at least one psychological disorder. Proper ASD psychological screening, patient counseling, and appropriate psychological support is recommended as a compliment to ASD treatment.

	N	% of Patients in each diagnosis					
		Depression	Substance Abuse	Sleep Disorders	Anxiety	Delirium	Any
ASD	17,537	16.50%	11.20%	7.50%	7.10%	3.40%	36.50%
Diabetes	1,137,435	10.30%	13.90%	2.50%	2.70%	1.00%	28.30%
Lung Cancer	363,334	7.20%	21.60%	2.30%	4.90%	1.60%	33.30%
Cardiac Disease	2,675,767	7.00%	4.80%	4.80%	3.10%	0.70%	24.30%
P value	-	0.001	0.001	0.001	0.001	0.001	0.001

Prevalence of DSM-5 psychological disorders in 4 diagnosis: adult spinal deformity (ASD), Diabetes, Lung Cancer and Cardiac Disease



# PAPER ABSTRACTS

## 69. Evoked Potentials Monitoring Strategy of Osteotomy and Non-Osteotomy in Spinal Deformity

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### Summary

There has been a long-term application of evoked potentials monitoring strategy in spinal deformity surgeries. Motion evoked potential (MEP), somatosensory evoked potential (SSEP) and descending neurogenic evoked potential (DNEP) were utilized in various strategies in different hospitals. However, there is a lack of systemic researches investigating different modes of combined neurophysiological monitoring applied in spinal deformity surgery, and how to choose effective monitoring mode during correction.

### Hypothesis

simultaneous monitoring of SSEP, MEP and DNEP can effectively reflect the real neural functions.

### Design

A retrospective study design.

### Introduction

To evaluate different modes of combined neurophysiological monitoring applied in spinal deformity surgery, and choose effective monitoring mode during correction.

### Methods

We retrospectively reviewed the cases of 188 consecutive patients who had undergone spinal deformity correction from May 2008 to February 2012. Based on surgery strategy, they were divided into two groups: non-osteotomy (Group A) and osteotomy (Group B). Group A was further divided into 2 sub-groups, A1 (SSEP/MEP, 67 cases) and A2 (SSEP/MEP/DNEP, 52 cases) by different monitoring modes. Group B was further divided into B1 (SSEP/MEP, 27 cases) and B2 (SSEP/MEP/DNEP, 42 cases). The effect of different combined monitoring modes were compared within each group.

### Results

All cases were diagnosed as adolescent idiopathic scoliosis (AIS) in Group A, from which either SSEP/MEP or SSEP/MEP/DNEP were elicited successfully, no neurological complication occurred. There were 16 cases appeared positive for MEP during surgery in B1, among which intra-operative wake-up tests all appeared to be negative and had no neural complications after operation. In B2, there were 5 cases appeared positive for all channel (SSEP/MEP/DNEP), among which wake-up tests and post-op neurological complications were also positive. 8 cases had positive finding in MEP, in which no wake-up tests were performed, but no complications occurred. No neurological complications were observed in cases all three EP were normal. Within Group B, simultaneous monitoring of SSEP/MEP/DNEP was unable to perform in 9 cases. We adopted intra-operative SCEP monitoring in 2 out of 9 cases, and it was proved to be effective.

### Conclusion

Intra-operative simultaneous monitoring of SSEP and MEP can effectively reflect neural functions. In osteotomy cases, simultaneous monitoring of SSEP, MEP and DNEP can effectively avoid unnecessary interference of false alarming of

MEP. As to patients with spinal cord deformity or neurological symptoms, SCEP is an alternative effective means to monitor.

## 70. Concurrent Validity and Responsiveness of PROMIS Health Related Quality of Life Assessment in Patients with Lumbar Degenerative Spine Disease

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### Summary

Health related quality of life is an important component in the value equation for health care. Valid and responsive measures are needed that can compare quality across medical and surgical conditions. The NIH developed and PCORI supported PROMIS health domains offer a potential tool to demonstrate quality of care following surgery.

### Hypothesis

PROMIS health domains are valid measures of quality of life and responsive to change with surgery.

### Design

Prospective, single center

### Introduction

Health related quality of life is an important component in the value equation for health care. Valid and responsive measures are needed that can compare quality across health conditions.

### Methods

Concurrent validity was demonstrated using correlation of PROMIS health domains with legacy measures before surgery. Responsiveness to surgery was determined using the methods of Coyne, et al. (Qual Life Res, 2005).

### Results

PROMIS health domains had good concurrent validity (Table 1): pain correlated strongly with interference (.59), ODI (.63), and MCS (-.54) and moderately with back (.37) and leg (.38) pain, PCS (.32), GAD (.41), and PHQ (.49); physical function correlated strongly with ODI (-.71) and moderately with interference (-.49), MCS (.39), and GAD (-.37); fatigue correlated strongly with interference (.55), ODI (.58), MCS (-.55), GAD (.50), and PHQ (.67) and moderately with back (.39) and leg (.37) pain, and PCS (.36); anxiety correlated strongly with MCS (-.60), GAD (.69), and PHQ (.63) and moderately with interference (.41), ODI (.43), and PCS (.49); depression correlated strongly with PCS (.50), MCS (-.63), GAD (.62), and PHQ (.68) and moderately with interference (.45) and ODI (.47); sleep disturbance correlated strongly with ODI (.53), GAD (.53), and PHQ (.58) and moderately with back (.31) pain, interference (.43) and MCS (-.38); and satisfaction with social roles correlated strongly with ODI (-.58) and moderately with interference (-.46), MCS (.46), GAD (-.34), and PHQ (-.44).

PROMIS health domains demonstrated large responsiveness for physical function (1.19), fatigue (.91), and satisfaction with social roles (1.03); moderate for pain (-.69), anxiety (-.62), and sleep disturbance (-.73); and small responsiveness for depression (-.30).

# PAPER ABSTRACTS

## Conclusion

PROMIS health domains are in this population and responsive to reductions in symptoms and improvements in quality of life after surgery.

## 71. Impact of Obesity on Complications and Outcomes: A Comparison of Fusion and Non-Fusion Spine Surgery

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## Summary

Equivalent clinical outcomes were seen among obese and non-obese patients treated for lumbar spinal stenosis with either decompression alone or decompression and fusion. There may be a higher blood product requirement in obese patients following spine surgery, and an extended hospital stay when fusion is performed. While obesity may influence the decision for or against surgery, this data suggests that obesity should not necessarily alter the appropriate procedure for well-selected surgical candidates.

## Hypothesis

There is no difference in clinical improvement or complication rates for obese patients following decompression alone compared to decompression and fusion for lumbar spinal stenosis (LSS).

## Design

Longitudinal Cohort

## Introduction

Prior studies have shown obesity to be associated with higher complication rates, but equivalent clinical outcomes following lumbar spine surgery. These findings have been reproducible across lumbar spine surgery in general, and specifically for lumbar fusion. Despite this, surgeons seem inclined to limit the extent of surgery, perhaps opting for decompression alone rather than decompression and fusion, in obese patients.

## Methods

The N2QOD registry was queried for patients who had decompression and fusion (D+F), or decompression alone (D+O) for LSS stratified by BMI  $\geq 30$  (Obese) or  $< 30$  (Non-obese). Demographic, surgical and HRQOL data were compared.

## Results

In the Non-obese cohort, 947 had D+O and 319 had D+F. In the Obese cohort, 844 had D+O and 337 had D+F. There were no significant differences in ODI, back or leg pain improvement at 12-months when comparing D+O to D+F in either Obese or Non-obese cohorts. Blood loss and operative time were lowest in the Non-obese D+O cohort and were higher in Obese patients irrespective of fusion. Obese patients had a longer in-hospital stay (4.1 days) than non-obese (3.3 days) when fusion was performed. In-hospital stay was similar in Obese and Non-obese D+O cohorts. No significant differences were seen in surgical levels or 30-day readmission rates among the cohorts.

## Conclusion

Consistent with the prior literature, we found equivalent clinical outcome among obese and non-obese patients treated for lumbar spinal stenosis. In addition, we observed no difference in clinical outcomes between obese and non-obese patients related to the extent of the surgical procedure. There may be a higher blood product requirement in obese patients following spine surgery, and an extended hospital stay when fusion is performed. While obesity may influence the decision for or against surgery, this data suggests that obesity should not necessarily alter the appropriate procedure for well-selected surgical candidates.

	Non-Obese		Obese		p-value
	No Fusion	Fusion	No Fusion	Fusion	
N	947	319	844	337	
Age	68.10	64.26	63.58	61.51	0.000
BMI	26.03	25.53	35.66	36.20	0.000
Back Pain					
Pre-Operative	6.17	6.72	6.39	7.21	0.000
12-month Change	3.34	3.62	3.03	3.19	0.041
Leg Pain					
Pre-Operative	6.70	6.60	6.73	6.80	0.814
12-month Change	4.19	4.16	3.82	3.98	0.153
Oswestry Disability Index					
Pre-Operative	43.70	48.21	46.91	51.57	0.000
12-month Change	22.92	24.00	21.25	21.54	0.099
Estimated Blood Loss	87.15	281.55	130.87	340.55	0.000
Operative Time	95.39	179.85	102.77	186.49	0.000
In-hospital Stay	1.77	3.26	1.88	4.10	0.000
30-day Re-admission	24	6	26	8	0.685

## 72. Acetabular Component Orientation in the Setting of Spinal Deformity Correction

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## Summary

Adult spinal deformity (ASD) correction changes acetabular anteversion. Debate exists regarding the optimal sequence of spinal operation and total hip arthroplasty (THA). Forty-two patients were identified from a prospective database with THA prior to ASD correction, 13 patients with THA after ASD correction. Patients undergoing THA first had a 7.2% revision rate for dislocation, and significantly less anteversion than patients having THA after ASD correction (20.51deg vs 27.18deg,  $p=0.04$ ). Acetabular inclination did not differ significantly between groups or perioperatively

## Hypothesis

Acetabular component orientation varies between patients who had total hip arthroplasty (THA) prior to- or after adult spinal deformity (ASD) correction.

## Design

Retrospective review of prospective database.

## Introduction

Adult spinal deformity (ASD) correction changes acetabular anteversion. Debate exists regarding the optimal sequence of spine surgery and total hip arthroplasty (THA).





# PAPER ABSTRACTS

## Methods

Patients receiving multi-level spine surgery for ASD and THA were identified from a multi-center prospective ASD database. Patients were divided into two cohorts; THA performed prior to ASD correction (PRIOR), and THA performed after ASD correction (AFTER). Changes in spinopelvic alignment and acetabular anteversion and inclination were evaluated, acetabular orientation was compared between PRIOR and AFTER groups, and changes in acetabular orientation following spine surgery was evaluated in the PRIOR group. Revision rate for dislocation were also compared between groups.

## Results

PRIOR contained 42 patients (53 THA), and AFTER contained 13 patients (13 hips). PRIOR had a mean reduction in anteversion of 5.7 degree following spine surgery (26.2 preop vs 20.5 deg postop,  $p < 0.0001$ ). Three PRIOR patients (7.2% of patients; 5.6% hips) required THA revision following spine surgery for recurrent THA dislocation. No patients in AFTER had revision THA. No difference in spinopelvic alignment existed between groups after ASD correction and THA. PRIOR had smaller mean acetabular anteversion following spine surgery (20.51 deg) than AFTER (27.2 deg,  $p < 0.04$ ). AFTER had more acetabular components with anteversion  $> 25$  degrees (61.5%) than PRIOR at baseline (45.28%) and following spine surgery (26.41%;  $p < 0.05$ ). Acetabular inclination was similar between groups.

## Conclusion

ASD surgery can change acetabular component orientation. ASD patients undergoing THA before spine surgery had similar acetabular anteversion prior to spine surgery as patients undergoing THA after spine surgery, however acetabular anteversion was reduced following spine surgery. Reduction in anteversion following spine surgery may place THA patients at risk for recurrent dislocation.

	ALL PATIENTS									
	PI	PT	PP-LL	LL	TK	SVA	T1SP	TPA	Acetabular Anteversion	Acetabular Inclination
PRIOR Group	59.12	22.02	5.15	94.07	41.31	51.03	-1.5	19.75	20.51	44.28
AFTER Group	52.05	23.01	6.11	45.93	45.92	61.04	-1.65	21.35	27.18	43.92
p-value	0.127	0.8	0.83	0.054	0.256	0.633	0.678	0.666	0.04	0.9

Table 1: Comparison of post-operative spinal alignment and acetabular component orientation between patient undergoing THA prior to- or after spinal realignment surgery.

## 73. Novel "Dual Construct" for the Management of Complex Spinal Reconstructions: Evaluation of 57 Consecutive Patients

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United States

## Summary

Rod fracture and resulting pseudarthrosis can necessitate revision surgery in many complex spine cases. To address this challenge, a novel Dual Construct that uses four uncoupled rods was developed. 57 patients treated with this technique were retrospectively reviewed. No patients had all four rods fractured, though 3 patients (7.7%) had fracture of 1 or 2 rods; none required additional surgery. Excellent long-term clinical and radiographic outcomes were observed. Use of the Dual Construct may reduce revision rates following instrumented fusions.

## Hypothesis

The Dual Construct decreases the rate of revision surgery due to rod fracture.

## Design

Retrospective review

## Introduction

Pseudarthroses with rod fractures can approach 31.6%. To address these concerns, a novel Dual Construct, which utilizes four uncoupled rods for stabilization of the spine was developed. The purpose of this study is to review radiographic and clinical outcomes of the "Dual Construct" technique for complex spinal reconstructions.

## Methods

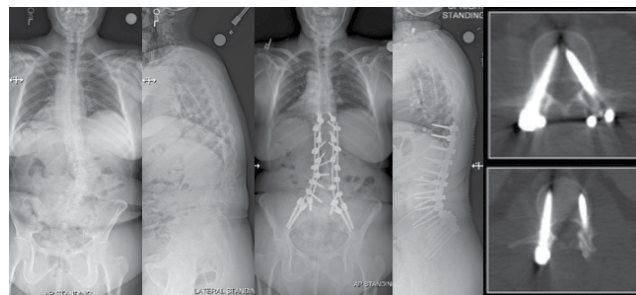
In total, 57 patients (mean age 63.8, range: 26-82 yrs) were treated with a Dual Construct for surgeries of the thoracolumbar spine. Diagnoses were pseudarthrosis (40.4%), infection (8.8%), metastatic cancer (8.8%), and junctional disease (15.8%). Alternating pedicle screw trajectories were utilized to accept four longitudinal rods for stabilization of the spine (Fig 1). Fifty-four patients (94.7%) were treated with multilevel laminectomy. TLIF was utilized in 39 patients (68.4%). Twelve patients (21.1%) were treated with corpectomy. One patient was treated with sacrectomy. Osteotomies were used in 15 patients (26.3%).

## Results

Forty patients (71.2%) were revision surgeries. Average BMI was 31.3 kg/m<sup>2</sup> (range: 19.8-61.2). Average EBL was 1.9 L (range: 0.4-6.0 L). Twelve patients (21.1%) had incidental durotomies. One patient had early infection and medial screw placement that necessitated early revision. Five patients required late revision for junctional stenosis. Long-term radiographic follow-up was available for 39 patients (2.0 +/- 1.1 yrs, range: 0.50-4.7 yrs). No patients had all four rods fractured, though 3 patients (7.7%) had fracture of 1 or 2 rods; none required additional surgery. Long-term clinical follow-up was available for 44 patients (2.1 +/- 1.2 yrs, range: 0.50-4.9 yrs). Twenty-one patients (47.7%) reported excellent pain palliation at last follow-up.

## Conclusion

The novel "Dual Construct" is a safe alternative to traditional 2-rod constructs, with encouraging outcomes at an average follow-up of 2 years. Rod fracture rates remain at, or lower than other comparable reported studies. Rod fracture did not necessitate revision surgery in any cases.



Images of the Dual Rod construct

# PAPER ABSTRACTS

## 74. Anterior Column Realignment: A Detailed Analysis of Neurologic Risk and Radiographic Outcomes

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### Summary

A retrospective, single center observational study was completed to assess neurologic and radiographic outcomes after anterior column realignment (ACR). Radiographic parameters including lordosis, pelvic tilt, and PI-LL mismatch were significantly improved at latest follow-up, as did their clinical outcomes (VAS back pain, ODI and SRS-22). There was an increase in thigh numbness, and motor deficit during the early post-operative period, however decreased below baseline at mean 2.4yrs follow-up.

### Hypothesis

ACR will correct sagittal imbalance with an acceptable neurologic risk

### Design

Single center, retrospective, longitudinal cohort

### Introduction

Anterior Column Realignment (ACR) is a less invasive alternative to three column osteotomy for correction of sagittal imbalance. ACR involves sectioning the anterior longitudinal ligament and placing a hyperlordotic cage via a lateral transposas approach. We aim to report a detailed analysis of neurologic risk and radiographic outcome after ACR.

### Methods

Patients > 18 who underwent ACR from 2005-2013 were eligible. Standing scoliosis radiographs were studied at pre-, and post op (<6 weeks; EARLY) and latest follow up (LFU). Clinical/radiographic data was collected by retrospective chart review, with T1SPI used as the angular surrogate for SVA. Wilcoxon signed rank and McNemar's test were used to assess significant differences.

### Results

35 patients met inclusion, 29 had complete data, with mean follow up 2.4 yrs (1-7). Pre-op, sagittal parameters: LL of 18.3, PI-LL 40, T1SPI 3.7 and PT 32. LL improved by 28.9 (p<0.001). Mean change in PT (-8), SS (7.1), T1SPI (-5.2), and PI-LL (-29.9) were all significant (Table 1). The motion segment angle (superior endplate of vertebra above and inferior endplate of vertebra below) improved by 23.4, from 3.8 to -19.3 (p<0.001). Neurologic complications occurred in 38% (n=11; 1 patient with both sensory and motor). Thigh numbness/paresthesia in 5 (17%; p=0.063) at EARLY; all resolved at LFU. 9 (31%) had preop motor deficit and 7 (24.1%) developed a new deficit (p=0.549), with 3 (10.3%) having persistent weakness at LFU. Of the original 9 with preop weakness 3 had persistent weakness. Patients saw improvement in VAS, ODI and SRS (p<0.05).

### Conclusion

ACR carries a 38% new onset neurologic risk in the immediate postoperative period, with no long term sensory deficits and 10% persistent weakness at latest follow up. Radiographic results demonstrate that ACR is a useful tool

to address patients with severe sagittal plane deformity with improvement in HRQOL despite its inherent neurologic risk

Table 1. Radiographic and Clinical Outcomes of ACR patients at pre-op, early post-op, and latest follow-up.

Radiographic Parameters	Pre-Op	6 Weeks Post-Op	Latest Post Op	Δ Pre to Latest
PT	32	23*	24*	-8
SS	25.8	33.9*	32.9*	7.1
PI	58.1	57.3	57.3	-0.8
T1SPI	3.7	-0.9*	-1.5*	-5.2
PI-LL	40	7.7*	10.1*	-29.9
LL	18.3	47.7*	47.2*	28.9
IDA	3.4	-22.4*	-17.7*	-21.2
MSA	3.8	-20.9*	-19.3*	-23.4
VAS Back	6.7	5.2*	3.7*	-2.9
ODI	55.3	57.1	37.7*	-17.6
SRS	2.3	2.9*	3.1*	0.83

\*Significantly different from pre-op, p<0.05

Table 1. Outcomes

## 75. The Safety and Efficacy of Intraoperative Acute Normovolaemic Haemodilution (ANH) in Complex Spine Surgery at an SRS GOP Site in Ghana

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Ghana

### Summary

Acute normovolemic hemodilution (ANH) has been reported to be a safe and effective method for blood conservation in spine surgery. However its benefit to reduce/obviate allogeneic transfusion in complex deformity surgery in underserved regions is unclear. A review of 106 complex spine patients treated at a single center in West Africa show that ANH can be safely performed to reduce allogeneic transfusion requirements, transfusion related complications and hospital cost.

### Hypothesis

ANH safely reduces allogeneic blood transfusion

### Design

Retrospective case series

### Introduction

Complex spine surgeries are associated with significant blood loss, requiring blood transfusion. Allogeneic blood transfusion is related to surgical time and blood loss. Underserved regions have limited blood product supply and therefore alternative blood conservation methods such as ANH will reduce/obviate this transfusion demand. We hypothesized that ANH can safely be applied in this population and sought to show its efficacy in reducing allogeneic transfusion in complex spine surgery.

### Methods

106 complex spine pts aged ≥7 with pre op Hb ≥ 12 treated at an SRS GOP site in Ghana were retrospectively reviewed. 47 ANH (Grp 1) pts were compared to 59 non-ANH (Grp 2) pts. They were matched with respect to age, wgt., preop hemoglobin levels, OR time and fusion levels. Data was analysed for EBL,





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transfusion, post op Hemoglobin (Hb) and complications. Statistical analysis with odds ratio and paired T- test was utilized for the comparative variables.

### Results

There were 106 pts: 32M/15F in Grp 1 vs 26M/33F Grp 2) with an average age of 19yrs in both grps. Avg pre op wgt., 45kg (Grp 1) vs 40.5kg (Grp 2). Fusion levels were similar in both Grps. Avg EBL: 1867ml (Grp 1) vs 1359ml (Grp 2) ( $p=0.03$ ). Allogenic blood transfusion was 34/47pts (72%) in Grp 1 vs 51/59pts (86%) in Grp 2. The volume of allogenic blood transfusion was significantly higher in Grp 2 (1192ml) vs Grp 1 (860ml) ( $P=0.01$ ). Cell saver blood transfusion avg 697ml (Grp 1) vs 522ml (Grp 2) ( $p=0.02$ ). There was no significant difference in Hb at POD 0 or POD 1; (10.4mg/ml vs 10.5mg/ml;  $p=0.62$ ). Allogenic transfusion relative risk was similar in both groups.

### Conclusion

This review showed that ANH can be safely performed in complex spine surgery in underserved regions. ANH group received lower volume allogenic blood transfusion to attain the same post op Hemoglobin levels. This technique will help make allogenic blood available for the general blood pool and reduce transfusion related complications and hospital cost

### 76. Retrospective Comparative Review of Robotic-Guidance vs. Freehand Instrumentation in 705 Adult Degenerative Spine Patients Operated in Minimally Invasive (MIS) and Open Approaches

*Thomas Sweeney, MD, PhD; Andrew F. Cannestra, MD, PhD; Kornelis Poelstra, MD, PhD; Samuel R. Schroerlucke, MD*

#### Summary

Data were collected retrospectively from 4 surgeons on 705 patients operated with robotic-guidance in a MIS approach (RGM), and compared with patients operated with fluoroscopic-guidance MIS (FGM) or open (FGO) approaches. Logistic regression analysis was used to assess the odds ratio of complications and surgical revisions. Rates of complications were significantly higher in FGM and FGO compared to RGM. Revision rates were significantly higher in FGM compared to RGM but did not reach significance in FGO (small sample size).

#### Hypothesis

Complications and rate of revision surgeries can be decreased with the use of Robotic guidance in MIS lumbar fusions when compared to freehand pedicle screw placement.

#### Design

Retrospective, multicenter, comparative chart review

#### Introduction

Minimally invasive spinal fusion surgeries are becoming more common. In recent years, robotic-guidance has become available, aiding surgeons in shortening the learning curve to transition to MIS techniques and reducing the intraoperative exposure to harmful radiation. However, few data were presented on its impact on clinical outcomes, especially in the hands of experienced MIS surgeons.

### Methods

Data were collected retrospectively from 4 surgeons for patients operated with robotic-guidance in a MIS approach (RGM), and compared with patients operated with fluoroscopic-guidance MIS (FGM) or open (FGO) approaches. All cases were instrumented fusions using either a minimally invasive technique with pedicle screws inserted in a percutaneous para-median approach, or a classic open approach through a median dissection. Logistic regression analysis was used to assess the odds ratio of complications and surgical revisions.

### Results

Altogether, 705 patients were pooled, 403 in RGM, 224 in FGM and 78 FGO. There were no significant differences in age, sex or BMI between arms or surgeons, except for 1 of the 4 groups in RG that was significantly older. Surgical complications had an odds ratio of 3.0 and 3.1 for FGM and FGO, respectively ( $p=0.014$  and  $p=0.009$ , 95% confidence intervals (CI95) = 1.2-7.1 and 1.3-7.3, respectively). Surgical revisions for FGM had an odds ratio of 3.8 ( $p=0.006$ , CI95 = 1.5-10.0). The revision rate of both FGO and FGM was 7.7%, but FGO had a smaller patient sample and was not statistically significant. Surgeon, age, gender, BMI, or length of surgery were non-significant parameters in the regression model.

### Conclusion

This retrospective analysis demonstrates that use of robotic guidance MIS can significantly reduce surgical complications and revision surgeries when compared to fluoro-guided MIS in the hands of experienced MIS surgeons.

### 77. Sacral Screw Strain in a Long Posterior Spinal Fusion Construct with Sacral Alar-Iliac (S2AI) versus Iliac Fixation

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*United States*

#### Summary

There has been increasing popularity of S2AI fixation with its purported advantages of 1) decreased implant profile and 2) obviating the need for a lateral offset connector. We set out to compare the biomechanical stability of S2AI versus traditional iliac screw fixation on S1 screw strain. Our study demonstrated both modes of fixation provide a significant reduction in S1 sacral screw strain, and therefore S2AI is a viable and biomechanically comparable alternative to traditional iliac fixation.

#### Hypothesis

To evaluate the biomechanical effect of S2AI fixation compared to traditional iliac screw fixation on stability across the lumbosacral junction through analysis of S1 screw strain.

#### Design

Fresh-frozen human cadaveric biomechanical study.

#### Introduction

Long instrumented posterior fusion constructs to the lumbosacral spine have a significant rate of pseudoarthrosis and S1 screw failure. There has been increasing popularity of of Sacral Alar-Iliac (S2AI) fixation technique, however,

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the biomechanical properties compared to the well-established iliac screw fixation have not been completely evaluated.

## Methods

Five fresh-frozen human cadaveric specimens were instrumented from L2-pelvis, maintaining all osteoligamentous structures, with bilateral titanium 6.0x40mm pedicle screws and 5.5-mm cobalt-chromium rods. Bilateral S1 pedicles were instrumented with 8.0x50mm screws that were centrally cored out and two uniaxial strain gauges inserted at 0° and 90°. S2AI and/or iliac fixation with 8.0x80mm titanium pedicle screws was performed to evaluate three different constructs: (1) Bilateral S1 Screws (control); (2) Bilateral S2AI; (3) Bilateral Iliac. Bilateral S1 screw strain was measured (microstrain), and pure moment loads (12.0 Nm) were applied in axial rotation (AR), flexion-extension (FE) and lateral bending (LB).

## Results

Compared to S1 screws alone, both S2AI and Iliac fixation significantly reduced sacral screw strain in FE by 58% and 67%, respectively ( $p < 0.05$ ), in AR by 35% and 41%, respectively ( $p < 0.05$ ), with no difference in LB for either construct ( $p > 0.05$ ). When S2AI and Iliac fixation were compared, there was no significant difference in screw strain for all bending moments ( $p > 0.05$ ).

## Conclusion

Both S2AI and Iliac fixation provide significant reduction in S1 screw strain compared to sacral fixation alone. Bilateral S2AI fixation is a viable and biomechanically comparable alternative to traditional Iliac fixation, and presents another option to achieve protection of the S1 screws for long segment constructs to the pelvis.

	Axial Rotation		Flexion Extension		Lateral Bending	
	Strain	Normalized %	Strain	Normalized %	Strain	Normalized %
<b>S1 Screws Alone</b>	135.2±77.3	100	176.2±68.6	100	82.1±57.8	100
<b>S1 + bilateral S2AI</b>	74.5±36.1 *p=0.025^	65.0	64.8±33.5 *p<0.001^	41.9	52.1±32.4 p=0.081^	88.9
<b>S1 + bilateral Iliac</b>	73.4±44.2 *p=0.006^	58.9	54.1±23.8 *p<0.001^	32.8	45.0±32.1 p=0.053^	74.4
<b>p-value (S2AI v Iliac)</b>	p=0.929		p=0.293		p=0.428	

Normalized % – normalized value is a percentage of S1 screws alone strain  
 S2AI – sacral-alar-iliac screw fixation  
 p-value^ comparing mean of S1 screws alone to test group (S2AI or Iliac). \*notes significant difference with p-value<0.05

## 78. Changes Following Acute Traumatic Cervical Spinal Cord Injury: A Prospective Pilot Study on Serial MRIs

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Canada

## Summary

The extent of spinal cord changes on MRI scans of patients with acute spinal cord injury have been associated with potential neurological recovery. However, little is known regarding the temporal changes of these MRI findings in the first weeks after injury. A prospective study of 6 serial MRIs in 17 patients with cervical spinal cord injury was performed. Although preliminary, this study

identified a clear pattern of spinal cord changes in the first weeks after spinal cord injury on MRI

## Hypothesis

Spinal cord changes on MRIs in patients with cervical spinal cord injury are dynamic in the first 3 weeks after injury.

## Design

Prospective study on serial MRIs in patients with cervical spinal cord injury.

## Introduction

The extent of spinal cord compression, hemorrhage, and edema on MRI scans of patients with acute spinal cord injury (SCI) have been reported to be potential predictors of neurological recovery. However, little is known regarding the temporal changes of these MRI findings in the first weeks after injury. Therefore the objective of this study is to characterize the dynamic nature of these MRI findings during the first weeks following SCI. Our goal is to understand how these MRI changes relate to both early and late neurologic functional status.

## Methods

Patients with acute traumatic cervical SCI admitted within 24hrs after injury were eligible. Six serial scans were planned at 24hrs, 48hrs, 96hrs, 1, 2 and 3 weeks after injury. On each scan, vertical length of cord edema, anatomic point of cord compression, maximum spinal cord compression, maximum canal compromise, presence and length of hematoma were determined.

## Results

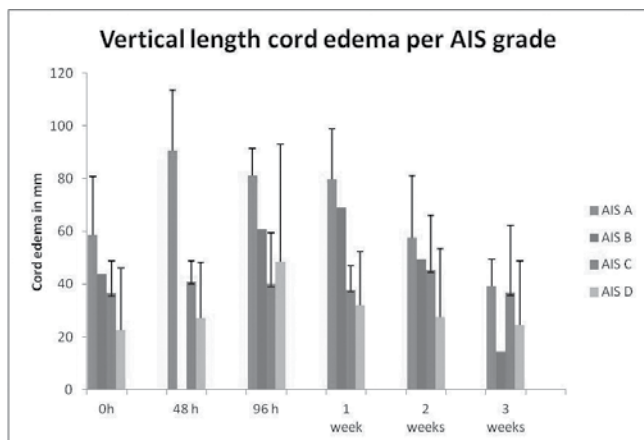
17 patients, mean age 56.5 years, with acute traumatic cervical SCI were included. Injury level ranged from C2-T1 and the baseline ASIA Impairment Scale (AIS) grade ranged from A-D. Compared to the initial MRI, the length of cord edema increased in the first 48hrs by 50% followed by a gradual decrease, resulting in 74% of the initial length at 3 weeks. The increase in edema length was most profound in the AIS-A and B patients. Hematoma was found in all AIS-A and B patients, in 50% of the AIS-C patients and in none of the AIS-D patients. Spinal cord compression and bony spinal canal compromise were respectively 17% and 10% on the initial MRI and were both resolved at 3 weeks.

## Conclusion

Although preliminary, this study identified a clear pattern of spinal cord changes in the first weeks after spinal cord injury on MRI. The vertical length of edema peaks around 48hrs and then begins to subside. Most of the acute changes have reduced by 3 weeks post-injury.



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## 79. Prediction of Muscular Volume Of Functional Groups From A Reduced Set Of MRI Slices

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France

### Summary

Recent studies have investigated the role of musculature in adult spinal deformity (ASD), particularly the relationship between degradation and evolution of spinal pathology. This study proposed a new method computing muscular volume from a reduced set of MRI slices. Using multilinear regression analysis, 5 slices (3 in the lumbo-pelvic region and 2 in the thigh region), yielded an estimate of the muscular volumes with an error less than 11% of the volume from extensive segmentation.

### Hypothesis

A reduced set of MRI slices provides enough information to estimate accurately muscular volumes, thus reducing the analysis time.

### Design

Prospective single-center study.

### Introduction

Recent studies have investigated the role of musculature in adult spinal deformity (ASD), particularly the relationship between aging, muscle degradation and evolution of spinal pathology. However, the extensive amount of time needed for muscle segmentation on MRI slices limits clinical use. The objective of this study is to evaluate a model predicting the muscular volumes from a reduced set of MRI slices, versus muscular volumes computed from the extensive segmentation.

### Methods

23 subjects (18-24yrs; 12F, 11M) underwent MRI acquisition from T12 to the knee. Spinopelvic muscles were segmented to obtain an accurate 3D reconstruction, allowing precise computation of muscle volume. Muscles were grouped by functional groups (flexors and extensors) of the spine, hip and knee. A multilinear regression model was used to compute muscular volume of each functional group from a reduced set of MRI slices. Various slice numbers

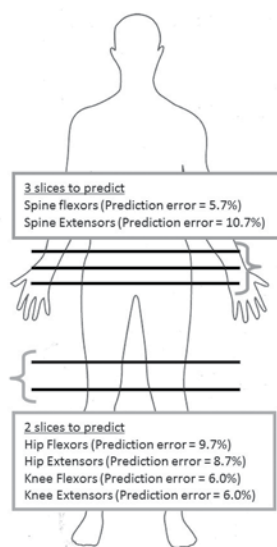
(i.e. locations) were investigated. These results were compared against muscular volumes computed from the extensive segmentation.

### Results

A set of 5 MRI slices was defined as the best set of slices, based on volume prediction error. 3 slices were located in the lumbo-pelvic region and 2 in the thigh (Fig). The volume prediction error of the limited slice set compared to the extensive segmentation ranged from 6% (Knee flexors and extensors, and Spine flexors) to 11% (Spine extensors). This error is around 9-10% for Hip flexors and extensors (Fig).

### Conclusion

Overall, the current study appears promising for its use in clinical practice to more rapidly quantify the degradation of the muscular system in ASD patients. The Spine Extensor muscle group seems to be less predictable and could be investigated in further study.



Set of 5 slices used to predict muscular volumes and volume prediction error.

## 80. Operative Management of Combat Spine Trauma

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United States

### Summary

Operations Enduring and Iraqi Freedom have yielded an incredibly high rate of spine trauma. The burden of operative spinal trauma has been relatively unexplored. We found 89 cases of operatively managed spine trauma cases at our institutions over a ten year period; the majority involved the lumbar spine, and most were treated within two weeks of injury. Almost half were medically retired on final follow up. Ultimately, we found a high rate of poor outcomes for operative combat spine trauma.

### Hypothesis

The operative burden of combat spine trauma is relatively low, but associated with high morbidity and poor outcomes.

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## Design

Retrospective analysis

## Introduction

Several recent studies have examined the rate of combat-related spinal injury among casualties in Operations Iraqi and Enduring Freedom. We set out to provide more detailed information on operatively treated spinal trauma at three large military treatment facilities in the United States over a ten-year period.

## Methods

We performed a retrospective analysis of a surgical database at three military institutions. Patients undergoing spine surgery following a combat-related injury in Operations Enduring and/or Iraqi Freedom between July 2003 and July 2013 were evaluated. Inclusion criteria included trauma sustained in direct relation to combat operations while in theater requiring operative treatment after evacuation to the United States. Medical records and radiographic images of identified patients were reviewed for demographic information, mechanism of injury, characterization of spine injuries, neurologic examination, and work/return to duty.

## Results

Eighty-nine consecutive patients were included. The most common mechanism of injury was the mounted improvised explosive device. The lumbar spine was the most commonly involved region (62.9%). Neurological injuries were present in 41.6% of all patients. The mortality rate for all patients with spinal injuries after evacuation to the United States was 2.2%. The average time to definitive spinal surgery was 57.8±276.4 days; 64% were treated within 14 days of being injured. The overall infection rate was 8.9%. Average follow up after injury was 27.8 months. At most recent follow up, 43.2% of patients had been medically retired.

## Conclusion

To our knowledge, this study is the largest review evaluating the demographic information, resource utilization and follow up data for patients sustaining operative war-related spine trauma in Iraq and Afghanistan. These spine injuries involve multiple spinal levels per patient, have a high rate of associated neurologic injury, and represent a significant burden to the American military health care system.

## 81. Three-Dimensional Analysis of Severe AIS Curve Correction with Anterior Vertebral Tethers

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*United States*

### Summary

Three-dimensional correction of severe spinal deformity was evaluated in AIS patients treated with anterior vertebral tethers. Scoliosis correction was significant at 50% ( $p < 0.001$ ) with good preservation of thoracic and lumbar sagittal contours but little change in axial rotation.

### Hypothesis

Our hypothesis was that anterior vertebral tethering of severe AIS curves would demonstrate significant correction in the coronal plane, preservation of the thoracic and lumbar sagittal contours and improved axial rotation.

## Design

Retrospective review of consecutive patients (2013-2015).

## Introduction

Fusionless scoliosis surgery with anterior vertebral tethers has been proposed as an alternative to fusion surgery for severe AIS curves in the 40-60° range. This study analyzed the 3D correction of severe thoracic, thoracolumbar and lumbar AIS curves treated with anterior vertebral tethers.

## Methods

Ten consecutive AIS patients were treated with anterior vertebral tethers for severe thoracic, thoracolumbar and lumbar curves in the 40-60° range. Cobb angles in the coronal and sagittal planes, as well as rotation in the axial plane (Nash-Moe), were compared pre-op, post-op and final.

## Results

Ten AIS patients (8F, 2M) with 13 curves (5T, 8TL/L) underwent anterior vertebral tethering at an average age of 15+1 and Risser 3.4. Overall scoliosis correction from 51.6° pre-op to 27.7° post-op to 25.5° final at 5-24 months was significant ( $p < 0.001$ ) with slightly better correction for lumbar (51.9° pre-op to 24.4° post-op to 23.1° final) than for thoracic (51.2° pre-op to 33° post-op to 29.4° final) curves. Thoracic kyphosis (35.3° pre-op to 43.7° post-op to 37.8° final) and lumbar lordosis (62.1° pre-op to 59.5° post-op to 61.7° final) were well preserved within a normal range. Axial rotation improved only slightly (Nash-Moe 1.7 pre-op to 1.6 post-op to 1.5 final).

## Conclusion

Three dimensional analysis of severe AIS curve correction using anterior vertebral tethers demonstrated good correction in the coronal plane and good preservation of the thoracic and lumbar sagittal contours but little improvement in axial rotation. The scoliosis correction of 50% from 51.6° to 25.5° was significant. Though these early results are encouraging, additional follow-up is warranted.

## 82. Pedicled Vascularized Bone Grafts for Posterior Occipitocervical and Cervicothoracic Fusion: A Cadaveric Feasibility Study

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*United States*

### Summary

Patients at high risk for pseudarthrosis require alternate strategies for maximizing fusion rates. Vascularized bone graft (VBG) has been used to successfully augment fusion rates in a variety of skeletal pathologies, and pedicled VBG has numerous advantages over free transfer VBG. This feasibility cadaveric study is the first to demonstrate that pedicled VBGs can be successfully applied to posterior OC and CT spinal arthrodesis. Patients at high risk for nonunion may benefit from this strategy.

### Hypothesis

It is feasible to rotate pedicled VBG from occiput to T12 via a posterior approach.





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## Design

A cadaveric study.

## Introduction

Successful arthrodesis is critical for achieving favorable outcomes with posterior occipitocervical (OC) or cervicothoracic (CT) reconstructive surgery. Patients at high risk for pseudarthrosis require alternate strategies for maximizing fusion rates. Vascularized bone graft (VBG) has been used to successfully augment fusion rates in a variety of skeletal pathologies, and pedicled VBG has numerous advantages over free transfer VBG. Pedicled VBG has not been described for posterior OC or CT fusion.

## Methods

A multidisciplinary team of plastic and neurosurgeons hypothesized that it is feasible to rotate pedicled VBG from occiput to T12 via a posterior approach. In 6 cadavers, 3 VBG donor sites were evaluated: occiput (O-VBG), scapula (S-VBG), and rib (R-VBG).

## Results

1. Occiput. Split- and full-thickness O-VBG was mobilized on a semispinalis pedicle. Mean graft dimensions: 5.6cm x 3.3cm x 5mm or 1.0cm (split- or full-thickness). O-VBG could be mobilized from occiput to T1 and span up to 4 levels. 2. Medial Scapula. S-VBG was mobilized on a subscapular pedicle. Mean graft dimensions: 15.1cm x 1.9cm x 8.8mm. S-VBG could be mobilized from occiput to T7 and span up to 8 levels. 3. Rib. R-VBG was mobilized on subcostal pedicles. The first rib was anatomically unsuitable to function as a VBG. Mean graft dimensions for ribs T2-T12: 7.2cm x 1.3cm x 0.5cm, and varied with level. R-VBG could be mobilized from C6 to T12. Ribs T2-T4 and T11-T12 were capable of covering 2 levels, and T5-T10 were capable of covering 3 levels. The concave and convex rib surfaces could be selectively used to fit the contour of the spinal segment of interest. (Figure 1)

## Conclusion

This feasibility cadaveric study is the first to demonstrate that pedicled VBGs can be successfully applied to posterior OC and CT spinal arthrodesis. VBG can be harvested through same or separate incisions to fit the clinical scenario. Patients at high risk for nonunion may benefit from this strategy. Further investigation in patients is warranted.

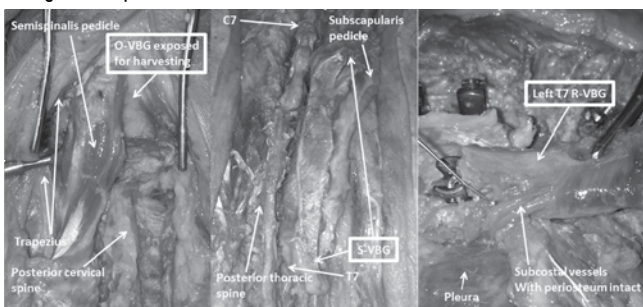


Figure-1

## 83. Novel Methods of Spinal Cord Injury Treatment Using Magnetic Nanoparticles in Combination with Electromagnetic Field

Arkadii Kazmin, MD; Sergey Kolesov, MD, PhD; Maxim Sazhnev, MD, PhD; Andrey A. Panteleyev, MD

Russian Federation

## Summary

The effect of injury site administration of magnetic iron oxide nanoparticles was evaluated on laboratory rats with spinal cord transection of varying extent over a period of four weeks.

## Hypothesis

Magnetic iron oxide nanoparticles in the presence of external magnetic field can stimulate regenerative processes in injured spinal cord tissues.

## Design

NA

## Introduction

In most cases, spinal cord injury leads to severe disability. The use of magnetic nanoparticles to restore spinal cord injury related loss of function represents a novel approach to this problem and can be helpful in developing clinical treatment methods.

## Methods

The study was conducted on 72 Wistar rats. The animals were divided into 6 groups, according to the extent of spinal cord transection: 50% in the first, 80% in the second and a complete transection in the third study group. All the animals in the three study groups were administered a magnetic iron oxide nanoparticle suspension to the site of injury every other day for 4 weeks. The other three (control) groups with corresponding transections but no magnetic nanoparticle administration. All animals were exposed to a static direct current 3 mT magnetic field for 5 hours every other day for 4 weeks. Postoperative function loss and recovery were assessed using the BBB motor function scale and somatosensory evoked potential monitoring on the first day after surgery and then weekly.

## Results

After a drastic decrease in function on the first day after surgery, the animals in the control groups had no statistically significant improvement in either BBB scores or evoked potential amplitude over four weeks. No improvement was also observed in the study group with complete spinal cord transection. In the group with 50% transection, however, there was an average of  $14 \pm 3.5\%$  ( $p < 0,05$ ) increase in evoked potential amplitude and  $11 \pm 4\%$  ( $p < 0,05$ ) increase in BBB scores four weeks after surgery. In the group with 80% spinal cord transection, the numbers were  $5 \pm 3.0\%$  ( $p < 0,05$ ) and  $6 \pm 2.1\%$  ( $p > 0,05$ ) respectively.

## Conclusion

The use of magnetic iron oxide nanoparticles in combination with a magnetic field leads to higher rates of functional recovery after spinal cord injury in laboratory animals. The mechanism of this functional improvement needs further investigation.



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## 84. First Report From MIS ReFRESH: A Prospective, Comparative Study of Robotic-Guidance vs. Freehand Pedicle Screw Placement in Minimally Invasive Lumbar Surgery

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United States

### Summary

MIS ReFRESH is the first prospective, comparative, multi-center study designed to assess differences in surgical complication rates, rates of revision surgery and exposure to intra-operative radiation for MIS lumbar fusions. Altogether, 4 sites enrolled 143 cases, split 118 in the robotic arm vs. 25 in the freehand arm. Significant reduction in fluoroscopy times (75%) and in complications and revisions were found in the robotic arm.

### Hypothesis

Robotic guidance can decrease fluoroscopy times and revision rates in MIS posterior lumbar spinal fusion.

### Design

A prospective, comparative, multi-center study designed to assess differences in surgical complication rates, rates of revision surgery and exposure to intra-operative radiation for MIS lumbar fusions (1-3 levels) for adult degenerative conditions.

### Introduction

The use of robotic-guidance in spine surgery is becoming more common. The majority of the clinical evidence is retrospective, with the focus limited to accuracy and fluoroscopy times. MIS ReFRESH is the first prospective, comparative, multi-center study comparing the use of robotic guidance vs freehand in MIS lumbar spinal fusion.

### Methods

Data were prospectively collected from adult patients indicated for fusion surgery, including demographics, patient based outcomes questionnaires, surgical complications, revision surgery and intra-operative fluoroscopy (in seconds). A single site randomized patients between arms, while other sites enrolled exclusively to one arm.

### Results

Altogether, 4 sites enrolled 143 cases, split 118 in the robotic arm (RO) vs. 25 in the freehand arm (FH), of which 4 were randomized to RO and 6 to FH. There were no significant differences between arms in gender (60% female), age (58), BMI (30.8) or Charlson comorbidity Index (0.5). There were 1.4 levels (range 1-3) on average in RO vs. 1.1 (range 1-2) in FH ( $p=0.006$ ). Use of fluoroscopy was  $3.2\pm 2.8$  seconds/screw RO vs.  $12.5\pm 7.9$  FH ( $p<0.001$ ). There were 2 complications in FH: one neurological deficit and one infection, both of which required revision surgery. There were no complications or revisions in RO ( $p=0.03$ ).

### Conclusion

These are the first findings reported from a prospective, multi-center, comparative study of robotic-guidance vs. freehand screw placement in MIS lumbar fusions. Significant reduction of 75% in fluoroscopy needed for pedicle

screw insertion is consistent with the published literature. The reduction in complications and revisions are statistically significant yet in a small number of patients and a limited follow-up period.

## 85. A Novel Posterior Rod-Link-Reducer System Provides Safer Easier and Better Correction of Severe Scoliosis

Hong Zhang, MD; Daniel J. Sucato, MD, MS

United States

### Summary

A new rod link reducer (RLR) technique has been developed to provide outstanding corrective control for severe spinal deformities. A retrospective review of 18 cases utilizing the RLR versus 18 cases using the traditional corrective technique (TCT) performed for severe scoliosis. The RLR system provides significantly better Cobb correction (RLR-73.1% vs. TCT-56.6%), less operative time (RLR-316.6mins vs. TCT-391.4mins), and no infection and neuro-monitoring changes. This novel tool is especially useful in challenging patients who have the most severe spinal deformities.

### Hypothesis

Current implant strategies provide for good correction especially for moderate curves, however, severe spinal deformity continues to be challenging to obtain correction in a safe and effective manner.

### Design

A novel correction device was developed so that two provisional rods are placed on the convex side of the scoliosis proximally and distally which are then linked to an external reduction device termed the rod-link-reducer (RLR). The significant lever arm forces generated allow the surgeon to easily and simultaneously derotate, translate and correct the spine in the coronal, sagittal and axial planes. The apical segment becomes "unhinged" allow for improved apical correction. When correction is maximized, the contralateral rod is placed and secured and the RLR is removed.

### Introduction

The purpose of this study was to compare the  $>75^\circ$  scoliosis correction obtained utilizing the RLR versus traditional corrective techniques (TCT) in patients with severe AIS.

### Methods

A retrospective analysis was performed comparing the outcome of spine deformity surgery for large curves (Cobb  $>75^\circ$ ) comparing the RLR and TCT. The mean follow-up period was 32.3 months.

### Results

A total of 36 patients were evaluated (RLR-18, TCT-18). The data sets were similar for age, gender, coronal Cobb, curve flexibility, fusion levels (RLR-13.1 vs. TCT-13.4), and follow-up period. The mean Cobb for RLR was  $91.7^\circ$  ( $76^\circ$ - $113^\circ$ ) and TCT  $91.8^\circ$  ( $78^\circ$ - $108^\circ$ ). The mean coronal Cobb correction was significantly greater for RLR (73.1% vs. 56.6%,  $p<0.0001$ ). The mean operative time was 74.8 mins shorter in RLR (316.6 mins vs. 391.4 mins,  $p=0.03$ ). There were 2 infections and 3 neuro-monitoring changes during the correction maneuver in TCT compared with none in RLR ( $p=0.02$ ). There were no differences in the EBL (RLR-1022.2 cc vs. TCT-1250.0 cc,  $p=0.52$ ).



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## Conclusion

In a matched cohort, the use of the rod-link-reducer system exhibited greater coronal Cobb correction, shorter operative time, and was less likely to have critical neuro-monitoring changes compared with the traditional techniques. The rod-link-reducer provides safer and improved correction for severe curves without adding surgical risk.

## 86. A Randomized Control Trial of Low Radiation Imaging During Minimally Invasive Spine Fusion

*Sarah Byrd, BS, MS, RN, Nurse Practitioner; David A. Vincent, MD*

*United States*

## Summary

In a randomized controlled fashion we have shown dramatic decreases in radiation to all members of the surgical team and patient using ultra low radiation imaging used during minimally invasive spine surgery.

## Hypothesis

Our goal with this work was to see if by using ultra-low dose radiation settings, this exposure could be minimized. This benefit would impact potentially everyone in the operating room, from the patient to the physician to the scrub nurse.

## Design

An IRB approved, perspective, internally randomized controlled trial was performed comparing ultra-low dose radiation settings coupled with image enhancement software to conventional imaging.

## Introduction

While the benefits of MIS is lauded by many, the amount of radiation that both the patient and the physician are exposed to can be significant.

## Methods

In this study, each patient served as their own control, randomly assigning one side for cannulation and k-wire placement using each imaging modality. Further, the case was also randomly divided into screw placement and cage placement/final images to allow further comparisons amongst patients. Radiation dose to the patient, as well as all other members of the surgical team in the operating room, were recorded. Data was kept in an Excel spreadsheet and analyzed using Matlab.

## Results

20 patients were randomly assigned to undergo a single level minimally invasive TLIF had one institution with a single surgeon performing all procedures. In no case was low radiation imaging abandoned, and no patient had a neurologic decline or required hardware repositioning. Everyone in the operating room - the patient, scrub nurse, Xray tech, physician and anesthesiologist - all benefited with 73-98% less radiation exposure during cannulation to screw placement aided by Lessray. In every case but the anesthesiologist dose, this was statistically significant ( $p < 0.05$ ). This benefit required no additional time ( $p = 0.86$  for kwire placement).

## Conclusion

Ultra low radiation imaging, when aided by image enhancement software, affords the ability for all parties in the operating room, from the patient to the

surgeon to ancillary staff, to substantially decrease their radiation exposure during minimally invasive fusion. Without adding additional time or an increased complication rate, ultra-low radiation imaging can offer all parties over 70% less radiation exposure.

## 87. Diagnosing The Undiagnosed: Osteoporosis In Patients Undergoing Lumbar Fusion

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*United States*

## Summary

We utilized a recent technique analyzing Hounsfield Units (HU) from computed tomography (CT) scans to estimate bone mineral density (BMD) of the lumbar spine. We found a large proportion of patients over age 50 undergoing TLIF with undiagnosed osteoporosis of the lumbar spine. The clinical significance of this finding requires further study, but it is clear that increased vigilance on the part of the surgeon is required.

## Hypothesis

There will be a high percentage of undiagnosed osteoporotic patients undergoing TLIF.

## Design

Retrospective analysis.

## Introduction

We used HU from computed tomography (CT) scans to estimate bone mineral density (BMD) of the lumbar spine and hypothesized that this technique would reveal a high percentage of undiagnosed osteoporotic patients undergoing transforaminal lumbar interbody fusion.

## Methods

A retrospective analysis of patients over age 50 undergoing TLIF. The BMD of the lumbar spine was recorded if DEXA data were available. The average HU values of L4, measured on axial computed tomography (CT) scan, were also determined. Average HU values for patients with diagnosed lumbar osteoporosis (DEXA BMD  $< 0.75$  g/cm<sup>2</sup>) were then compared to those with osteopenia and normal BMD (between 0.75 to 0.9 g/cm<sup>2</sup> and  $> 0.9$  g/cm<sup>2</sup>, respectively).

## Results

We found 128 patients with available preoperative lumbar CT scans. Based on available DEXA scans, a HU cutoff of  $\leq 112.36$  was used to classify osteoporotic patients; and a HU cutoff of  $\leq 150.09$  to classify osteopenic patients. The remaining patients had a mean BMD of  $1.10 \pm 0.13$  and mean HU of 165.9. We found a significant correlation between HU and BMD ( $r^2 = 0.22$ ,  $p = 0.01$ ). Based on our cutoff values, there were a total of 25 patients with osteoporosis, 38 with osteopenia and 65 patients without bone mineral loss. The mean age of the osteoporotic patients was 66.2 years, significantly older than osteopenic (56.7 years) or normal BMD (57.6 years) patients ( $p < 0.001$ ). Females represented a significantly higher proportion of the osteoporotic cohort (60%) compared to the osteopenic (23.7%) or normal BMD groups (41.5%) ( $p = 0.015$ ). Only 36% of patients with osteoporosis

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based on HU had DXA scans on record, with only 40% of these patients prescribed medications to treat low bone mineral density at any time period.

## Conclusion

HU may provide accurate assessment of BMD of the lumbar spine. We found a large proportion of patients over age 50 undergoing TLIF with undiagnosed osteoporosis of the lumbar spine. The clinical significance of this finding requires further study, but it is clear that increased vigilance on the part of the surgeon is required.

## 88. Pelvic Incidence: A Fixed Value or Can You Change it?

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### Summary

Using a series of radiographs on 50 healthy volunteers, we have demonstrated that the Pelvic Incidence (PI) value frequently changes when one moves from resting pelvic position to either maximum anterior pelvic rotation or maximum posterior pelvic rotation. This was confirmed by independent measurements made by an orthopaedic surgeon and a musculoskeletal radiologist. The inter-observer reliability of the measurements was 0.971.

### Hypothesis

PI is a fixed value and can not be varied with pelvic rotation.

### Design

One-sample observational study with inter-rater reliability testing

### Introduction

There has been a renewed emphasis on the pelvic vertebrae. Three key measurements have been used to assess the position of the pelvis: pelvic tilt (PT), sacral slope (SS), and pelvic incidence (PI). Many consider the PI to be a fixed measurement for an individual while the PT and SS are responsive to external forces. We assessed this hypothesis.

### Methods

Standing lateral radiographs were taken of 50 healthy volunteers in 3 different postures: resting, anterior pelvic rotation, and posterior pelvic rotation. An orthopaedic spine surgeon and a musculoskeletal radiologist then measured PT, SS, and PI independently. Interobserver reliability was assessed using Chronbach's alpha.

### Results

The internal consistency for all 150 PI measurements by the two observers was 0.971. PI values changed in 44 of 50 subjects (88%) going from resting to maximal anterior pelvic rotation. The mean change was  $2.9^\circ$ ; 23 of 50 (46%) changed  $\geq 3^\circ$ . PI measurements changed in 40 of 50 subjects (80%) from resting to maximal posterior pelvic rotation. The mean change was  $2.82^\circ$ ; 27 of 50 (54%) changed  $\geq 3^\circ$ .

### Conclusion

We have demonstrated that the PI for a high percentage of healthy subjects can change when the subject varies their pelvic position. This calls to question the truism that PI is a fixed morphologic parameter. Our data from a series of

dynamic radiographs suggests a potential functional motion at the SI joints. It also brings forth the idea that intentionally changing pelvic position could cause a change in PI. More study is needed to determine if these changes can be maintained with appropriate education/training. Since the PI changes with pelvic position, further study is needed to see which component of PI, either PT or SS, changes more. This may help guide further treatment of patients with adult spinal deformity.

## 89. Incidence of Lumbar Plexopathy Utilizing Mechanomyography (MMG) for Transpoas Lateral Lumbar Interbody Fusion (LLIF)

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### Summary

The reliability of electromyography (EMG) to detect nerve injury has been questioned. Mechanomyography (MMG) is a useful alternative to EMG to monitor the lumbar plexus for transpoas lumbar lateral interbody fusion (LLIF). Using MMG, the overall rate of ipsilateral thigh symptoms was 21.2% (18/85). Most patients with thigh symptoms (16/18) had multi-level procedures performed for degenerative scoliosis, and included L45. MMG is a safe alternative to EMG to monitor the lumbar plexus when performing transpoas LLIF.

### Hypothesis

MMG is a safe alternative to EMG to monitor the lumbar plexus when performing transpoas LLIF.

### Design

Multicenter retrospective review

### Introduction

Reported incidences of thigh complications during transpoas LLIF range from 0.7% to 75%. The reliability of electromyography (EMG) has been questioned due to false-positives and false-negatives. Common operating-room equipment can also cause electrical interference with EMG. Mechanomyography (MMG) may provide a safe alternative to EMG. We evaluated the incidence of thigh complications of transpoas LLIF using MMG.

### Methods

A retrospective review of prospectively collected data was completed at four institutions. 85 consecutive patients (175 levels fused) who underwent transpoas LLIF surgery (L1-L5) during a one-year period were included. Immediate postoperative and routine follow-up clinical exams were obtained.

### Results

The rate of all ipsilateral thigh symptoms (pain, numbness, and weakness) was 21.2% (18/85). Eight patients (9.4%) had iliopsoas or quadriceps weakness (3/5 motor strength). Ten patients (11.8%) had anterior thigh pain and/or numbness. Most patients with postoperative thigh symptoms (16/18) had 3 or 4 level procedures performed for degenerative scoliosis and included L45. All thigh symptoms resolved within 3 months.



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## Conclusion

MMG is the mechanical signal seen from the surface of a muscle when it contracts after stimulation. MMG is an effective alternative to EMG for nerve mapping during transposas LLIF surgery and overcomes deficiencies related to electrical interference and high rates of false-positives and false-negatives inherent to EMG. With MMG, the rate of ipsilateral thigh symptoms was 21.2%, which is consistent with currently reported rates for transposas procedures utilizing EMG. Most thigh symptoms occurred in multi-level procedures; direct trauma to the psoas may have contributed to our results. All symptomatic patients had L4/5 included in their construct. MMG is a safe alternative to EMG to monitor the lumbar plexus when performing transposas LLIF.

## 90. Does Pelvic Incidence Increase with Age? An Analysis of 1625 Adults

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United States

## Summary

Recent work proposed that Pelvic Incidence (PI) increases after 60 years with a strong correlation with age. This study investigated this concept in 1510 patients and 115 asymptomatic subjects. Data revealed that PI increases in females in a linear fashion with increasing age, especially for those over 45 years old. Spinal malalignment may potentially accelerate or prompt this increase in PI, which may benefit surgical planning. However, a causal link cannot yet be identified due to lack of longitudinal data.

## Hypothesis

Pelvic incidence (PI) increases with age

## Design

Retrospective review of two full-body imaging databases

## Introduction

PI has been proposed as the foundation of spinal alignment: determining the orientation of the sacrum, pelvic tilt (PT) and the capacity of compensation. PI has been proposed as constant once skeletal maturity is achieved. However, recent reports argue that PI increases after 60 years with a strong correlation with age. Due to small sample size in prior study, a large sample sized study should be conducted to clarify the change in PI.

## Methods

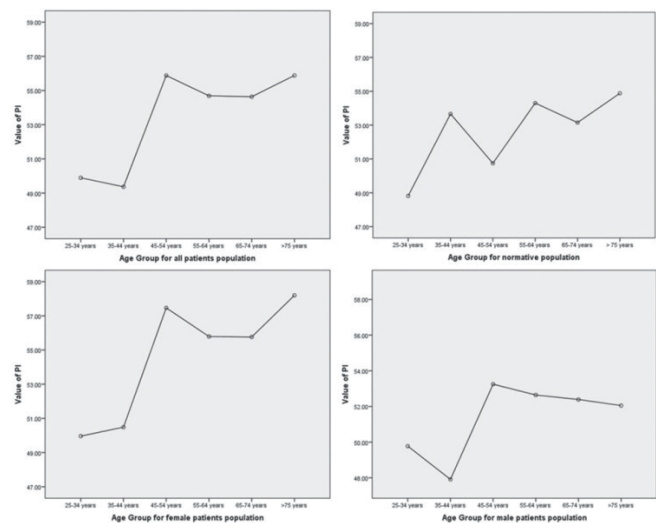
Patients visited a spine surgeon's office with various spinal degenerative and deformity pathologies representative of the general population were enrolled, along with an additional 115 asymptomatic volunteers. Spondylolisthesis pts were excluded. Subjects were divided into 6 age subgroups with 10 year intervals (25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years and over 75 years). PI was compared between age subgroups. Linear regression was performed to identify factors associated with increased PI.

## Results

There were 1510 symptomatic patients (550 males, 960 females) and 115 asymptomatic subjects. PI averaged  $54.1^\circ \pm 14.4$  (range 11-105°) in all patients. PI was significantly higher in the 45-54y age group than the 35-44y age group ( $55.8^\circ$  vs.  $49.7^\circ$ ,  $p < 0.001$ ). After 45 years, PI remained unchanged. PI was significantly higher in women than men (M:  $51.8^\circ$  vs. F:  $55.5^\circ$ ,  $p < 0.001$ ). In the age subgroup analysis, there were significant PI differences between genders after age 45. In the asymptomatic subjects, however, a non-significant trend of PI increase was observed ( $p = 0.548$ ), and females had a higher PI than males ( $p = 0.007$ ), especially after 55 years old. Linear regression revealed age, gender and malalignment as associated factors for increased PI with R2 of 0.22 ( $p < 0.001$ ).

## Conclusion

PI is higher in female patients and in older patients, especially those over 45 years old. Spinal malalignment also may have a role in increased PI; however, a causal link cannot yet be identified due to lack of longitudinal data. These findings may benefit both surgical decision-making and planning, but should also encourage further investigation.



## 91. Factors Associated with the Development of and Revision for Proximal Junctional Kyphosis in 458 Consecutive Adult Spinal Deformity Patients

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## Summary

Between 2003 and 2011, 458 consecutive patients who underwent surgical intervention for adult spinal deformity (ASD) were identified. Older patients with all screw constructs and higher pelvic tilt (PT) and thoracic kyphosis (TK) were more likely to develop proximal junctional kyphosis (PJK). Higher post-operative proximal junctional angle (PJA) and sagittal vertical axis (SVA) along with fracture, listhesis or instrumentation failure at the upper instrumented



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vertebra (UIV) were predictive of the need for revision. No differences were observed based on UIV.

### Hypothesis

Clinical and radiographic features common to ASD patients can predict the occurrence of PJK and the eventual need for revision surgery.

### Design

Retrospective review of prospectively collected data

### Introduction

Multiple parameters are considered when planning correction of ASD. Determining which of these factors contribute to the development of and need for revision surgery in PJK presents a challenging clinical problem. We propose to examine which radiographic parameters and surgical strategies are most closely associated with PJK, the need for proceeding to revision surgery, and whether these differ based on the UIV.

### Methods

All patients undergoing fusion from the thoracic spine to the pelvis in a single institution between 2003 and 2011 were reviewed. Other criteria for inclusion were age over 18 and radiographs adequate for analysis. Along with chart review, measurement of PJA, sagittal balance and pelvic parameters were performed on pre-operative, post-operative and follow-up long, standing x-rays.

### Results

458 patients with a mean follow up time of 34 months met the inclusion criteria, 162 of whom developed PJK (35%), with 65 going on to revision surgery (40%). Higher preoperative PT ( $p=0.02$ ) and postoperative TK ( $p=0.002$ ) were predictive for development of PJK while hooks at the UIV were protective (odds ratio 0.04). In patients who develop PJK, revision was more frequent in younger patients ( $p=0.04$ ) with greater post-operative SVA and PJA ( $p=0.027$ ,  $p=0.002$ ). Proximal junctional failure with spondylolisthesis, fracture or instrumentation failure at the UIV had the highest odds ratios for proceeding with revision (6, 1.6 and 2.25 respectively).

### Conclusion

TK and PT are important indicators of overall rigidity and reference the ability of the spine to compensate for sagittal plane deformity. Special attention should be paid to these characteristics and to the choice of proximal instrumentation when attempting to prevent PJK. Prevention of proximal junctional failure and subsequent sagittal plane decompensation may hold the key to reducing the need for revision surgery.

### 92. Inter/Intra-Observer Reliability of T1 Pelvic Angle (TPA), a Radiographic Measure for Global Sagittal Deformity

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*United States*

### Summary

T1 Pelvic Angle (T1PA), a novel spinopelvic parameter, is theorized as an excellent measure of global sagittal deformity. In this study, intra- and inter-observer agreement of the T1PA was assessed, as well as its relationship with

pelvic position, in a large consecutive series of healthy adults. Excellent intra- and inter-observer agreement was observed. However, the T1PA was found to vary greatly with pelvic position. Thus, to use T1PA as a valid postoperative outcome measure may not be appropriate.

### Hypothesis

T1 Pelvic Angle (T1PA) is a reliable and reproducible measure of sagittal spinal alignment in healthy adults and its value does not change based on pelvic position.

### Design

Reliability Analysis

### Introduction

Recent theory suggests that, compared to traditional parameters, the T1PA is a more reliable measure of global sagittal alignment. However, previous research focuses only on post-operative patients with known spinal deformity. Conclusions and targets for treatment using the T1PA are based on correlations with health related outcomes and quality of life measures. To date, there is no research on healthy subjects. The purpose of this study is to assess the reliability of this measurement in a population with no pre-existing spinal disorder and examine its relationship to pelvic position.

### Methods

Seven observers of varying orthopaedic experience digitally measured the T1PA in radiographs of 50 consecutive healthy adults in each of three pelvic positions: resting, anterior and posterior. Measurements were repeated after 4 weeks. Using intraclass correlation coefficients (ICC), the intra- and inter-rater agreement for the T1PA was analyzed. In addition, the T1PA was compared across radiographs for each subject to assess its accuracy and relationship to pelvic position.

### Results

There was a very high level of agreement in measurements of the T1PA, ICC ( $r=0.98$ ). At each pelvic position, all examiners had excellent intra-observer reliability ( $>0.85$ ). In comparison to a gold standard (measurements made by an expert fellowship trained spine surgeon), examiners consistently measured the T1PA within  $\pm 2$  degrees. Furthermore, the data shows that the T1PA changes with pelvic position,  $p<0.001$ .

### Conclusion

The T1 Pelvic angle is a reproducible and reliable measure of global sagittal alignment. Each observer accurately and consistently measured the T1PA, regardless of his or her level of training. However, the T1PA was found to vary significantly based on pelvic position. At baseline, a large variability with pelvic position between subjects existed. Thus, to use a target T1PA as a goal of surgical correction to obtain an expected clinical result may be questionable.





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T1 Pelvic Angle INTRA-Rater Reliability							
	Gold Standard	Attending Spine Surgeons		Senior Orthopaedic Surgery Residents		Junior Orthopaedic Surgery Residents	
		#1	#2	#1	#2	#1	#2
Neutral	0.95	0.86	0.99	0.99	0.98	0.95	0.99
Anterior	0.96	0.84	0.99	0.99	0.99	0.98	0.99
Posterior	0.98	0.83	0.99	0.99	0.99	0.98	0.99

T1 Pelvic Angle INTER-Rater Reliability							
Read #1		#1	#2	#1	#2	#1	#2
		Neutral	0.92	0.98	0.98	0.99	0.87
Anterior	0.86	0.98	0.99	0.98	0.83	0.99	
Posterior	0.91	0.98	0.98	0.97	0.90	0.98	

## 93. Combined Antero-Posterior Approach Does Not Increase the Risk of Proximal Junctional Kyphosis in Adult Spinal Deformity

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France

### Summary

This study compared adult patients with posterior only vs. antero-posterior (AP) approach. Results revealed that both approaches had similar % of proximal junctional kyphosis (PJK). However, AP approach had less fusion levels and more deformity correction.

### Hypothesis

Combined AP approach may increase PJK risk in adult spinal deformity (ASD).

### Design

Retrospective review of prospective multicenter ASD database.

### Introduction

Combined AP surgery was reported as the most important risk factor for developing PJK in adolescent scoliosis. However, PJK risk after anterolateral interbody fusion followed by posterior correction in ASD has not been evaluated.

### Methods

Inclusion criteria were ASD pts defined by the SRS-Schwab classification and 2 yr FU. Pts either underwent anterolateral interbody fusion followed by posterior correction (AP group, 9pts) or posterior correction only (P group, 35pts). T-tests were performed to compare surgical data, radiographic parameters and clinical outcomes between two groups. 10° threshold was used for PJK criteria.

### Results

44 patients were enrolled. AP and P groups had comparable baseline demographic (age (61 vs 63), gender, BMI) and surgical data (OR time, BMP use, iliac screw (100% vs 85%), rod material, LIV location). AP group had shorter fusion levels (10.3 vs. 6.1) and lower LIV location. More severe baseline deformity was observed in AP group (smaller LL and TK, greater PI-LL, TS-CL and TPA in AP group,  $p < 0.05$ ). At post-op and 1 yr, PI-LL and TPA were well corrected in both groups with similar PJA. PJK rates were similar at post-op (55.6% in AP group vs. 51.4% at P group), 1-year follow-up (50% vs 50%) and 2-year follow-up (57.1% vs 50%; all  $p > 0.05$ ). AP group had greater changes in the unfused TK in post-op period, but this difference disappeared at 1 yr. No difference exists in QOL between two groups at baseline, post-op, 1 yr and 2 yr FU.

## Conclusion

In shorter length fusions for ASD, combined antero-posterior approach may achieve better lumbar deformity correction than posterior fusion alone without increasing PJA or the incidence of PJK.

## 94. Relationship Between Knee Osteoarthritis and Spinopelvic Sagittal Alignment: Knee-Spine Syndrome

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Japan

### Summary

We investigated the relationship between severity of knee osteoarthritis using Kellgren-Lawrence (KL) grading scale and spinopelvic sagittal alignment. Cases with KL grade 4 knee OA had significant higher pelvic incidence-lumbar lordosis (PI-LL) mismatch and higher pelvic tilt (PT).

### Hypothesis

Knee osteoarthritis has significant correlation with poor spinopelvic sagittal alignment.

### Design

A radiographic study of high age volunteers.

### Introduction

Recent studies have reported that knee flexion is considered to be one of the compensatory mechanisms in case of sagittal malalignment. Usually, knee osteoarthritis assessed by KL grading which is evaluated by anteroposterior radiograph. Relationship between spinopelvic alignment in sagittal plane and knee osteoarthritis in coronal plane has not been well evaluated.

### Methods

In this IRB approved study, volunteers with age over 50 underwent radiographic analysis in Toei town. Whole-spine lateral radiograph and full length lower extremity anteroposterior radiograph in standing position were taken. Radiographic parameters (SVA, PI-LL, PT) were measured by spine surgeons and KL grading was assessed by joint surgeons. We investigated the difference of spinopelvic parameters in each KL grade by using Tukey multiple comparison.

### Results

In the present study, 391 volunteers (158 Male, 233 Female 74.4y.o.) were analyzed. Average of SVA, PI-LL, and PT were 22mm, 9.5°, and 21.2°, respectively. By KL grade evaluation, 39 classified as KL1, 93 as KL2, 152 as KL3, and 107 as KL4. Average age of KL1, 2, 3, and 4 were 74.1, 75.1, 72.7 and 76.3, respectively, and there was no significant difference among all groups. SVA in KL1, 2, 3, and 4 were 11, 22, 18, and 31mm, respectively, and there was also no significant difference among all groups. Average PI-LL in KL1, 2, 3, and 4 were 3.7°, 7.4°, 8.7°, and 14.4°, respectively. PI-LL in KL4 was significantly higher than other groups. Average PT in KL1, 2, 3, and 4 were 15.9°, 19.3°, 21.4°, and 24.6°, respectively. PT in KL4 was significantly higher than other groups, and PT in KL3 was significant higher than KL1.

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## Conclusion

High age volunteers with severe knee osteoarthritis (KL4) had poor spinopelvic sagittal alignment, especially pelvic retroversion has a strong relationship. Because there is the possibility that pelvic retroversion leads to hip external rotation and varus knee deformity, spinopelvic malalignment might have a significant relationship between knee osteoarthritis.

## 95. Risk of Total Hip Arthroplasty Dislocation after Adult Spinal Deformity Correction

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United States

## Summary

Adult spinal deformity (ASD) correction results in changes in acetabular anteversion. Spinopelvic fusion also reduces the protective motion of the pelvis between sitting and standing to prevent THA dislocation. Retrospective analysis revealed 42 patients with Total Hip Arthroplasty (THA) in-situ prior to ASD correction, 3 (7.2%) requiring revision for dislocation between 9 months and 2 years. All prostheses were previously stable, all were within Lewinnek's 'safe zone' and all patients were fused to the pelvis in their SSD correction.

## Hypothesis

Spinal deformity correction may result in dislocation of previously stable total hip arthroplasty (THA) due to changes in acetabular orientation and fixation to the pelvis.

## Design

Retrospective review of prospective database.

## Introduction

Osteoarthritis of the hip often co-exists with Adult Spinal Deformity (ASD). Debate exists whether spinal deformity correction or total hip arthroplasty (THA) should be performed first.

## Methods

Patients with previously implanted THA were identified from a prospective database of patients undergoing spinal realignment for ASD if they had a THA in situ prior to spinal realignment. Only patients with at least 6 months postoperative follow-up and visible THA prostheses were included. All postoperative imaging was reviewed until most recent follow-up to identify any changes in THA components. A further chart review was performed to determine the indication for all revised THAs. Acetabular orientation was measured pre- and post-SSD correction as were global and regional spinopelvic parameters.

## Results

Forty-two patients (53 THAs) met the inclusion and exclusion criteria. Twenty-seven of these patients underwent a 3-column osteotomy. Four patients (7.2% of patients - 5.7% hips) required revision of a THA after spinal realignment procedure: all revisions were for recurrent dislocation of the prosthesis. All had stable THAs prior to spinal realignment surgery. All acetabular components were within Lewinnek's 'safe zone' after ASD correction. The degree of sagittal

spinal correction was not significantly different between the revised and non-revised group, nor was the mean anteversion, inclination or amount of change in acetabular prosthesis alignment (Table 1). All hips requiring revision were fused to the pelvis as part of their SSD correction and 28 of the 37 (76%) of the non-revised patients were also fused to the pelvis.

## Conclusion

Dislocation of a previously stable THA is a potential complication after ASD correction. Instability may be a result of a combination of change in alignment of the acetabular prosthesis, as well as reduced spinopelvic motion from spinopelvic fusion.

	ALL PATIENTS										Acetabular Anteversion	Acetabular Inclination
	PI	SS	PT	PI-LL	LL	TK	SVA	T1SP	TPA			
Pre-ASD Correction	59.27	31.35	27.933	31.48	28.12	34.38	131.55	4.02	35.64		26.2	46.79
Post-ASD Correction	59.12	37.11	22.02	5.15	54.07	41.31	51.03	-2.5	19.75		20.52	44.4
Change	-0.15	5.76	-5.913	-26.33	25.94	6.93	-75.59	-6.56	-15.52		-5.4	-2.39
p-value	0.369	<0.001	<0.001	<0.001	<0.001	p<0.001	<0.001	<0.001	<0.001		<0.001	<0.001
REVISION FOR THA DISLOCATION												
	PI	SS	PT	PI-LL	LL	TK	SVA	T1SP	TPA		Acetabular Anteversion	Acetabular Inclination
Pre-ASD Correction	56.02	16.01	49.01	49.4	6.63	26.53	155.53	4.67	44.91		30.8	43.33
Post-ASD Correction	55.33	33.09	23.37	12.93	42.37	35.27	55.26	-2.55	24.07		24.91	43.33
Change	-0.69	17.08	-16.64	-36.47	35.74	8.74	-100.27	-7.22	-20.84		-6.69	0
p-value	0.054	0.07	0.07	0.039	0.059	0.008	0.028	0.194	0.083		0.102	0.333
THA NOT REVISED FOR DISLOCATION												
	PI	SS	PT	PI-LL	LL	TK	SVA	T1SP	TPA		Acetabular Anteversion	Acetabular Inclination
Pre-ASD Correction	59.52	28.82	30.7	30.14	29.73	34.97	129.25	5.97	34.92		25.99	46.84
Post-ASD Correction	59.41	37.41	22	4.57	54.94	41.76	50.81	-2.49	19.53		20.27	44.47
Change	-0.11	8.59	-8.70	-25.57	25.21	6.79	-78.44	-6.46	-15.39		-5.72	-2.47
p-value	0.411	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001		<0.001	<0.001
COMPARING DISLOCATION VS NO DISLOCATION												
	PI	SS	PT	PI-LL	LL	TK	SVA	T1SP	TPA		Acetabular Anteversion	Acetabular Inclination
p-value preop	0.35	0.055	0.075	0.02	0.025	0.212	0.307	0.45	0.071		0.211	0.324
p-value post-op	0.325	0.262	0.487	0.171	0.049	0.2	0.463	0.495	0.294		0.193	0.416
p-value change	0.37	0.068	0.057	0.147	0.157	0.408	0.215	0.499	0.049		0.234	0.349

Table 1: Perioperative changes in spinopelvic alignment and acetabular prosthesis orientation after ASD correction.

## 96. Spino-Femoral Muscles Affect Sagittal Alignment and Compensatory Recruitment: A New Look into Soft Tissues in Adult Spinal Deformity

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United States

## Summary

The muscular system plays an essential role in maintenance of postural alignment. However, few studies studied the impact of volume and fat infiltration of the spinal and hip muscles. Using novel 3D MRI reconstruction techniques and validated Dixon method, this study quantitatively suggested that the degeneration of the spinal flexors/extensors and hip extensors is associated with larger spinal malalignment, altered pelvic compensation, and worse clinical outcomes.

## Hypothesis

Spinal and hip muscle degeneration plays an essential role in spinal malalignment.

## Design

Prospective

## Introduction

The muscular system is necessary in the maintenance of postural alignment. Previous work linked spinal muscle degeneration to loss of lumbar lordosis, but was limited to cross-sectional muscle area. This study investigated the contribution of muscle degeneration to sagittal malalignment and compensatory mechanism recruitment.



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## Methods

Female ASD patients aged 35-80y with no history of spinal surgery or hip/knee instrumentation underwent standing X-rays and T1-weighted MRI from the proximal tibia up to the T12 vertebra. Using the Deformation of Parametric Specific Objects (DPSO) method, 3D reconstructions of 17 muscles, including extensors and flexors of spine, hip and knee, were obtained. Standardized muscle volume and percentage of fat infiltration (Pfat) were calculated. Lower volume and more Pfat indicated more muscle degeneration. Correlations were performed between classic spinopelvic radiographic parameters, muscle parameters, and HRQL.

## Results

22 ASD patients (mean 61 yo) were included. Significant correlations were observed between sagittal alignment and muscle parameters (Table). More fat infiltration of the hip and knee flexors and extensors correlated with greater C7-S1 SVA. Smaller spinal flexor/extensor volumes correlated with greater PI-LL mismatch ( $r=-0.45$  and  $-0.51$ ). Greater PT correlated with smaller volumes of spinal flexors and extensors, hip and knee extensors. Smaller volume of spine and hip extensors correlated with larger PT/PI (recruitment of pelvic compensation). SRS-22 image domain significantly correlated with Volume of Spine/Volume of leg ( $r=0.52$ ).

## Conclusion

Using novel MRI 3D reconstruction techniques, this pilot study is the first to quantify the relationship between degeneration of spinal flexors/extensors and hip extensors and sagittal malalignment. Muscle degeneration significantly limits pelvic compensation for spinal malalignment. Future surgical planning algorithms should incorporate patients' soft tissue profiles.

			PT	TPA	SVA	PI-LL	PT/PI
Volume	Spine Flexor	r	-0.53*	-0.48*	-0.24	-0.45*	-0.38
		P	0.01	0.02	0.29	0.04	0.08
	Spine Extensor	r	-0.51*	-0.41	-0.11	-0.51*	-0.62*
		P	0.02	0.06	0.63	0.02	0.00
	Hip Flexor	r	-0.40	-0.42*	-0.36	-0.37	-0.29
		P	0.06	0.05	0.10	0.09	0.19
	Hip Extensor	r	-0.47*	-0.38	-0.15	-0.30	-0.43*
		P	0.03	0.08	0.49	0.18	0.04
	Knee Flexor	r	-0.43*	-0.42*	-0.33	-0.39	-0.42
		P	0.04	0.05	0.14	0.07	0.05
	Knee Extensor	r	-0.48*	-0.52*	-0.45*	-0.48*	-0.35
		P	0.02	0.01	0.04	0.03	0.12
Pfat	Spine Flexor	r	0.12	0.19	0.29	0.35	0.36
		P	0.58	0.40	0.20	0.11	0.10
	Sext	r	0.31	0.38	0.44*	0.28	0.20
		P	0.17	0.08	0.05	0.21	0.38
	Hip Flexor	r	0.15	0.27	0.44*	0.32	0.31
		P	0.52	0.23	0.04	0.15	0.16
	Hip Extensor	r	0.15	0.31	0.49*	0.27	0.20
		P	0.50	0.17	0.02	0.23	0.37
	Knee Flexor	r	0.22	0.37	0.55*	0.35	0.26
		P	0.33	0.09	0.01	0.11	0.24
	Knee Extensor	r	0.28	0.42*	0.55*	0.35	0.29
		P	0.20	0.05	0.01	0.11	0.20

## 97. Towards the Development of a Global Core Outcome Set for Adult Spinal Deformity.

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### Summary

The COSSCO (Core Outcome Set for SCOLiosis) Study Group aims to reach evidence-based consensus, across global spine societies, about which patient-relevant outcome domains (e.g. physical function) and accompanying measurement instruments (e.g. SRS-22) are to be included in spine outcome registries and future clinical trials regarding patients with Adult Spinal Deformity (ASD) undergoing spinal surgery. This paper presents the results of phase 1, the systematic review of the literature.

### Hypothesis

International formal consensus can be reached on which outcomes and predictive factors should be included in core outcome sets for spinal deformity surgery.

### Design

Systematic review of the literature

### Introduction

In view of the growing ASD population, the frequency of spine-related interventions and accompanying costs are increasing. Policy makers are putting more emphasis on patient-driven healthcare with value creation as the overall goal. In particular for spinal deformity where a tremendous treatment variability exists, outcome monitoring by means of outcome registries would be of value. Outcome registries are most valuable if they include comparable outcomes that are relevant to the patient population of interest. Therefore, it is important to agree internationally upon the most important outcomes and the predictive factors contributing to these outcomes.

### Methods

This study ultimately consists of three phases: 1) a systematic review of patient-reported and clinician-based outcome measures used to evaluate outcomes after ASD surgery. We used the domains of the WHO International Classification of Disability, Functioning and Health (ICF) as a framework. 2) a modified three-round Delphi study among experts starting July 2016, and 3) validation with patient focus groups.

### Results

Phase 1. The systematic review has included 144 papers, 12 frequently used outcome measures were identified and were linked to a total of 43 potential ICF second-level core domains. Top three reported domains are: b280 Sensation of Pain, d450 Walking, and d850 Remunerative Employment. Domains were linked to the components activities and participation ( $n=19$ ), body function ( $n=16$ ), environmental factors ( $n=6$ ), and body structure ( $n=2$ ).

### Conclusion

Multiple outcome domains were identified (e.g. b134 Sleep Functions and d540 Dressing). In phase 2, using a modified Delphi method these potential outcome domains will be reduced to a core outcome set for ASD surgery. Identifying these core outcome domains will facilitate comparisons across

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studies, registries, and nations in order to improve the quality of daily clinical practice in adults undergoing spinal deformity surgery.

## 98. Predictors of Health-related Quality-of-Life After Complex Adult Spinal Deformity Surgery: A Scolio-RISK-1 Secondary Analysis

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United States

### Summary

Data from the Scolio-Risk-1 study showed that age, ASA grade, pre-op Cobb angle, number of three-column osteotomies and the occurrence of both neurologic and non-neurologic complications were predictive of two year HRQOLS after surgery for complex adult spinal deformity. Most of these factors are beyond the control of surgeons. Still, surgeons should medically optimize a patient prior to surgery to minimize the risk of complications and offer the best chance of improving a patient's quality of life.

### Hypothesis

There are variables that predict two-year SF-36 PCS and SRS22R Total score after surgery for complex adult spinal deformity.

### Design

Longitudinal Observational Cohort

### Introduction

Increasingly, treatment effectiveness is assessed by the extent that the procedure improves a patient's health-related quality-of-life (HRQOL). This is especially true in patients with complex adult spinal deformity.

### Methods

The dataset from the Scolio-Risk-1 was queried for patients with complete two-year SF-36 and SRS-22R. Regression analysis was performed to determine predictors of two-year SF-36 PCS and SRS-22R Total scores. Factors included were sex, age, smoking status, BMI, ASA grade, Lower Extremity Motor score improvement, indication for surgery, pre-op and two-year maximum coronal Cobb angles, number of prior spine surgeries, number of three-column osteotomies, number of surgical levels, number of surgical stages, lowest instrumented level, presence and type of neurologic complication and number of reported serious adverse events (SAE).

### Results

Of 279 cases enrolled, 206 (74%) cases were included in this analysis, 143 (69%) females, mean age of 57.7 years. Factors predictive of two-year SF-36 PCS were age ( $p < 0.001$ ), ASA grade ( $p < 0.001$ ), maximum pre-op Cobb angle ( $p = 0.007$ ), number of three-column osteotomies ( $p = 0.049$ ) and type of neurologic complication ( $p = 0.068$ ). Factors predictive of two-year SRS22R Total scores were maximum pre-op Cobb angle ( $p = 0.001$ ) and the number of SAEs ( $p = 0.071$ ).

### Conclusion

Factors predictive of two year HRQOLS after surgery for complex adult spinal deformity were age, ASA grade, pre-op Cobb angle, number of three-column osteotomies and the occurrence of both neurologic and non-neurologic complications. Most of these factors are beyond the control of surgeons. Still, surgeons should medically optimize a patient prior to surgery to minimize the risk of complications and offer the best chance of improving a patient's quality of life.

## 99. The Seattle Spine Team Predictive Risk Model for 30-Day Postoperative Complications in Adult Spinal Deformity Surgery.

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United States

### Summary

Adult spinal deformity surgery carries with it substantial complication risk. The predictive risk algorithm developed here enables the calculation of the likelihood that a patient will experience complications within 30 days of undergoing adult lumbar scoliosis surgery involving six or more levels of fusion, based on routinely collected preoperative information.

### Hypothesis

The likelihood of 30-day postoperative complications in adult lumbar scoliosis surgery can be predicted using a set of routinely measured preoperative independent variables.

### Design

The study was designed as a retrospective analysis.

### Introduction

The assessment of risk in adult lumbar scoliosis surgery is based primarily on retrospective percentage statistics and surgeon judgment. This study aimed to build a data-driven predictive model to accurately ascertain the likelihood of a patient experiencing complications within 30 days of undergoing adult lumbar scoliosis surgery.

### Methods

Data was collated for 107 cases where 6 or more levels were fused. Logistic regression was conducted. Independent variables included age, BMI, gender, smoking status, and the presence or absence of preoperative hypertension, anxiety, depression, bipolar, diabetes and anemia. Complications included readmission to the hospital, pneumothorax, pneumonia, wound infection, wound dehiscence, UTI, return to surgery and death. The presence of any complication was coded 1 and absence was coded 0.

### Results

The model was significant ( $\chi^2(10) = 31.35, p < .01$ ) and performed well (figure 1, ROC area = 0.827,  $p < .01$ ), predicting postoperative complications with 81.3% accuracy.

Log odds(30DayComplications=1) =  $-9.93 + 0.05(\text{Age}) + 0.51(\text{Sex}) + 1.61(\text{Smoking}) + 0.13(\text{BMI}) - 0.68(\text{Hypertension}) + 0.31(\text{Anxiety}) + 0.91(\text{Depression}) + 3.25(\text{Diabetes}) + 2.13(\text{Bipolar}) + 2.59(\text{Anemia})$



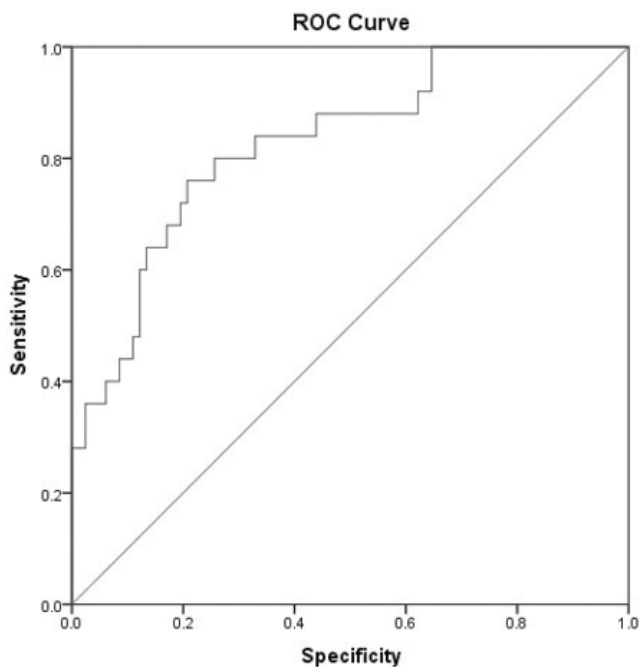


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The strongest predictors were BMI ( $B=1.133$ ,  $p<.05$ ), smoking status ( $B=1.61$ ,  $p<.05$ ) and diabetes ( $B=3.25$ ,  $p<.05$ ). The odds ratio for the smoking coefficient was 5.02. Patients classified as former smokers were five times more likely to have complications. The odds ratio for the diabetes coefficient was 25.84. Patients with diabetes were 26 times more likely to have complications. Our model predicted a BMI cutoff of 38, above which, patients had complications.

## Conclusion

These results facilitate more accurate preoperative risk assessment. This algorithm can be used to develop a live decision support tool for use in the multidisciplinary conference setting, thus applying real-time quantitative risk assessment approaches to enhance safety.



## 100. Predictors of Mortality Following Odontoid Peg Fractures in the Elderly

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### Summary

Mortality rates as high as 25-30% has been described following odontoid peg fractures in the elderly. The cause of this is not completely understood. Variables could be recognized in these patients on admission which can help identifying those with high risk of mortality. This will help guide both spinal and multidisciplinary team in their management to improve survival.

### Hypothesis

Presence of easily identifiable variables present on admission are associated with mortality following odontoid peg fractures in the elderly.

## Design

A retrospective review of consecutive elderly patients presenting with odontoid peg fracture following low impact injury.

## Introduction

Mortality rates as high as 25-30% has been described following odontoid peg fractures. The aim of this study is to examine if easily identifiable variables present on admission which are associated with mortality

## Methods

A consecutive series of 83 patients with odontoid peg fractures following low-impact injuries in patients over the age of 65 years was identified. These were retrospectively reviewed including demographics, past medical history and admission serum investigations. Radiological investigations were used to assess fracture classification and displacement. Treatment received was reviewed.

## Results

The average age was 82.9 years with most patients suffering a type 2 fracture 79.5% (66 patients). Neurological deficit was present in 13.3% (11 patients). The rate of mortality was 16% (13 patients) at thirty days increasing to 24% (20 patients) at one year. A low haemoglobin count and the presence of neurological deficit were independent predictors of thirty day mortality on binary logistic regression analysis. Similarly, low haemoglobin, admission from an institution, neurological deficit and type 3 fractures were found to be independent predictors of mortality at one year.

## Conclusion

We suggest that these easily recognizable predictors present on admission can be utilised to identify patients at high risk and guide both spinal and multidisciplinary team management to improve survival.

## 101. Are "Unstable" Burst Fractures Really Unstable? Comparison of Denis Classification and TLICS

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### Summary

This study analyzed burst fracture to compare the need of surgical treatment according to the Denis classification and TLICS. In Denis classification, 78.1% of patients showed unstable fracture while 69.1% of patients showed TLICS score 4 or more. There are differences between two classification systems and careful evaluation of patients are mandatory.

### Hypothesis

Interpretation of thoracolumbar fracture are different between various classification systems.

### Design

Retrospective analysis of radiology studies and medical records.

### Introduction

The stability is an important factor to decide the treatment plan in thoracolumbar burst fracture patients. Patients with an unstable burst fracture generally need operative management. On the other hand, in thoracolumbar injury classification system (TLICS), surgery is recommended in patients with



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TLICS of 4 or more points. The purpose of this study was to apply the TLICS score in patients with thoracolumbar burst fractures and to distinguish the differences of treatment plan on burst fracture

## Methods

All patients diagnosed as a thoracolumbar burst fracture between January, 2006 and February, 2015 were included in this study. Unstable thoracolumbar burst fracture was defined as burst fracture with neurologic deficit, three-column injury, kyphosis over 30 degrees, decrease of anterior body height over 40 percent and canal compromise more than 50 percent. TLICS score was measured with morphology, neurological involvement and posterior ligamentous complex (PLC) integrity. The existence of instability was compared with TLICS score.

## Results

Total 233 (131 men, 102 women) patients were included in this study. Their mean age was 52.9 year-old (range 15 - 83). In Denis classification, 51 patients (21.9%) diagnosed as stable burst fracture while 182 patients (78.1%) had unstable burst fracture. According to TLICS, 72 patients (30.9%) scored less than 4, while 161 patients (69.1%) scored 4 or more. All the patients with stable burst fracture scored 2 in TLICS. Among unstable burst fracture patients, 21 patients (11.5%) scored 2 in TLICS.

## Conclusion

Although the unstable thoracolumbar burst fracture was regarded as a critical factor for surgical intervention, therapeutic strategies by TLICS do not exactly match with the concept of instability. According to the concept of TLICS, it should be reconsidered whether the unstable burst fractures are truly unstable that need of operation.

## 102. Upper Cervical and Infra-cervical Compensation in Cervical Deformity Patients

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United States

## Summary

Compensatory mechanisms have been well studied for thoracolumbar deformity patients but not for primary cervical deformity (CD) patients. CD Patients with progressively larger C2-C7 SVA (cSVA) had a progressive increase in the upper cervical lordosis (CO-C2A) and pelvic tilt (PT), whereas patients with increasing cervical kyphosis compensated primarily with upper cervical hyperlordosis. There was no significant lower thoracic, or lumbar compensation noted in the groups. With correction of the cervical deformities, there was relaxation of the upper cervical compensation.

## Hypothesis

CD patients recruit upper cervical and infra-cervical compensation to maintain horizontal gaze and standing alignment

## Design

Prospective cohort study

## Introduction

Compensatory mechanisms for standing alignment have been described in thoracolumbar deformity. Such mechanisms have not been studied prospectively in patients with primary cervical deformity.

## Methods

Global spinal alignment was studied in a prospective database of operative cervical deformity patients. Inclusion criteria were cervical kyphosis (CK)  $>10^\circ$ , cervical scoliosis  $>10^\circ$ , cSVA  $>4$ cm or chin-brow vertical angle  $>25^\circ$ . Patients were sub-classified by the severity of their cSVA (Groups A: 0-4cm, B: 4-6cm, C:  $>6$ cm) and cervical kyphosis (Groups D: lordotic, E:  $0-10^\circ$ , F:  $>10^\circ$ ). The groups were compared for preoperative upper- and infra-cervical compensatory alignment.

## Results

93 CD patients (mean age 62 yrs, 66% female, 41% revisions, min f/u 3 mo.) were included. Patients with progressively larger cSVA had a progressive increase in the upper cervical lordosis (A= $36^\circ$ , B= $42^\circ$ , C= $45^\circ$ ,  $p=.005$ ), C2Slope (A= $29^\circ$ , B= $37^\circ$ , C= $53^\circ$ ,  $p<.001$ ) and PT (A= $16^\circ$ , B= $22^\circ$ , C= $23^\circ$ ,  $p=.04$ ). These patients had progressively more thoracic kyphosis (A= $36^\circ$ , B= $52^\circ$ , C= $63^\circ$ ,  $p<.001$ ) and CT junctional deformity (TS-CL: A= $27^\circ$ , B= $41^\circ$ , C= $54^\circ$ ,  $p<.001$ ). As the C2-C7 kyphosis increased, there was a progressive increase in the upper cervical lordosis (D= $36^\circ$ , E= $39^\circ$ , F= $45^\circ$ ,  $p=.01$ ), and C2Slope (D= $30^\circ$ , E= $31^\circ$ , F= $45^\circ$ ,  $p=.01$ ). There was no significant lower thoracic, or lumbar compensation in the groups. Postoperatively at 3 months, there was a significant improvement in cSVA (4.8 to 3.9cm,  $p=.001$ ), cervical kyphosis (1.8 to  $-9.5^\circ$ ,  $p=.001$ ) with resultant relaxation of upper cervical lordosis (38 to  $34^\circ$ ,  $p=.01$ ).

## Conclusion

Primary cervical deformity patients with increasing cSVA compensate with both upper cervical hyperlordosis and increased pelvic tilt for the maintenance of horizontal gaze and standing alignment. Patients with increasing cervical kyphosis increase their upper cervical lordosis but do not recruit pelvic retroversion. Postoperatively, with improvement in cervical sagittal alignment there was relaxation of upper cervical compensation.

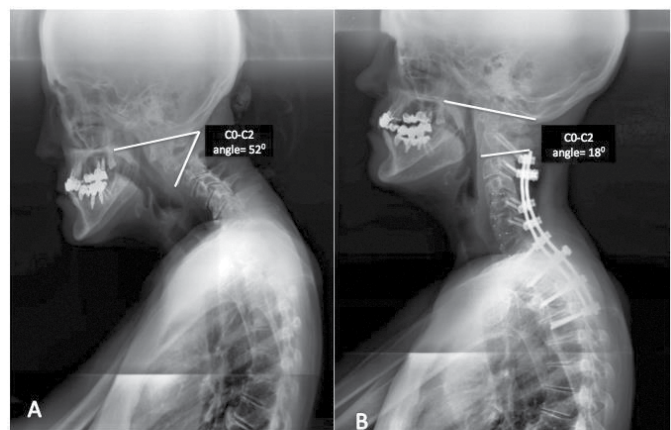


Figure: A. Preop. cervical radiographs of a patient with cervical kyphosis and upper cervical hyper-lordosis. B. Following deformity correction there is resolution of the upper cervical compensation.



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## 103. Characterization and Outcomes of Combat-Related Spinal Cord Injuries Requiring Operative

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### Summary

We characterized the incidence and outcomes of patients sustaining combat-related spinal cord injuries. We found a high rate of SCI (29.5%) and a high rate of complete injuries. Patients with complete injuries did not recover, and most patients with SCI were medically retired.

### Hypothesis

A high percentage of operative combat-related spine trauma involves spinal cord injuries, and the outcomes of these patients are poor.

### Design

Retrospective analysis

### Introduction

Few studies examining combat-related spine trauma have described clinical follow-up after complete and incomplete spinal cord injuries (SCI). We set out to characterize combat-related SCI, and report outcomes following operative treatment.

### Methods

We performed a retrospective analysis of a surgical database at three military institutions. Patients undergoing spine surgery following a combat-related spinal cord injury in Operations Enduring and/or Iraqi Freedom between July 2003 and July 2013 were evaluated. Medical records and radiographic images of identified patients were reviewed for demographic information, mechanism of injury, characterization of spine injuries, neurologic examination, and work/return to duty.

### Results

Our review identified 105 casualties requiring definitive surgical management for combat-related spine injuries after return to the United States. Thirty-one (29.5%) of these patients sustained complete or incomplete spinal cord injuries, including four patients with injuries isolated to the conus medullaris or cauda equina. Almost half sustained complete (ASIA A) SCI. The most common mechanism of injury was gunshot wound (45.2%). Average length of follow up after injury was 27.8 months. There was no significant recovery of function in the remainder of ASIA A patients. 42.0% of patients had been medically retired at the time upon most recent follow up, and the average time from injury to retirement was 20.1 months.

### Conclusion

Almost one-third of patients sustaining operative spine trauma also had a spinal cord injury in this population. We found that ballistic penetrating trauma was the most common mechanism of injury, and no patients sustaining an ASIA A SCI had any significant functional recovery after injury. Almost half of all patients sustaining any SCI were unable to return to duty. These patients represent a severely injured population, and have a poor prognosis.

## 104. Long-term Survival after Surgical Treatment of Spinal Metastasis: The Predictive Role of Gender

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Denmark

### Summary

The role of gender as an independent predictor of long-term survival after surgical treatment of spinal metastasis has not been reported.

A prospective database including 58 operated patients for spinal metastasis with 10-years survival-status follow-up.

Survival time was significantly longer for women compared to men; 32 vs. 10 months ( $P < 0.05$ ). Hazard-ratio for womens survival time was 2.12 ( $P < 0.01$ ).

These results could indicate that gender should be included in pre-operative scoring systems used for patients with spinal metastasis.

### Hypothesis

The hypothesis of the presents study was that that gender is an independent predictor of long-term survival after surgical treatment of patients with symptomatic spinal metastasis.

### Design

Prospective study.

### Introduction

An increasing number of patients are undergoing surgical treatment for symptomatic spinal metastasis, and evidence suggests that surgical treatment followed by radiation in selected patients may preserve neurological function for a longer period of time compared to radiation therapy alone. Numerous pre-operative scoring systems based on clinical and imaging variables have been suggested, but the possible role of gender as an independent predictor of survival has not been reported. Since 2005 the Spine Unit, Rigshospitalet, has been responsible for the treatment of patients with acute symptoms of spinal metastasis and serves as a referral unit for the Eastern half of the country. This unique organization makes it possible to obtain important data regarding long-term outcome in these patients.

### Methods

A prospective database including all patients referred with acute symptoms of spinal metastasis was established in 2005. Relevant variables were registered including age, gender, and primary oncologic diagnosis. From January through December 2015 the survival status of all patients was obtained through the Central Office of Civil Registration.

### Results

A total of 58 patients were operated in 2005. The average age of the patients was 63 years and 55% were males. At ten-years follow-up 55 patients had died and the average survival time after surgery was 20 months. Survival time was significantly longer for women compared to men; 32 vs. 10 months ( $P < 0.05$ ). The hazard-ratio for womens survival was 2.12 ( $P < 0.01$ ). This difference remained significant after adjusting for specific primary tumors and operation-age.

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## Conclusion

In spite of the small sample size, these results could indicate that gender should be included in pre-operative scoring systems used for patients with spinal metastasis.

## 105. Costs and Readmissions Rates for the Surgical Resection of Primary and Metastatic Spinal Tumors: A Comparative Analysis of 181 Patients

Darryl Lau, MD; Alexander Theologis, MD; Dean Chou, MD; Praveen V. Mummaneni, MD; Shane Burch, MD; Sigurd H. Berven, MD; Vedat Deviren, MD; Christopher P. Ames, MD

United States

## Summary

This study compares direct costs and 90-day readmission rates between surgical resection of metastatic and primary spinal tumors. Overall mean cost was \$52,083 and 90-day readmission rate was 11.6%. There was no difference in costs and readmission rates between primary and metastatic tumors when taken other factors into account. Costs are influenced by health status, complexity of surgery, and postoperative course.

## Hypothesis

There is no difference in cost based on tumor diagnosis; rather perioperative factors and surgical technique influence cost. Readmission rate is higher in patients with metastasis.

## Design

Retrospective review and comparison of consecutive patients.

## Introduction

As surgical strategies for primary and metastatic spinal tumors are different, respective associated costs and morbidities associated with those treatments may vary.

## Methods

Adults who underwent surgical resection of spinal tumors between 2008 and 2013 were studied. Direct costs of index hospitalization and 90-day readmission rate were compared between patients with primary and metastatic tumors. Independent factors were identified using multivariate analysis.

## Results

A total of 181 patients were included: 63 primary and 118 metastatic. Mean index hospitalization cost was \$52,083. There was no significant difference in cost between primary (\$55,801) and metastatic (\$50,098) tumors ( $p=0.426$ ). Independent factors associated with higher cost were: male gender ( $p=0.032$ ), preoperative inability to ambulate ( $p=0.002$ ), more than 3 comorbidities ( $p=0.037$ ), corpectomy ( $p=0.021$ ), instrumentation greater than 7 levels ( $p<0.001$ ), combined anterior-posterior approaches ( $p<0.001$ ), presence of complication ( $p<0.001$ ), and longer stay ( $p<0.001$ ). Perioperative complication rate was 21.0%. Of this cohort, 11.6% were readmitted within 90-days and mean hospitalization cost of readmission was \$20,078. Readmission rates between primary and metastatic tumors were similar (11.1% vs. 11.9%) ( $p=0.880$ ). Prior hospital stay greater than 15

days (OR 6.62,  $p=0.016$ ) and diagnosis of lung metastasis (OR 52.99,  $p=0.007$ ) were independent predictors of readmission.

## Conclusion

Primary and metastatic spinal tumors have similar index surgical hospitalization cost and 90-day readmission rate. Factors independently associated with costs relate to health status, complexity of surgery, and postoperative course.

## 106. Clinical Significances of Preoperative Embolization for Metastatic Spine Disease

Young-Hoon Kim, MD, PhD; Kee-Yong Ha, MD, PhD; Jaewon Lee; Sang-Il Kim, MD Korea

## Summary

Preoperative embolization for metastatic spine lesions did not present favorable results in reduction of perioperative blood loss. However, identification of the major feeder artery of the spinal cord in the involved lesions could provide more information for the management of metastatic spine diseases.

## Hypothesis

Preoperative transarterial embolization for metastatic spine diseases other than renal or thyroid cancer, decreases perioperative blood loss.

## Design

A retrospective cohort study

## Introduction

Preoperative transarterial embolization for metastatic spine diseases with hypervascular tumors such as renal cell or thyroid cancer, is generally recommended to reduce perioperative blood loss and morbidity. However, there was still debate on the efficacy of preoperative embolization for other metastatic spine lesions.

## Methods

76 (25 preoperative embolization and 51 non-embolization) patients with metastatic spine lesions other than thyroid and renal Ca were enrolled. The average patient age was  $54.9 \pm 13.5$  years of 64 men and 12 women. Intraoperative and perioperative (the amount of drain for postoperative 2 days) estimated blood losses (EBL) were investigated with the amount of transfused packed red blood cells. The differences in EBL along the type of surgery, the incidence of the Adamkiewicz artery and complications were assessed for investigating the clinical significances of preoperative embolization.

## Results

Lung (33%), hepatocellular (24%), gastrointestinal (22%) and others (21%) were the primary cancers. Corpectomy was done for 34 patients (45%), and palliative laminectomy was performed in 42 patients (55%). There was no significant difference in intraoperative EBL, perioperative EBL and transfusion amount by preoperative embolization. The type of surgery did not also showed significant differences in intraoperative or perioperative EBL along the preoperative embolization. Complications by embolization were not noted in any patients. However, the Adamkiewicz artery was noted in two patients (8%) with thoracolumbar lesions. Disruption of this major feeder artery made significant changes in intraoperative neuromonitoring.





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## Conclusion

Preoperative embolization for metastatic spine lesions did not present favorable results in reduction of perioperative blood loss. However, identification of the major feeder artery of the spinal cord in the involved lesions could provide more information for the management of metastatic spine diseases.

Table 1. Estimated blood loss between the two groups

	No-embolization (n=51)	Embolization (n=25)	P value
Intraoperative EBL	1276.5 ± 1643	1365 ± 1310	NS
Perioperative EBL	499.6 ± 286.7	495.4 ± 574.6	NS
N. of transfused PRC	3.9 ± 4.6	4.8 ± 3.1	NS
Cal. EBL	4.9 ± 4.7	5.4 ± 3.9	NS

EBL, estimated blood losses; PRC, packed red blood cells; Cal. EBL, calibrated estimated blood losses

Table 2. Estimated blood loss between the two groups according to type of surgery done

	Corpectomy			Laminectomy		
	No embol (n=16)	Embol (n=18)	P value	No embol (n=36)	Embol (n=9)	P value
Intraoperative EBL	1350 ± 1494.4	1366.6 ± 1390.7	NS	941 ± 804.7	1070 ± 1136.2	NS
Perioperative EBL	518.7 ± 365.6	557.9 ± 662.2	NS	491.1 ± 251.3	385.6 ± 230.1	NS
N. of transfused PRC	4.1 ± 4.6	4.6 ± 3.1	NS	3.2 ± 2.6	3.5 ± 2.7	NS
Cal. EBL	4.7 ± 4.1	4.9 ± 3.7	NS	4.4 ± 2.9	3.7 ± 3.3	NS

## 107. The Accuracy of Prognostic Scoring Systems in Predicting Survival of Lung Cancer Patients with Spinal Metastases

Jiong Hao Jonathan Tan Jiong Hao Tan; Kimberly-Anne Tan; Aye Sandar Zaw, MBBS, MPH; Naresh Kumar, FRCS

Singapore

### Summary

The best system among modified Tokuhashi, Tomita, modified Bauer and Oswestry scores for predicting survival in patients with lung cancer spinal metastases remains undetermined. Our study showed that although better prognostic scores correlated with longer survival, all four scoring systems are inaccurate in prognosticating patients with lung cancer spinal metastases. Specific lung cancer histology appears prognostic and should be given consideration especially given the increased survival of patients receiving new targeted therapies appropriate to their disease.

### Hypothesis

All the present prognosticating scoring systems are inaccurate in predicting survival for patients with lung cancer spinal metastases. This is primarily due to better understanding of histological subtypes & response to newer chemotherapeutic agents.

### Design

Retrospective analysis

### Introduction

The modified Tokuhashi, Tomita, modified Bauer and Oswestry scores are currently used to guide decisions regarding operative treatment of patients with spinal metastases. The best system for predicting survival in patients with lung cancer spinal metastases remains undetermined. We aimed to evaluate these scoring systems in patients with spinal metastases from lung cancer.

### Methods

The study included 180 patients with lung cancer spinal metastases treated at our institution between May 2001 and August 2012. The primary outcome measure was survival from the time of diagnosis.

Scoring-predicted survival was compared with actual survival. Potential prognostic factors were investigated using Cox regression analyses. Predictive values of each scoring system for 3 and 6-month survival were measured via receiver operating characteristic (ROC) curves.

## Results

51 patients were treated surgically. Histological subtype ( $p=0.015$ ), gender ( $p=0.001$ ), Karnofsky performance scale ( $p=0.001$ ), extent of neurological palsy ( $p=0.002$ ) and visceral metastases ( $p=0.037$ ) are significant predictors of survival. Besides the Oswestry spinal risk index, no significant differences were found between different prognostic subgroups within the individual scoring systems. Although the modified Bauer score was most accurate, all 4 scoring systems had areas under the ROC curve  $\leq 0.5$ .

## Conclusion

Although better prognostic scores correlated with longer survival, all four scoring systems are inaccurate in prognosticating patients with lung cancer spinal metastases. Specific lung cancer histology appears prognostic and should be given consideration especially given the increased survival of patients receiving new targeted therapies appropriate to their disease.

## 108. Functional Outcome of IS Patients

Yang Junlin, MD, PhD; Huang Zifang, MD, PhD  
China, People's Republic of

### Summary

Longer spinal fusions have been shown to result in improved deformity correction. However, loss of normal flexibility in the fusion area should not be ignored. Current consensus was to achieve a shorter fusion while preserving as much of the distal motion segment as possible. However, the correlation between the length of fusion and functional outcome remains controversial. To the best of our knowledge, few previous study has demonstrated the function outcomes and the differences in HRQoL with specific fusion levels.

### Hypothesis

The motion segments preserved strongly correlated with lumbar mobility. Less fusion levels can preserve better lumbar flexibility by keeping more motion segments

### Design

This is a cross-sectional study in patients with idiopathic scoliosis treated with all pedicle screw instrumentation and spinal fusion.

### Introduction

Longer spinal fusions have been shown to result in improved deformity correction, however, loss of normal flexibility in the fusion area should not be ignored. Current consensus was to achieve a shorter fusion while preserving as much of the distal motion segment as possible. However, the correlation between the length of fusion and functional outcome remains controversial. Hitherto, few previous study has demonstrated the function outcomes and the differences in HRQoL with specific fusion levels.

### Methods

172 patients (mean age, 17.8 y) with idiopathic scoliosis treated by spinal fusion (mean time since surgery, 29.7 mo) were included. Patients were

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assigned to 5 groups according to the lower instrumented vertebra (LIV) level: group A (fusion above L2) 26 patients; group B (fusion to L2) 21 patients, group C (fusion to L3) 46 patients, group D (fusion to L4) 53 patients and group E (fusion to L5) 26 patients. At each follow-up, patients were asked to complete the Scoliosis Research Society 22 (SRS-22) Questionnaire. Lumbar mobility was assessed using a dual digital inclinometer.

### Results

Average spinal range of motion (ROM) was 41.4 degrees (SD, 20.7), forward flexion was 29.2 degrees (SD, 15.0), and backward extension was 12.2 degrees (SD, 9.5). The total spinal range of motion and forward flexion dropped noticeably as the LIV got more distal. Statistically significant between-group differences (One-way ANOVA) were found for ROM ( $P<0.001$ ), forward flexion ( $P<0.001$ ) or backward extension ( $P<0.001$ ). The motion segments preserved significantly correlated with ROM ( $r=0.76$ ,  $P<0.001$ ), ROMF ( $r=0.76$ ,  $P<0.001$ ) and ROME ( $r=0.39$ ,  $P<0.001$ ). However, no significant between-group differences was found for each domain of SRS-22 questionnaire.

### Conclusion

The motion segments preserved strongly correlated with lumbar mobility. Less fusion levels can preserve better lumbar flexibility by keeping more motion segments.

### 109. Three-column Osteotomy for Correction of Cervical Deformity: Alignment Changes and Early Complications in A Multicenter Prospective Series of 24 Patients

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United States

### Summary

Based on prospective data for 24 adult cervical deformity (ACD) patients treated with three-column osteotomy (3CO; pedicle subtraction osteotomy [PSO] or vertebral column resection VCR), 17 (71%) had at least one complication (6minor/19major) within 90 days of surgery. The most common complications were excessive blood loss ( $>1.7L$ ), neurologic deficit, distal junctional kyphosis (DJK), wound infection, and cardiorespiratory failure. Cervical alignment improved significantly following 3CO, including cervical lordosis (CL), C2-7 sagittal vertical axis (SVA), and T1 slope minus CL (TS-CL).

### Hypothesis

Prospective assessment of ACD patients treated with 3CO will demonstrate significant improvement of alignment but high complication rates.

### Design

Review of prospectively collected multicenter consecutive case series.

### Introduction

Although 3CO can provide powerful alignment correction and disability improvement in ACD, these procedures are complex and have high complication rates.

### Methods

ACD patients treated with 3CO with minimum 90-day follow-up were identified from a prospectively collected multicenter ACD database. Complications within 90-days of surgery were collected. Baseline and 90-day standing radiographs were obtained.

### Results

All 24 ACD patients treated with 3CO (15 PSO/9 VCR) had minimum 90-day follow-up (71% women, mean age 62 yrs, previous surgery in 54%). Diagnoses included: cervical sagittal imbalance (92%), cervical kyphosis (38%), proximal junctional kyphosis (17%), coronal deformity (8%) and distal junctional kyphosis (4%). The mean number of posterior fusion levels was 13, and 4% also had an anterior fusion. The most common 3CO levels were T1 (38%), T2 (29%) and T3 (21%). A total of 25 (19 major/6 minor) complications were reported, with 14 (58%) and 6 (25%) patients affected, respectively. Overall, 17 (71%) patients had at least one complication. The most common complications were excessive blood loss ( $>1.7L$ , 25%), neurologic deficit (17%), DJK (8%), wound infection (13%) and cardiorespiratory failure (8%). 4 (17%) patients required re-op within 90-days (2 for nerve root motor deficit, 1 deep wound infection, 1 implant pain/prominence). Cervical sagittal alignment improved significantly following 3CO: CL (3 to 13°,  $p=.031$ ), C2-7 SVA (66 to 44mm,  $p<.001$ ) and TS-CL (46 to 27°,  $p<.001$ ).

### Conclusion

Among 24 ACD patients treated with 3CO, cervical sagittal alignment improved significantly following surgery. Overall, 17 (71%) patients had at least one complication (19 major/6 minor). The most common complications were excessive blood loss ( $>1.7L$ ), neurologic deficit, DJK, wound infection and cardiorespiratory failure.

### 110. Compensation Mechanism in Thoraco-Lumbar Segments in Patients with Symptomatic Primary Cervical Kyphosis

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Japan

### Summary

This study mentions correlation between cervical deformity and cervical regional sagittal imbalance, and also mentions compensation mechanism of thoraco-lumbar segment in patients with symptomatic primary cervical deformity.

### Hypothesis

Cervical spine deformity may affect global sagittal balance.





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## Design

A retrospective multi-center study was conducted. Patients with primary cervical kyphosis on full-length standing radiographs were enrolled (C-group: N=103). All patients had primarily cervical symptoms and underwent cervical reconstruction surgery. Age and gender matched patients were selected from the adult spinal deformity database (TL-group: N= 119).

## Introduction

While previous studies have defined cervical kyphosis in terms of regional kyphosis or chin-brow angle, cervical kyphotic deformity as it relates to global sagittal balance has not been well studied. Also Correlation between cervical kyphosis and cervical sagittal imbalance has not been elucidated.

## Methods

Spino-pelvic parameters including thoracolumbar junctional parameters were compared between C-group and TL-group. In addition, the C-group was divided into two sub-groups and assessed according to C7-SVA (positive: C7P, negative: C7N)

## Results

C-group had a larger LL and TK than the TL-group ( $P<0.0001$ ,  $P=0.023$ ). C7-SVA was shorter in C-group (-2.0cm) than TL-group (6.6 cm,  $P<0.0001$ ). Cervical kyphosis and Center of gravity of the head (COG) -C7SVA, was correlated ( $R^2=0.419$ ,  $p<0.0001$ ). Cervical kyphosis correlated with more severe cervical sagittal imbalance. According to comparison between C7N and C7P, The C7N had a shorter COG-SVA 32.9mm as compared to C7P 115.9mm  $P<0.0001$ . There was a statistical significant difference in TK8-12 (10.1 and 16.2:  $P=0.011$ ), T10-L2 (1.1 and 7.5:  $p=0.027$ ), LL4-S (-34.6 and -26.6:  $p=0.0036$ ), LL (-57.1 and -41.5:  $p<0.0001$ ) and PI-LL (-2.2 and 10.0:  $p=0.0003$ ), and C7-SVA (-49.5 and 45.1:  $p<0.0001$ ), respectively. These results indicate that C7N had larger lumbar lordosis compensation, a more straight thoraco-lumbar junction, and larger thoracic kyphosis allowing for overall global balance of the head.

## Conclusion

Patients with cervical kyphosis, modify their global spinal alignment to keep their balance including head position. However, even for patients with primary cervical pathology, relatively large PI-LL becomes to affect to the compensation mechanisms.

## 111. Complications and Reoperation Rate Following Cervical Lateral Mass Screw Fixation

*Daniel G. Kang, MD; Jacob M. Buchowski, MD, MS; Panya Luksanaprukpa, MD; Ronald A. Lehman, Jr., MD; K. Daniel Riew, MD*

*United States*

## Summary

This retrospective analysis evaluates the complication and reoperation rate following lateral mass screw fixation. We report one of the largest series of lateral mass screw fixation complications, and found a low rate of complications requiring reoperation (7.1%) over a 15 year period. There was also a low rate of screw malposition, with none requiring reoperation. Overall,

lateral mass screw fixation is an effective and safe method of posterior cervical fixation.

## Hypothesis

Lateral mass screw (LMS) fixation will have a low rate of complications and reoperation.

## Design

Retrospective analysis

## Introduction

There has been limited reports on complications following LMS fixation of the posterior cervical spine. This study evaluates the complication and reoperation rate following LMS fixation.

## Methods

Analysis of consecutive series of patients following posterior spinal fusion, with placement of LMS fixation between C3 to C7 from a single center, single-surgeon between 2000-2014. All charts, records and imaging studies were reviewed for each patient, and pre-operative and final follow-up plain films were evaluated. Postoperative CT scans when available were reviewed for screw positioning, noting facet joint, foraminal or foramen transversarium violation.

## Results

Overall, we found 168 patients (102 M and 66 F) with LMS fixation as part of their posterior spinal fusion construct, with a total of 1040 LMS placed. Mean patient age was  $56.9\pm 4.5$  y/o, with mean BMI  $28.9\pm 6.5$ , and mean XR follow-up of 2.1 years. In regard to primary diagnosis, 29 patients had pseudarthrosis, 38 with radiculopathy, 16 with myelopathy, 23 with myeloradiculopathy, 26 cervical spondylosis. Other secondary diagnoses included 21 with trauma, 5 tumor, 13 deformity, 13 with OPLL and 4 with RA. Overall there were on average 5.4 posteriorly fused levels, with 203 LMS at C3, 213 LMS at C4, 240 LMS at C5, 231 LMS at C6, and 153 LMS at C7. There were 54 pts (32.1%,  $n=323$  LMS) with postoperative CT, and 5 screws (1.5%) were found to be malpositioned ( $n=3$  facet joint violation, and 2 neural foramen), however there were no reoperations in this group. Overall, there were 12 reoperations (7.1%) due to pseudarthrosis ( $n=3$ ), deep wound infections ( $n=4$ ), pseudomeningocele ( $n=1$ ), and adjacent segment degeneration ( $n=4$ ).

## Conclusion

We report one of the largest series of LMS fixation, and found a low rate of complications requiring reoperation (7.1%) over a 15 year period. There was also a low rate of screw malposition, with none requiring reoperation. Overall, lateral mass screw fixation is an effective and safe method of posterior cervical fixation.

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## 112. One-Level vs Two-Level Cervical Total Disc Replacement (TDR) vs Anterior Cervical Discectomy and Fusion (ACDF) at 7-year Follow-up

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### Summary

1- and 2-level TDR, 1-level ACDF treated patients demonstrated similar and higher overall success than 2-level ACDF patients at seven years follow-up.

### Hypothesis

The safety and effectiveness of 2-level treatment with TDR is equivalent to 1-level TDR.

### Design

Prospective, randomized, concurrently controlled FDA study conducted at 24 US sites.

### Introduction

Cervical total disc replacement (TDR) has been shown as safe and effective as anterior cervical discectomy and fusion (ACDF) at both one and two levels. The relation between the number of treated levels and safety and effectiveness out to 7 years has not previously been investigated.

### Methods

The study consisted of 575 patients randomized in a 2:1 ratio. The 1-level arm had 164 TDR vs 81 ACDF patients; the 2-level arm had 225 TDR vs 105 ACDF patients. TDR patients received a Mobi-C Cervical Disc. The ACDF control group was treated with allograft and anterior plating. Outcome measures were collected preoperatively and at each follow-up out to 7 years. Fisher's exact test was used to test for significant differences among categorical outcomes. One-way ANOVA with Tukey's test was used to test for significant differences for continuous variables.

### Results

TDR patients had similar overall success (1-level: 55.2%; 2-level: 60.8%;  $p=0.39$ ) while the 2-level ACDF group had a lower success rate than 1-level ACDF (1-level: 50.0%; 2-level: 34.2%;  $p=0.10$ ). NDI score improvement was almost identical between 1-level ( $35.2\pm 20.6$ ) and 2-level ( $35.6\pm 19.9$ ) TDR patients. Two-level ACDF patients had less improvement in NDI score than 1-level ACDF patients (1-level:  $35.3\pm 18.9$ ; 2-level:  $27.8\pm 21.8$ ;  $p=0.18$ ), though the difference was not statistically significant. No significant differences were observed between 1- and 2-level treatments for VAS neck or arm pain scores, SF-12 MCS/PCS, major complication rates, subsequent surgery, or patient satisfaction. However, two-level ACDF patients trended towards worse outcomes compared to one-level ACDF patients for most measures.

### Conclusion

Similar to that observed at previous follow-ups, no significant differences in safety and effectiveness were observed between 1- and 2-level TDR at seven years follow-up. Treatment with 2-level ACDF was less effective than 1-level ACDF for most outcome measures.

## 113. Revision Strategies in Cervical Disc Arthroplasty Failures

Daniel G. Kang, MD; Ronald A. Lehman, Jr., MD; Colleen Peters, MA; K. Daniel Riew, MD

United States

### Summary

This is the largest independent review of revision strategies for CDA at two high volume cervical centers. We found ~4% of CDAs required revision. Regardless of approach, all patients demonstrated neurologic recovery and relief of symptoms following surgery. This study outlines the low revision rate after CDAs, and provides guidance to revision strategies to maximize patient outcomes.

### Hypothesis

We set out to determine the occurrence of failed CDAs requiring revision surgery, and to determine the cause of each "failure" and the overall success after revision surgery.

### Design

Retrospective analysis

### Introduction

Cervical disc arthroplasty (CDA) has been espoused to lead to favorable results when compared to anterior discectomy and fusion. The benefits of motion preservation with a lower reoperation rate at the index level, with equivalent improvement of arm and neck pain have led to increasing use of this device for cervical radiculopathy and myelopathy. However, there has been limited literature regarding treatment strategies for failed cervical disc arthroplasty in patients with incomplete relief/recurrence of symptoms or implant related complications.

### Methods

We retrospectively analyzed a surgical database from two major academic centers that perform a high volume of CDA. We reviewed the database to determine the total number of CDA performed at each institution. All charts, records and imaging were reviewed for each case that underwent a revision operation at the index level following a CDA. We determined the cause of failure and analyzed the treatment approach to address the pathology.

### Results

We evaluated 325 CDA from the database, and found 14 revisions (4.3%) at the index level. The average time to revision surgery was 18 months (range 1.8 to 37 months), with an average of 33 months follow-up. The cause of failure included 11 with incomplete relief/recurrence of radicular symptoms, 1 for malpositioned implant, 1 disc extrusion and 1 infection. Revision strategies included 5 salvage ACDFs, 2 revised TDRs, 4 posterior laminoforaminotomies (PLFs) and 3 posterior cervical fusions with PLFs/decompressions. There were 13 patients (93%) demonstrated neurologic improvement and relief of neck or arm pain after surgery.

### Conclusion

This is the largest independent review of revision strategies for CDA at two high volume cervical centers. We found ~4% of CDAs required revision. Regardless of approach, all patients demonstrated neurologic recovery and relief of symptoms following surgery.



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### 114. Long Term Clinical and Radiographic Results of Two-level Cervical Total Disc Replacement from a Level 1 Prospective, Randomized, Clinical Trial

*Jeffrey McConnell, MD; Randall Dryer, MD; Todd Lanman, MD; Matthew Gornet, MD; Scott D. Hodges*

*United States*

#### Summary

Cervical total disc replacement at two contiguous levels continues to provide superior results at 7 years compared to 2-level ACDF based on overall success criteria, Neck Disability Index and Neurological success.

#### Hypothesis

Cervical TDR at 2 contiguous levels is considered safe and effective at 7 year follow-up.

#### Design

Prospective, randomized, controlled multicenter FDA investigational device exemption clinical trial.

#### Introduction

Cervical total disc replacement (TDR) treats symptomatic cervical disc disease (SCDD) while maintaining motion at the treated level. The primary objective of this study was to compare the long term safety and efficacy of cervical TDR to ACDF at 2 contiguous levels.

#### Methods

An FDA IDE trial of a low profile titanium ceramic composite ball-in-trough cervical artificial disc was conducted at 30 US centers. 397 patients with 2-level SCDD between C3 and C7 were randomized to cervical TDR (n=209) or the control, ACDF (n=188). Patients were followed for 84 months after surgery. Overall clinical success was defined as improvement in Neck Disability Index (NDI)  $\geq 15$  points, maintenance/improvement of neurologic status, no implant or surgical related adverse events (AE), and no additional surgical procedures at the index level. Clinical effectiveness was analysed using NDI, visual analog scores (VAS) for neck and arm pain, SF36, radiographic outcomes and patient satisfaction.

#### Results

At 7 years TDR was superior to ACDF based on overall success (observed rate 78.6% vs 62.7%, probability of superiority [ps]=99.8%), NDI success (87.0% vs 75.6%, ps=99.2%) and neurological success (91.6% vs 82.1%, ps=99.0%). Implant and surgical related adverse events were significantly lower for the TDR group than ACDF group (3.2% vs 7.2%, log hazard ratio [LHR] and 95% Bayesian Credible Interval (BCI):-1.19(-2.29,-0.15)). Subsequent surgeries at the index level were significantly lower in the TDR vs ACDF group (4.2% vs 14.7%, LHR(95% BCI):-1.29(-2.12,-0.46)). Adjacent level surgeries were lower in the TDR group (6.5%) vs ACDF group (12.5%). Motion in the TDR group averaged 6.5° and 6.3° and Grade-4 HO rates were 8.6% and 7.3% at the superior and inferior level respectively.

#### Conclusion

Longer term clinical results of this Level 1 IDE trial continue to demonstrate the efficacy of total disc replacement at 2 contiguous levels in the cervical spine.



### 115. Does Chewing Gum Hasten the Return of Bowel Function Post-operatively in Patients Undergoing Spinal Surgery?

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*United States*

#### Summary

Delayed return of bowel function is a common clinical concern following spinal surgery. Chewing gum has a demonstrated clinical benefit in preventing bowel dysfunction in the general surgery literature. The aim of this randomized, prospective clinical trial was to investigate the role of chewing gum in accelerating post-operative bowel recovery following spinal surgery. The results of this study suggest there may be small, but limited role for chewing gum in post-surgical spine patients.

#### Hypothesis

Providing chewing gum to spinal patients post-operatively hastens the return of bowel function.

#### Design

Randomized, prospective clinical trial

#### Introduction

Delayed return of bowel function and ileus are associated with significant patient morbidity, decreased patient satisfaction, prolonged hospitalization, and increased healthcare costs. A delayed return of bowel function is common following spinal surgery with 1.2-12% developing clinical ileus. In the general surgery literature, chewing gum has been studied extensively and has been shown to reduce post-operative ileus.

#### Methods

A total of 142 patients underwent posterior decompression 2+ levels, posterior spinal instrumentation and fusion 1+ levels, or any posterior surgery combined with any anterior surgery and were included. Patients were randomized to either the chewing gum or control group. Chewing gum was initiated three

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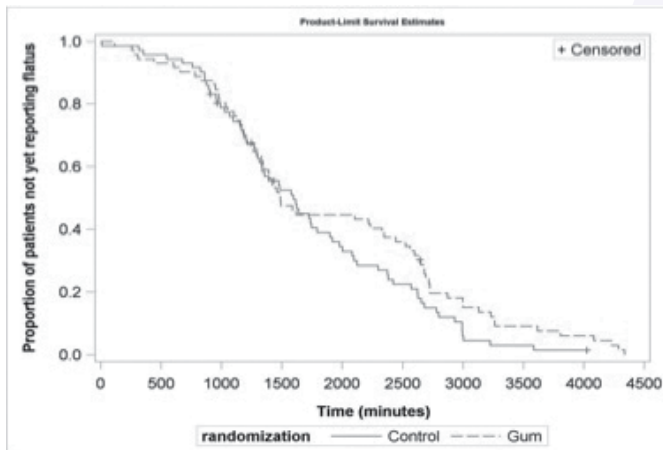
to six hours post-operatively in the experimental group. The primary outcome measure was time until return of bowel function defined as passage of flatus. Adverse events related to chewing gum use were recorded. Median time to first flatus was estimated via the Kaplan-Meier method. A Cox proportional hazards model was used to compare hazard rate for first flatus between groups.

## Results

The standardized difference between groups showed significantly more patients in the chewing gum group underwent combined anterior/posterior surgery. Median times to first post-operative passage of flatus were as follows: gum group, 24.8 hours (22.2-39.1 hrs); control group, 26.6 hours (21.9-31.6 hrs). Unadjusted hazard ratio was 0.76 (95% CI 0.54, 1.08) with  $p=0.121$ . Adjusting for the procedure performed, the hazard ratio was 0.79 (95% CI: 0.55,1.12) with  $p=0.184$ . There were no significant gum-related complications.

## Conclusion

This study is the first investigation of chewing gum in the high-risk spine patient population. There is a trend toward improved bowel function; however, significant differences in surgical procedures performed may have limited this effect. Ultimately, though, the results of our analysis suggest a limited role for chewing gum in hastening return of bowel function.



Flatus vs time

## 116. Predictive Factors in Spine Surgery Complication Malpractice Litigation

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United States

### Summary

Complications associated with spine surgery commonly lead to litigation. Catastrophic complications following spine surgery are a predictor of medicolegal case outcome in favor of the plaintiff and are linked to large sums awarded to the plaintiff.

## Hypothesis

There are associations between spine surgery complications, medical malpractice proceedings, outcomes, and awards granted.

## Design

Database search

## Introduction

Complications associated with spine surgery commonly lead to litigation. Few studies have evaluated the association between spine surgery complications, malpractice proceedings, outcomes, and awards granted.

## Methods

A search for "spine surgery" utilizing the medicolegal research service was conducted spanning from February 1988 to May 2015. Complications were sorted into catastrophic and non-catastrophic categories. Catastrophic complications were defined as paralysis, anoxic/hypoxic brain injury, and death, whereas non-catastrophic complication included all other complications. Chi-squared and t-tests were utilized to evaluate the effect of these variables on case outcomes and awards granted.

## Results

In total, 569 legal cases were examined; 335 cases were excluded due to irrelevance/insufficient information, yielding 234 complication cases for review. Catastrophic cases accounted for 28.2% of the cases examined (66/234). Overall, 54.2% (115 cases) resulted in a defendant ruling, 26.1% (58) resulted in a plaintiff ruling, and 19.7% (42) resulted in settlement. Total liabilities of the 234 cases were \$335,550,287. The plaintiff rulings ranged from \$134,000 to \$38,323,196 (mean \$4,045,205±\$6,804,647), while settlements ranged from \$125,000 to \$9,000,000 (mean \$1,930,278±\$2,113,593). In a plaintiff ruling, catastrophic complication cases resulted in awards significantly larger than non-catastrophic complication cases (\$6.1 vs \$2.9 million;  $p<0.04$ ). In cases of catastrophic complications, physicians were more likely to lose in court (66.7% vs 37.5%;  $p<0.001$ ) and to settle out of court (33.3% vs 14.3%;  $p<0.001$ ) compared to non-catastrophic complication cases. The medical specialty of provider and the age and sex of the patient were not statistically associated with case outcome or award granted.

## Conclusion

Catastrophic complications following spine surgery are a predictor of medicolegal case outcome in favor of the plaintiff and are linked to large sums awarded to the plaintiff.





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**TABLE 1 Case Characteristics for 234 Spine Surgery Malpractice Suits**

Variable	No. Cases
Avg. Age (±STDEV)	48.1 yrs (± 15.8)
Age not provided	10 cases
Sex	
Females	99 (42.3%)
Males	135 (57.7%)
State	
California	49
Massachusetts	13
New York	57
Ohio	13
Texas	26
Other states	76
(AR=1) (CO=1) (CT=4) (FL=8) (GA=11) (IL=4) (MD=11) (MI=8) (MO=1) (NJ=4) (NC=1) (OK=1) (OR=1) (PA=108) (SC=3) (VA=4) (WV=1) (Wash, D.C.=2)	
Procedure*	
Decompression	33
Discectomy	44
Foraminotomy	6
Fusion	90
Laminectomy	53
Other surgical procedure	60
Procedure not listed	11
Spine Region	
Cervical	13
Thoracic	8
Lumbar	20
Multiple	20
Complication**	
Death	8
Paralysis	60
Anoxic/hypoxic brain	2
Nerve root injury	37
Malpositioned instrumentation	6
Incorrect site surgery	11
Other medical complications	192
Delay in Diagnosis	
Yes	22
No	212
Delay in Treatment	
Yes	20
No	214
Profession Sued	
Orthopedic Surgery	136
Neurosurgery	79
Non-Surgical	19

\*88.4% of patients underwent multiple procedures  
\*\*54.3% of cases listed more than one complication

**TABLE 2 Catastrophic vs non-catastrophic case outcomes and amounts awarded**

Outcomes	Total No. Cases		Avg Award (±STDEV)		Range of Awards	
	Catastrophic	Non-catastrophic	Catastrophic	Non-catastrophic	Catastrophic	Non-catastrophic
Defense verdict	22	105	\$0	\$0	\$0	\$0
Plaintiff verdict	22	39	\$4,07M (±7.35)*	\$2,90M (±6.29)*	\$125,000-\$9,00M	\$225,000-\$6,60M
Settlement	22	24	\$2,35M (±2.60)**	\$1,34M (±1.50)**	\$400,000-\$26,8M	\$134,000-\$38,3M

N = 234  
28.2% catastrophic  
71.8% non-catastrophic

\*p<0.04 statistically significant  
\*\*p<0.09 not statistically significant

The patients were divided into two groups (Group 1 LS fusion and group 2 lumbar fusion) and the following were studied: the number of levels fused, average time between surgery and the first injection, and the location of pain in the sacroiliac joint. Those patients who presented SI pain following surgery, and with no improvement following medical treatment were administered an injection of local anesthetic and steroids.

## Results

399 cases are reviewed, 345 (86.5%) in Group 1, and 54 (13.5%) in Group 2. 192 males (48.1%), and 207 females (51.9%). 30 (7.5%) presented pain in the SI joint requiring infiltration. 8 (60%) females and 12 (40%) males, average age 55 years, 25 patients (84%) in Group 1 and 5 patients (16%) in Group 2. The most frequent level of arthrodesis in patients presenting SI joint pain was L2-S1 (24%). The number of levels fused ranged from 2 to 8, and were similar in both groups. The average time between surgery and infiltration was 22 months (5-46). 22 patients required one infiltration (71%), 7 required two infiltrations (23%) and two required more than two infiltrations (6%). Statistical analysis SPSS 13.0 and Chi-square test.

## Conclusion

In this series, the incidence of sacroiliac pain following lumbar and lumbosacral fusion was 7.5%. No correlation was found between the number of levels fused and postoperative sacroiliac pain, and there was no significant difference in sacroiliac pain between those patients who underwent arthrodesis up to L5 and those who had a lumbosacral fusion.

## 117. Sacroiliac Pain in Patients with Lumbar and Lumbosacral Fusion. A Comparative Study of 399 Cases.

Hani H. Mhaidli, MD, PhD

Spain

### Summary

A retrospective analysis of prospectively collected data was undertaken of 399 patients who underwent lumbar fusion and lumbosacral fusion (LS). 345 patients underwent lumbosacral fusion and 54 lumbar fusion to L5. We compare the incidence of postoperative sacroiliac (SI) pain between the two groups and analyze if there is a relationship between the number of levels fused and sacroiliac joint pain.

### Hypothesis

There is a different incidence of SI pain in patients who underwent only lumbar fusion compared to patients who underwent LS fusion.

### Design

A five year retrospective study is made of patients who underwent lumbar fusion (up to L5) and LS fusion (to S1).

### Introduction

There is controversy regarding the incidence of SI joint pain after fusion to L5 as compared to fusion to S1. We analyzed the incidence of postoperative SI joint pain of 399 consecutive patients who underwent lumbar fusion or LS fusion.

### Methods

A retrospective analysis of prospectively collected data was undertaken of 399 patients who underwent lumbar fusion (to L5) and LS fusion (to S1).

## 118. Morbidity Associated with Anterior Surgical Approaches to the Lumbar Spine is Minimal

John R. Dimar, II, MD; Thomas M. Bergamini, MD; Richard Head, BS; Mladen Djurasovic, MD; Steven D. Glassman, MD; Leah Yacat Carreon, MD, MSc

United States

### Summary

We prospectively studied 97 patients undergoing anterior lumbar spine surgery between L1-S1 to identify approach related problems using a validated measure. Contrary to prior reports in thoracolumbar and lumbar approaches, we found that carefully executed anterior lumbar approaches that preserve the anterior abdominal wall fascia and muscular layers results in successful outcomes without the previously reported chronic incisional pain and laxity problems.

### Hypothesis

Anterior approaches to the lumbar spine are safe, effective and well tolerated, with minimal long term consequences.

### Design

Longitudinal prospective cohort.

### Introduction

Anterior lumbar spine surgery is often valuable in the treatment of certain spine pathologies including tumors, osteomyelitis, fractures and deformities. Prior studies have reported significant morbidity associated with anterior thoracolumbar and lumbar approaches, primarily related to residual pain and



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hernias. This study reports on morbidity associated with the anterior surgical approach using a validated measure.

## Methods

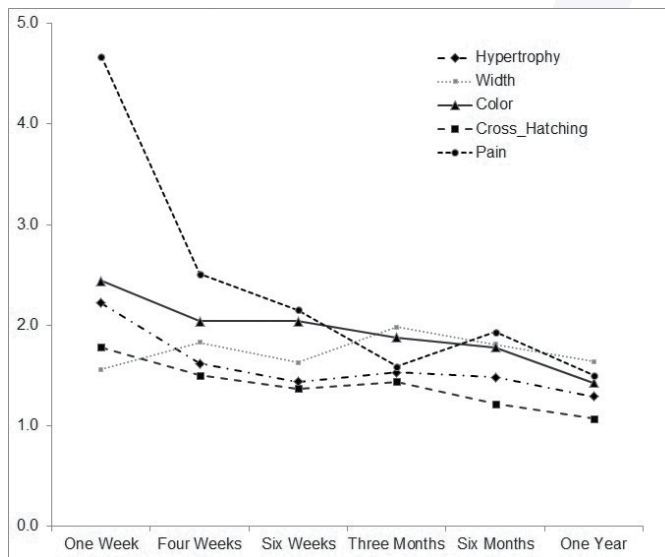
Patients that underwent anterior lumbar fusions from L1-S1 were prospectively enrolled and standard patient demographic and surgical data were collected. Incisional data including width, length, cross hatching, hypertrophy and pain were also collected using a standard anterior abdominal patient outcome measure.

## Results

97 patients undergoing anterior lumbar surgery were enrolled. 49% were males, 24% were smokers, mean BMI was 31.7kg/m<sup>2</sup>; 45% had prior abdominal surgery and 6% had prior anterior spine surgery. The majority of cases involved fusion at L5-S1 (28, 39%) followed by fusion at L4-S1 (22, 23%). The abdominal wall surgical outcome measure demonstrated that all domains had excellent improvement from four weeks post-op to 12 months post-op, including hypertrophy (2.2 to 1.3, p=0.039), color (2.4 to 1.4, p=0.003), cross hatching (1.8 to 1.1, p=0.038) and pain (4.7 to 1.5, p=0.039). No associations between outcomes and demographic or surgical factors were seen.

## Conclusion

Contrary to prior reports which included thoracolumbar and lumbar approaches, carefully executed anterior lumbar approaches that preserve the anterior abdominal wall fascia and muscular layers results in outcome measures that demonstrate none of the previously reported chronic incisional pain and laxity problems. Clinicians can feel confident that when patients require anterior lumbar spine surgery, previously reported approach related chronic pain issues can be avoided.



## 119. Outcomes in Adult Deformity Surgery: What Happens to Those Patients Who are Lost to Follow up?

Daniel Beckerman, BS; Shane Burch, MD; Linda Racine; Sigurd H. Berven, MD  
United States

## Summary

Patient follow-up is an important limitation of many clinical outcomes studies, and an unsolved challenge to clinical research. Patients who did not follow-up at 1 year after surgery for adult spinal deformity self-reported outcomes that are similar to those in patients who did follow-up as scheduled. The revision surgery rate was higher in patients who did follow-up. Barriers to follow-up include time, finance, clinic communication errors, surgeon availability and dissatisfaction with outcome. Reducing barriers may improve quality of clinical research.

## Hypothesis

Patients who are lost to follow-up have similar clinical outcomes compared with patients who do follow-up beyond 1 year

## Design

Case control study design

## Introduction

Measuring outcomes after spine surgery is important to guide an evidence-based approach to care. Loss of patients to follow-up is a significant limitation of many clinical outcome studies. The purpose of this paper is to report the reasons that patients lost to follow-up did not follow-up, and the outcomes of care in these patients.

## Methods

Retrospective study of patients treated with surgery for adult spinal who did not return to clinic for follow-up beyond 1 year post-op. Patients identified for the study were contacted by phone and interviewed using a survey to evaluate health status, complications, revision surgery rates, and the reason they did not return to follow up. Student's t-test was used to compare outcomes with patients who did follow-up after surgery.

## Results

42 patients completed the phone survey. The reasons that patients did not return included: Doing well and did not feel the need to return (26%), not offered an appointment (19%), burden of travel (17%), surgeon left the institution (9.5%), and disappointing result (7%). Other reasons included: time limitations(3), planned on booking a follow up appointment(2), financial burden (1), other health issues that prevented their return (1), forgot about their appointment (1), and deceased (1). Changes in health status were consistent amongst those who followed up (81% improved) and those who were contacted after being lost to follow (79% improved). 34pts(81%) said they would make the same decision to have surgery again, while 4pts (9.5%) of patients reported "unsure" and "no" respectively. 2 patients (5%) of patients had revision surgery at another institution.

## Conclusion

Patients who did not return to clinic had outcomes that are similar to patients who did return for follow-up after 1 year, and the rate of revision surgery was lower. Reducing barriers to follow-up and improving collection rates will increase the accuracy of clinical outcomes studies.



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## 120. The Health Impact of Symptomatic Adult Cervical Deformity: Comparison to United States Population Norms and Chronic Disease States Based on the EQ5D

*Justin S. Smith, MD, PhD; Breton Line, BS; Shay Bess, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Gregory M. Mundis, Jr., MD; Eric O. Klineberg, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; International Spine Study Group United States*

### Summary

The health impact of symptomatic adult cervical deformity (ACD) is substantial, with an EQ5D index that is 35% below the bottom 25th percentile for a similar age- and gender-weighted normative population. The mean ACD EQ5D index score demonstrates comparable or greater health impact than multiple other chronic disease states, including ischemic heart disease, blindness, and emphysema.

### Hypothesis

Symptomatic ACD patients will have substantial negative health impact based on the EQ5D compared with US normative and chronic disease state values.

### Design

Retrospective analysis of a prospective multicenter database

### Introduction

Although ACD has been empirically associated with significant pain and disability, the magnitude of this impact has not been quantified.

### Methods

ACD patients presenting for surgical evaluation were identified from a prospectively collected multicenter database. Baseline demographics, deformity characteristics and EQ5D-3L scores were collected. EQ5D scores were compared with US normative and chronic disease state values.

### Results

Of 121 ACD patients, 115 (95%) completed the EQ5D (61% women, mean age 61 yrs, previous cervical surgery in 46%). Diagnoses included: cervical sagittal malalignment (63%), cervical kyphosis (60%), proximal junctional kyphosis (9%) and coronal deformity (8%). Posterior fusion was performed in 86% (mean levels=10), and anterior fusion was performed in 49% (mean levels=5). 3-column osteotomy was performed in 21%. The mean EQ5D index was 0.511, which is 35% below the bottom 25th percentile score (0.790) for a similar age- and gender-weighted normative population and worse than the bottom 25th percentile for several other chronic disease states (diabetes [0.708], ischemic heart disease [0.708], and myocardial infarction [0.575]). The EQ5D index of 0.511 seen in this ACD cohort is comparable to the bottom 25th percentile for blindness (0.543), emphysema (0.508) and heart failure (0.437). Based on EQ5D subscores, patients reported impact on mobility (87%), daily self care (47%), daily activities (91%), pain/discomfort (98%) and anxiety/depression (67%).

### Conclusion

The health impact of symptomatic ACD is substantial, with an EQ5D index that is 35% below the bottom 25th percentile for a similar age- and gender-weighted normative population. The mean ACD EQ5D index score demonstrates comparable or greater health impact than multiple other chronic diseases, including ischemic heart disease, blindness, and emphysema.

## 121. Which Clinical Parameters of the Schwab-SRS Classification System for ASD is Significant in Predicting Treatment Outcomes for Surgically Treated Patients?

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### Summary

This study analysed the Schwab-SRS classification parameter's ability to predict treatment outcomes of surgically treated adult spine deformity patients.

European Spine Study Group database was used to analyse 186 patients with a minimum of 1-year follow-up. The results of the study show that baseline PT, Curve type and SVA were not significant prognostic indicators of improvement post surgery however baseline PI-LL is predictive of reaching MCID post surgery.

### Hypothesis

Schwab-SRS modifiers are co-linear and not all are significant in predicting treatment outcomes post surgery.

### Design

Retrospective study of a prospective multi-centric database

### Introduction

Adult spinal deformity (ASD) is a complex group of conditions with a broad range of clinical and radiological characteristics. There are concerns that the most widely used classification may lack the ability to evaluate all these characteristics and provide guidance on treatment alternatives. Specifically, although having shown to be associated with outcomes, a multitude of (only) radiological parameters may demonstrate co-linearity and may not necessarily be useful for classification and guidance.

### Methods

A multicentric adult deformity database of surgically treated ASD patients with a minimum of 1-year follow-up. Using MCID, patients were dichotomized into two groups of improved or unimproved. Chi-Square test analysed the difference in baseline Schwab-SRS modifiers (Curve types, PI-LL, PT and SVA) of the two cohorts for ODI, SF-36MCS, SF36-PCS and SRS22. A multivariate logistic regression model was then built when a relationship was found between these parameters and any of the outcome measures.

### Results

A total of 186 patients, (157 ♀, 29 ♂,) were included (Fig 1). There were no significant differences in baseline Schwab-SRS parameters between improved and un-improved cohorts for ODI, SRS22 and SF36-MCS (p-value <0.05). For SF36-PCS however a significant difference in baseline PI-LL (0,

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+, ++) between the cohorts was seen. Multivariate regression analysis shows Odds Ratio of 4.584 to improvement for 3FS6-PCS if PI-LL is  $<10^\circ$  (0) vs.  $PI-LL >20^\circ$  (++) ( $p=0.001$ ).

## Conclusion

Baseline PT, Curve type and SVA were not significant prognostic indicators of improvement post surgery for all outcome measures. Baseline PI-LL is predictive of reaching MICD post surgery. Findings suggest that the present classification may not be accurate for prognostication in surgically treated patients. Also, not all radiological parameters included may be needed; the usefulness of this classification may be reduced down to lesser essential parameters.

**Figure 1:** Chi-square test analysis grey area for SF36PCS & multivariate logistic regression analysis. (PI\_LL shows significance only with SF36PCS)

P<0.001		PI-LL_Baseline			Total
		<10° (0)	10°><20° (+)	>20° (++)	
SF36 PCS_MCID	Un-improved	48	16	13	77
	Improved	29	18	36	83
Total		77	34	49	160
Multivariate Logistic Regression Analysis					
SF36PCS	P-Value	Odds Ratio	95% C.I for OR		
			Lower	Upper	
PI_LL (0)	0.001				
PI_LL (+)	0.135	1.862	0.823	4.211	
PI_LL (++)	0.000	4.584	2.093	10.039	
Constant	0.032	0.604			

## 122. Analysis of Lumbar Flexibility on Supine MRI and CT May Reduce the Need for More Invasive Spinal Osteotomy in Adult Spinal Deformity Surgery

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United States

### Summary

Surgical planning for adult spinal deformity surgery (ASD) is crucial for optimizing postoperative alignment and health related quality of life. Surgeries are planned from preoperative standing radiographs using parameters such as Pelvic Incidence minus Lumbar Lordosis (PI-LL), which can be assessed intraoperatively for adequacy of correction. MRI or CT, which are standard preoperative assessments, provide useful information regarding lumbar flexibility and in some cases may obviate the need for more invasive three-column osteotomy (3CO).

### Hypothesis

CT and MRI provide useful information about lumbar flexibility for planning ASD corrections.

### Design

Retrospective review of an adult spinal deformity database.

### Introduction

Surgical correction for adult sagittal deformity (ASD) can be achieved with various grades of osteotomies. Osteotomies are necessary when there is a significant mismatch in PI-LL on standing radiographs. While computed tomography (CT) and/or magnetic resonance imaging (MRI) are routinely obtained prior to ASD surgery, the utility of these modalities in assessing flexibility for preoperative planning is unknown. The aim of this study was to examine the potential contribution of CT and MRI to planning for sagittal deformity correction.

### Methods

Patients were included from a single institution prospective adult spinal deformity database. Standing full-body stereotactic radiographs and supine lumbar CT and/or MRI were analyzed. Patients were grouped by the number of previously fused lumbar segments (0; 1-2; 3-4 levels).

### Results

122 patients were included. In patients with both CT and MRI available ( $n=45$ ), there was no significant difference in LL from each ( $p=0.17$ ). Mean LL was significantly different between standing radiographs and supine imaging ( $32.2^\circ$  vs  $38.4^\circ$ ,  $p<0.001$ ). Those with no previous segment fused had a greater change in mismatch than those who had either 1-2 or 3-4 segments previously fused, ( $7.7^\circ$  vs  $4.0^\circ$  vs.  $4.7^\circ$ ,  $p=0.13$ ). When supine flexibility was considered, 44/122 (36%) patients had an increase in LL of  $>10^\circ$ , 18 converted from  $PI-LL >30^\circ$  to  $<30^\circ$  and 15 converted  $>20^\circ$  to  $<20^\circ$ , potentially eliminating the need for a higher grade osteotomy. 4/18 patients whose PI-LL decreased to  $<30^\circ$  underwent a 3CO anyway.

### Conclusion

Alignment is often overlooked when reviewing advanced imaging modalities. Supine MRI and CT are useful in determining lumbar flexibility for planning ASD surgery. A change in PI-LL mismatch on supine imaging can obviate the need for a more invasive 3CO. In addition to standing radiographs, alignment should be assessed on supine imaging modalities where available as this may enhance surgical planning and reduce surgical morbidity.





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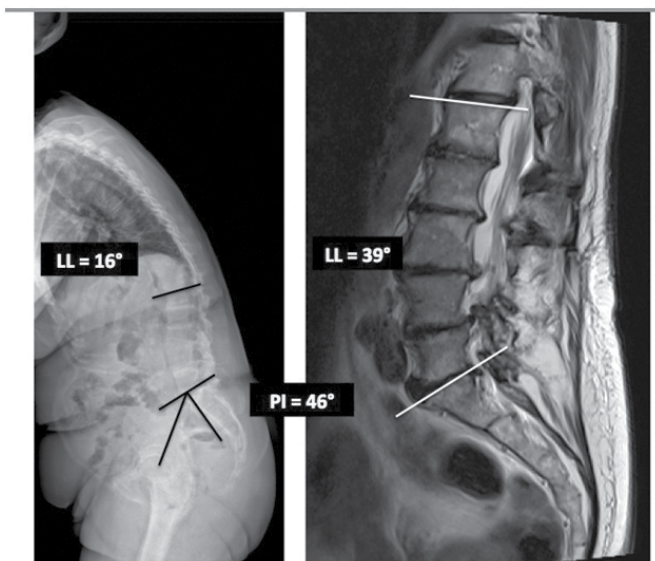


Figure: Pre-operative lateral standing X-ray and supine sagittal MRI of a 73 year old female adult spinal deformity patient. PI-LL mismatch decreases from 30° using the standing films to 7° using supine imaging.

## 123. Comparison of Stand-Alone, Trans-psoas Lateral Interbody Fusion to Transforaminal Interbody Fusion for the Treatment of Lumbar Adjacent Segment Disease

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United States

### Summary

In this retrospective cohort study, we compare the clinical and radiographic outcomes of stand-alone minimally invasive, lateral interbody fusion (MIS-LIF) vs transforaminal interbody fusion (TLIF) for the treatment of adjacent segment disease (ASD). Both MIS-LIF and TLIF patients had improvement in patient reported outcomes as well as radiographs. MIS-LIF patients had less estimated blood loss (EBL) and shorter hospital length of stay (LOS). MIS-LIF is a good alternative to posterior revision surgery.

### Hypothesis

MIS-LIF has similar outcomes as TLIF with lower EBL and shorter LOS.

### Design

Retrospective cohort study.

### Introduction

ASD is common after posterior lumbar fusion. Traditionally, surgical treatment has involved revision posterior surgery. MIS-LIF offers a promising alternative.

### Methods

Adults who underwent MIS-LIF or TLIF for single-level ASD between 2010-15 at a single institution were compared. Exclusion criteria: >grade I spondylolisthesis, posterior approach after a MIS-LIF, L5-S1 surgery. Patient demographics, EBL, LOS, complications, reoperations, clinical outcomes (Visual Analogue scale [VAS] back/leg, Oswestry disability index [ODI], and EQ-5D), and radiographs (segmental lordosis and intervertebral disc height) were

evaluated. Data was analyzed with the Chi-squared, Wilcoxon sign rank, and Mann-Whitney U tests.

### Results

Twenty-two MIS-LIF and 20 TLIF patients were included. The two groups were similar in regards to average age, gender, ASA, and smoking status. Follow up was similar (MIS-LIF: 13.0+/-15.3 v. TLIF 13.7+/-11.5 months;  $p=0.38$ ). MIS-LIF patients had significantly less blood loss (MIS-LIF: 35+/-16 mL v. TLIF: 607+/-709 mL;  $p<0.001$ ) and shorter hospital length of stay (MIS-LIF: 2.6+/-2.5 v. TLIF: 3.4+/-0.9 days;  $p=0.001$ ). There were no intra-operative complications and a trend toward a higher revision rate in MIS-LIF (MIS-LIF: 5/22 v. TLIF 2/20;  $p=0.30$ ). Baseline clinical outcome scores were similar, except for worse VAS back and left leg pain in TLIF group. In both groups, back and leg pain improved (Table 1). Baseline radiographic measurements were similar. Both groups had increase in intervertebral height (MIS-LIF: 4.7+/-3.1,  $p<0.001$ , TLIF: 2.4+/-3.9 mm,  $p=0.07$ ), which was significantly greater for MIS-LIF than TLIF ( $p=0.025$ ). Segmental lordosis also improved (MIS-LIF: 2.8+/-6.6,  $p=0.09$ , TLIF: 3.1+/-8.2 degrees,  $p=0.19$ ).

### Conclusion

Patients with ASD may receive significant clinical benefit from a stand-alone MIS-LIF or an open TLIF. MIS-LIF offers the advantages of less blood loss and shorter hospital length of stay.

	MIS-LIF	TLIF	p
<b>Revision</b>	5/22	2/20	0.30
<b>EBL (mL)</b>	35 ± 16	607 ± 709	<0.001
<b>LOS (days)</b>	2.6 ± 2.5	3.4 ± 0.9	0.001
<b>VAS Back</b>			
Pre-Op	5.2 ± 3.8	8.1 ± 1.6	0.034
Post-Op	2.9 ± 3.0	6.8 ± 2.3	0.29
p	0.057	0.03	
<b>VAS Right Leg</b>			
Pre-Op	4.8 ± 3.7	5.2 ± 2.9	0.73
Post-Op	1.8 ± 3.2	3.2 ± 3.4	0.069
p	0.027	0.082	
<b>VAS Left Leg</b>			
Pre-Op	3.4 ± 3.2	5.9 ± 3.4	0.029
Post-Op	0.9 ± 1.5	3.6 ± 3.3	0.017
p	0.032	0.051	
<b>ODI</b>			
Pre-op	52.9 ± 17.4	51.9 ± 14.8	0.76
Post-op	38.9 ± 21.1	48.1 ± 18.5	0.24
p	0.004	0.19	
<b>EQ-5D Utility</b>			
Pre-op	0.49 ± 0.21	0.48 ± 0.24	0.99
Post-op	0.71 ± 0.17	0.58 ± 0.22	0.09
p	0.006	0.07	

Table 1. Results.

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## 124. Does Percutaneous Pedicle Screw Instrumentation Prevent Long Term Adjacent Segment Disease?

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United States

### Summary

Adjacent Segment Disease (ASD) was lower (4.8%) than previously published rates in this consecutive cohort of 419 pts who underwent percutaneous pedicle screw instrumentation for augmentation of lumbar interbody spinal fusion.

### Hypothesis

ASD in patients undergoing lumbar interbody fusion with perc screws is not significantly different than previously published rates in open procedures.

### Design

Clinical case series

### Introduction

Percutaneous pedicle screw augmentation of lumbar interbody fusion procedures is an increasingly popular technique that avoids disruption of the posterior soft tissue stabilizers. ASD is a well-known complication of spinal fusion. This study aims to assess the long term clinical outcomes with regards to ASD in pts who underwent this procedure.

### Methods

Retrospective review between 2004-2014 of 419 consecutive patients who underwent percutaneous pedicle screw instrumentation for augmentation of lumbar interbody spinal fusion (including ALIF, LLIF, and minimally invasive TLIF). Patients with complete records and follow-up were included in final analysis. Standard binomial and categorical comparative analysis was performed.

### Results

419 patients were included in this analysis. Mean follow up time was 4.5 years (range: 3-12 years). Overall revision rate of entire cohort was 5.49% (n=23), revision rate secondary to ASD was 4.77% (n=20), and revision rate secondary to hardware malplacement with symptomatic radiculopathy was 0.72% (n=3). Of patients revised secondary to ASD, mean time to revision surgery was 2.5 years. There was no statistical difference in gender among patients with or without ASD. Patients who developed ASD were found to be younger (52.5 +/- 12.5 years) than those who didn't (56 +/- 11.5 years) (p=0.001). There was no difference in number of spinal levels initially fused between patients with ASD (2.6 +/- 1.5) and the remaining cohort (2.4 +/- 0.7).

### Conclusion

Adjacent segment degeneration in this population appears to be lower than previously published rates of adjacent segment disease (7-30%). This may be related to the greater preservation of the posterior stabilizing elements of the lumbar spine during percutaneous pedicle screw placement.

## 125. Compare the Outcome of Revision Discectomy and Discectomy/Decompression and Instrumented Fusion in Recurrent Lumbar Disc Prolapse

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India

### Summary

29 patients with recurrent disc prolapse who were managed with revision discectomy (17 patients) and revision discectomy with instrumented fusion (12 patients) were retrospectively analysed and long term clinical outcome was assessed after a minimum follow up of 2 years. Fusion offers better relief of back pain as compared with revision discectomy whereas both are equally efficacious when relief of leg pain and improvement in ODI score are concerned.

### Hypothesis

Instrumented Fusion has better long term clinical outcome than Revision Discectomy in Recurrent Lumbar Disc Prolapse

### Design

Retrospective study

### Introduction

Long term clinical outcomes of surgery in patients with recurrent lumbar disc prolapse is not conclusive regarding the recommended treatment protocol. The purpose of this study is to compare the outcome of Revision Discectomy & Instrumented Fusion in Recurrent Lumbar Disc Prolapse.

### Methods

29 patients with recurrent lumbar disc prolapse, with mean age of 45.6 years (range 20-72 years) and minimum follow up of 2 years were retrospectively analysed from 2003-2012. All the patients were operated in a single centre by the same surgeon. Patients were operated by revision discectomy alone or discectomy + instrumented fusion based on various preoperative & intraoperative findings. Preoperative clinical and radiographic analysis was done using Visual analogue scale (VAS)/ Oswestry Disability Index (ODI) scores & Xray/MRI respectively. Post-operative analysis was done using radiographs and VAS/ODI scores at 1 month, 3 months & yearly till final follow-up. Statistical analysis was performed using Student t-test (p<0.05 denoted statistical significance).

### Results

Revision discectomy was done in 17 patients and decompression/discectomy and instrumented fusion in 12 patients. Among revision discectomy vs instrumented fusion average improvement in VAS back pain is 1.9 (1-3) vs 3.2 (2-5) (p=0.00016), VAS leg pain is 8.3 (6-9) vs 7.9 (6-9) (p=0.15) and ODI is 70.5 (60-80) vs 71.3 (48-84) (p=0.38).

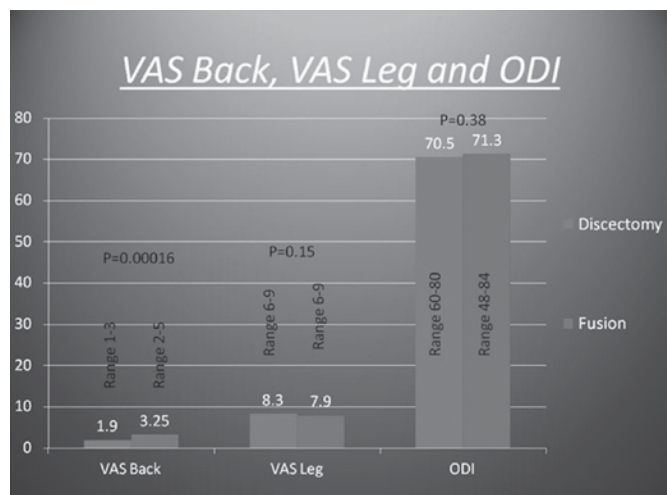
### Conclusion

Instrumented fusion offers better relief of back pain in recurrent disc prolapse as compared to revision discectomy and the result is statistically significant whereas both are equally efficacious when relief of leg pain and improvement in ODI score is concerned.





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Comparison of VAS and ODI Scores in Revision Discectomy alone and Fusion group

## 126. Predictors of Hospital Readmission and Surgical Site Infection in the US, Denmark and Japan: Is Risk Stratification a Universal Language?

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### Summary

As clinical decision-making becomes more data driven, risk stratification is increasingly critical. Whether models generated in one country will be applicable to other populations remains unknown. This study demonstrates that predictors of SSI and hospital readmission differ in the US, Denmark and Japan, suggesting that risk stratification models may need to be population specific or adjusted appropriately. This raises the question as to whether risk stratification efforts within the US need to be stratified by geographic region or demographic subgroup.

### Hypothesis

Predictors of Hospital Readmission and Surgical Site Infection (SSI) after lumbar fusion will be the same in US, Denmark and Japan.

### Design

Retrospective review of three spine surgery databases.

### Introduction

As clinical decision-making becomes more data driven, risk stratification will be crucial to minimize complications. Spine surgeons world-wide face this issue, leading to parallel efforts to address risk stratification. This raises the question as to whether pooled data would be valuable and whether models generated in one country would be applicable to other populations.

### Methods

Predictors of SSI and 30-day readmission from 3 prospective databases (N2QOD N=2653, DaneSpine N=1993, JAMSD N=3798) were determined and compared to identify common or divergent predictive risks.

### Results

Predictive variables differed in the 3 databases, for both readmission and SSI. Factors predictive for hospital readmission were ASA grade in N2QOD, ( $p=0.013$ , OR 2.08), fusion levels in DaneSpine ( $p=0.005$ , OR 1.67) and gender in JAMSD ( $p=0.001$ , OR=2.81). Associated differences in demographics and procedural factors included mean ASA grade (N2QOD=2.45, JAMSD=1.72) and fusion levels (N2QOD=1.39, DaneSpine=1.52, JAMSD=1.34). For SSI, gender ( $p=0.000$ , OR=3.30), diabetes ( $p=0.000$ , OR=2.90) and Length of Stay ( $p=0.000$ , OR=1.02) were predictive in JAMSD. No predictors were identified in N2QOD or DaneSpine.

### Conclusion

Predictors of SSI and hospital readmission differ in the US, Denmark and Japan, suggesting that risk stratification models may need to be population specific or adjusted. Some differences in measured parameters exist in the 3 databases analyzed, however, patient and procedure selection also appear to differ and may limit the ability to directly pool data from different regions. Therefore, risk stratification models developed in one country may not be directly applicable to other countries. While Denmark and Japan have relatively homogenous populations, the US does not. This raises the additional question as to whether risk stratification efforts within the US need to be adjusted by geographic region or demographic subgroup.

Predictors of 30-day Re-admission	N2QOD		DANESPINE		JAMSD	
	p-value	OR	p-value	OR	p-value	OR
Diagnosis	0.857	0.97	0.713	0.96	0.442	1.12
Age	0.150	1.03	0.188	0.99	0.245	1.02
Gender	0.666	1.14	0.247	0.74	<b>0.001</b>	<b>2.81</b>
BMI	0.507	1.01	0.645	1.01	0.890	0.99
Smoker	0.325	0.58	0.884	1.04	0.330	0.66
Symptom duration	0.448	2.20	0.089	0.49	0.836	0.91
Employment	0.047	0.89	0.041	1.17	0.269	1.06
ASA grade	<b>0.013</b>	<b>2.08</b>	NA	NA	0.622	1.12
Fusion levels	0.110	0.65	<b>0.005</b>	<b>1.67</b>	0.503	1.18
Estimated Blood Loss	0.083	1.00	NA	NA	0.617	1.00
Operative time	0.271	1.00	NA	NA	0.124	1.00
Length of stay	0.040	1.03	0.919	1.00	0.930	1.00

## 127. Smoking is an Independent Risk Factor of Reoperation due to Recurrent Lumbar Disc Herniation

*Stina Lykke Brogård Andersen, MHS; Elisabeth Corydon Smith; Christian Støttrup, MD; Leah Yacat Carreon, MD, MSc; Mikkel Osterheden Andersen, MD Denmark*

### Summary

Reoperation due to recurrent lumbar disc herniation (rLDH) is a common complication after lumbar discectomy. The purpose of this current study was to examine if age, gender, smoking status or BMI were risk factors of reoperation due to rLDH. The results indicated that neither age, BMI nor gender had any statistical significant association with the risk of rLDH. Binary logistic regression analysis showed that smoking is an independent risk factor of rLDH.

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## Hypothesis

Age, BMI, gender and smoking status are risk factors of recurrent disc herniation.

## Design

Case-control study

## Introduction

Around 2000 discectomies are undertaken due to lumbar disc herniation (LDH) in Denmark a year. Despite the effective clinical relief provided by surgical intervention, the overall risk of re-operation due to recurrent lumbar disc herniation (rLDH) ranges from 3-11 %. Many studies have reported rates of rLDH, and sought to identify risk factors for rLDH. Current literature though reports multiple risk factors with varying results. The aim of the present study is to examine the incidence of reoperations due to rLDH and to determine if age, gender, smoking status or body mass index (BMI) are significant risk factors of symptomatic rLDH leading to reoperation.

## Methods

All patients who underwent discectomy for LDH at Center for spine surgery and research, Middelfart, from June 2010 to January 2015 were included. Patients who underwent reoperation due to rLDH prior to August 2015 were identified. Data on reoperations, age, gender, smoking status and BMI were collected from DaneSpine. A comparison of the self-reported data was made between the non-rLDH and the rLDH group.

## Results

A total of 1378 patients were included. 115 patients (8,35 %) were re-operated, 103 patients (7,5%) for rLDH. The mean age of the two groups were 48.2 and 44.7, non-rLDH and rLDH respectively ( $p = 0.0128$ ). Gender distribution showed no significant difference between the groups (54,8% vs. 48,5% males;  $p = 0,222$ ). Mean BMI was equal in both groups (26.6;  $p = 0.458$ ). A significant higher prevalence of smokers was found in the rLDH group (33.1% vs. 51.5%;  $p = 0.000$ ). Binary logistic regression analysis showed that smoking is an independent risk factor of rLDH (OR 2.12;  $p = 0.000$ ).

## Conclusion

Smoking is an independent risk-factor of reoperation due to rLDH. Further research is needed, to determine if smoking cessation ahead of index surgery reduces the risk of reoperation.

## 128. Comparison of Intrathecal Diamorphine with Conventional Methods of Analgesia Following TLIF (Transforaminal Lumbar Interbody Fusion) Surgery

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United Kingdom

## Summary

Pain following lumbar spinal surgery can be severe. Unrelieved postoperative pain can lead to adverse clinical outcomes including DVT, PE, myocardial infarct, pneumonia and poor wound healing. Intrathecal opioids following spinal surgery are efficacious but the commonly used opiate is morphine which is associated with an increased incidence of late respiratory depression. This study shows that

spinal diamorphine (rather than morphine) is effective in patients undergoing TLIF surgery (when compared to a cohort without spinal opioids).

## Hypothesis

Spinal diamorphine provides better analgesia than conventional analgesia methods following lumbar spinal surgery.

## Design

This is a retrospective comparative study of 60 consecutive patients undergoing minimally invasive TLIFs performed by single surgeon and anaesthetist. Spinal diamorphine was injected by the anaesthetist with the patient under GA before the surgical incision. There were two cohorts - one with 32 patients who had spinal diamorphine and one with 28 patients who had no diamorphine. Patient demographics are comparable.

## Introduction

Unrelieved postoperative pain following lumbar surgery can lead to severe complications. Intrathecal opioids (morphine) following spinal surgery have been described but can be associated with an increased incidence of late respiratory depression. The purpose of present study is to show our experience with spinal diamorphine in patients undergoing TLIF (transverse lumbar interbody fusion) surgery (1-2 segments) and compare them with a cohort who had the same surgery without spinal opioids.

## Methods

Retrospective notes review and statistical analysis with a standard t-test. The following outcome parameters were analysed: Perioperative analgesic requirement, immediate recovery and postoperative pain scores, estimated blood loss, side effects, critical care and length of stay and indicators of gastrointestinal function.

## Results

The mean dose of diamorphine injected intrathecally was 1.56mg (range 1-2mg, 20-30mcg/kg). Patients in the diamorphine group had less blood loss (330 vs 556 mls), less PCA opioid consumption, less pain scores at recovery and for up to 48 hrs postoperatively, less pruritus (29% vs 47%) and opened their bowels earlier (3.7 vs 4.4 days). All were statistically significant ( $p < 0.05$ ). The length of stay in critical care (average 1 day both groups) and hospital were similar (5.4 days vs 6 days). There was no respiratory depression requiring naloxone in the diamorphine group.

## Conclusion

Spinal diamorphine provides better analgesia than conventional analgesia methods following lumbar spinal surgery. Spinal diamorphine is safe and might decrease intraoperative blood loss.



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## 129. Impact of Pre-Operative Diagnosis on Patient Satisfaction Following Lumbar Spine Surgery

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*United States*

### Summary

In a multi-center registry of 7207 patients, patients with primary lumbar disc herniation or spondylolisthesis were most likely to report that their expectations were met. Although patients with adjacent segment degeneration or mechanical collapse were least likely to have their expectations met, the majority reported that they would undergo the same surgery for the same results. The results of this study may help set realistic patient expectations based on pre-operative diagnosis, and thereby, improve patient satisfaction following spine surgery.

### Hypothesis

Pre-operative diagnosis (disc herniation, stenosis, spondylolisthesis, adjacent segment degeneration, mechanical disc collapse) will impact patient satisfaction following surgery.

### Design

Longitudinal cohort of patients enrolled in N2QOD.

### Introduction

Patient satisfaction is a metric that is commonly used in the current healthcare environment. While factors that affect patient satisfaction following spine surgery are complex, we hypothesize that specific diagnostic groups of patients may be more likely to be satisfied following spine surgery and this will be reflected in patient reported outcome measures.

### Methods

Patients enrolled in N2QOD completed patient reported outcomes including ODI, back pain (BP) and leg pain (LP) pre-operatively and one-year post-operatively. Patients were stratified by diagnosis and by their response to the satisfaction question: 1) Surgery met my expectations; 2) I did not improve as much as I hoped, but I would undergo the same operation for the same results; 3) Surgery helped, but I would not undergo the same operation for the same results; 4) I am the same or worse as compared to before surgery and compared.

### Results

A greater proportion of patients with primary disc herniation or spondylolisthesis report that surgery met expectations (66% and 67% respectively) followed by recurrent disc herniation and stenosis (59% and 60% respectively). A smaller proportion of patients undergoing surgery for adjacent segment degeneration or mechanical collapse had their expectations met (48% and 41% respectively). Patient would have same surgery again (sum of top two responses): 88% of disc herniation, 79% of recurrent disc herniation, 87% of spondylolisthesis, 88% of stenosis, 75% of ASD, 73% of mechanical collapse. Regardless of diagnosis, mean improvement and ultimate one-year post-op ODI, BP and LP reflected patient satisfaction category.

### Conclusion

Pre-operative diagnosis was predictive of patient satisfaction following spine surgery. Mean change and one-year ultimate ODI, BP, and LP reflected patient satisfaction regardless of pre-operative diagnosis.

## 130. Clinico-radiological Outcomes Following Minimally Invasive Lateral (LLIF) versus Transforaminal Lumbar Interbody Fusion (TLIF)

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*United Kingdom*

### Summary

We retrospectively reviewed patients undergoing minimally invasive lumbar interbody fusion through either a lateral (LLIF) or transforaminal (TLIF) approach. The lateral lumbar approach employs a retroperitoneal transpsoas window to accomplish interbody fusion. We compared the radiographic and functional outcomes following both procedures. LLIF was associated with significant improvement in the disc and foraminal height. Functional outcomes were also in favour of the lateral fusion.

### Hypothesis

LLIF is superior in restoring disc and foraminal height and has a better functional outcome compared to TLIF.

### Design

Retrospective study. Between 2012 and 2014, patients were enrolled who underwent interbody fusion with either approach at L3/4 and/or L4/5. 60 subjects, operated at 82 levels, fulfilled the inclusion criteria and were distributed among two groups. Group 1 LLIF (n=28) Group 2 MI-TLIF (n=32).

### Introduction

Disc height collapse results in loss of foraminal height, most likely unilateral. Restoration of the disc and foraminal height indirectly decompresses the nerve roots. LLIF procedure has been recently gaining popularity. It is used in a wide variety of degenerative disorders including spondylolisthesis and degenerative scoliosis. It allows better access for disc clearance and insertion of large footprint cages. This is associated with a significant improvement in coronal and sagittal balance. The foraminal height can also be restored which resolves the radicular symptoms.

### Methods

Radiographic parameters included disc height, foraminal height, segmental lordosis, overall lumbar lordosis. Clinical outcomes included VAS, ODI and EQ-5D. Radiological outcomes were measured on standing lateral x-rays preoperatively, immediately postoperatively and at the last follow-up. Clinical outcomes were recorded preoperatively, at 6-8 weeks postoperatively and at the last follow-up

### Results

The average follow-up was 19 months (range 14-36 months). Group 1: Mean improvement in disc height 9.1mm, foraminal height 5mm, segmental lordosis 6.75o, lumbar lordosis 15.4o, ODI 37, VAS 56.2, EQ-5D 54. Group 2: Mean

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improvement in disc height 5.8mm, foraminal height 3.5mm, segmental lordosis 4.5o, overall lordosis 10.3, ODI 18, VAS 26, EQ-5D 23.5. The difference in parameters was statistically significant ( $p < 0.05$ ) apart from ODI.

## Conclusion

Cages inserted via the lateral approach have the ability to improve lumbar/segmental lordosis and is superior in restoring disc and foraminal height compared to MI-TLIF. Furthermore, Patients in the LLIF group showed improved clinical outcomes compared to the TLIF group.

## 131. Patient Reported Outcomes Underestimate the Impact of Major Complications in Patients Undergoing Spinal Surgery for Degenerative Conditions

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United States

## Summary

PROs such as the Oswestry Disability Index (ODI) and EuroQOL5D (EQ5D) have become the primary metric for lumbar spine surgery. While PROs are an important reflection of patient perception, they may not accurately capture the impact of major complications. In this study, patients with major complications had significant deterioration in their general health, as evidenced by worse CCMI scores, despite reporting ODI and EQ-5D improvements equivalent to patients with no complications or minor complications.

## Hypothesis

Major complications after lumbar spine surgery result in deterioration in general medical health that is not reflected by commonly used patient-reported outcome (PRO) scores.

## Design

Longitudinal cohort.

## Introduction

PROs such as the Oswestry Disability Index (ODI) and EuroQOL5D (EQ5D) are widely used to evaluate treatment outcomes following spinal surgery for degenerative conditions. In theory, deterioration in general health should be captured by generic measures such as EQ5D, but this may not be the case. The goal of this study is to use Charlson Comorbidity Index (CCMI) as a measure of general health status, for comparison with standard PROs.

## Methods

We examined serial CCMI, complications and PROs in 371 patients treated surgically for degenerative lumbar spine conditions. The cohort included 152 males (41%) with a mean age of 58.7 years. Patients with No, Minor or Major complications were compared at baseline and at one year post-op.

## Results

Minor complications were observed in 177 patients (48%) and major complications in 34 (9%) patients. Deep wound infection (10), neurologic deficit (9), stroke (6), MI (4), DVT (5), PE (3) were the most commonly seen major complications. There were no significant differences in pre-op ODI, EQ5D or CCMI among the three groups. At one-year, there was a significantly

greater deterioration in CCMI in the Major complication group (1.03) compared to the Minor (0.66) and No complication groups (0.44,  $p < 0.006$ ), but no significant difference in ODI or EQ5D.

## Conclusion

Despite equivalent improvements in patient reported outcomes, patients with major complications actually had greater deterioration in their general health status as evidenced by worse CCMI scores. As CCMI is predictive of medical and surgical risk, patients who sustained a major complication now carry a greater likelihood of adverse outcomes with future interventions including subsequent spinal surgery. While PRO scores are a key metric, they fail to adequately reflect the potential long-term impact of major perioperative complications.

	COMPLICATION GROUP			p-value
	NO	MINOR	MAJOR	
N	160	177	34	
Age	57.14	59.66	60.92	0.112
BMI	30.99	30.61	32.89	0.151
Oswestry Disability Index				
Baseline	39.13	42.25	45.49	0.002
Twelve-month	16.39	19.85	21.28	0.004
Twelve-month Change	23.14	21.97	23.96	0.447
EuroQOL 5D				
Baseline	0.49	0.45	0.40	0.048
Twelve-month	0.69	0.62	0.56	0.006
Twelve-month Change	0.20	0.17	0.16	0.563
Charlson Comorbidity Index				
Baseline	3.68	3.98	3.79	0.523
Twelve-month	4.11	4.63	4.82	0.157
Twelve-month Change	0.44	0.66	1.03	0.006

## 132. The Effect of Prophylactic Vertebroplasty on the Incidence of Proximal Junctional Kyphosis and Proximal Junctional Failure Following Posterior Spinal Fusion in ASD: A 5 Year Follow up Study

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## Summary

Proximal junctional kyphosis (PJK) occurs in 9-46% of patients after undergoing ASD surgery. A subset develop proximal junctional failure (PJF) within 6 months postoperatively, requiring revision. To date, there are no studies evaluating the impact of prophylactic vertebroplasty on PJK/PJF incidence at long term follow-up. The 5 year results of this series demonstrate that the procedure may minimize the risk for junctional failure in the early postoperative period, however, it does not appear to decrease the incidence of PJK.

## Hypothesis

For long segment thoracolumbar posterior spinal fusion (PSF), prophylactic vertebroplasty can minimize the incidence of PJK/PJF.

## Design

Retrospective cohort study.

## Introduction

Approximately 66-76% of PJK occurs within 3 months of surgery. Of these, reportedly 6-17% develop PJF within 6 months postoperatively, requiring revision surgery. We present the 5 yr follow up results of prophylactic





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vertebroplasty, a technique we have previously described to minimize the incidence of PJF/PJK for long-segment PSF.

## Methods

Of the 41 patients who received 2 level prophylactic vertebroplasty at the upper instrumented and supra-adjacent vertebrae at the time of index PSF, 39 (95%) completed an average of 5 yr follow-up. PJK was defined as a change in the PJK angle  $\geq 10^\circ$  between the immediate post-operative and final follow-up radiograph. PJF was defined as proximal junctional fracture, fixation failure, or kyphosis requiring extension of fusion.

## Results

39 patients were evaluated (5 M, 34 F; average age: 65.6 yrs, range 41-87) at an average follow-up of 60.9 months. Of the 39 patients, 13 (33.3%) developed either PJK (9: 7.7% at 2 yrs, 15.4% between 3 to 5 yrs) or PJF (4: 5.1% at 2 yrs, 5.1% between 3 to 5 yrs). For the 4 patients: 1 developed acute PJK within 2 wks after surgery, 1 developed acute subluxation 3 months postop, 1 developed PJK 4 yrs after surgery, and 1 developed PJK with myelopathy 5 yrs after surgery. None of the patients had vertebral fractures adjacent to the vertebroplasty levels. There was no significant difference in ODI, SRS-22, SF-36 scores or radiographic measures between those with and without PJK ( $P > 0.05$ ). 5 patients required revision for reasons other than PJK/PJF.

## Conclusion

This long term follow up demonstrates that prophylactic vertebroplasty may minimize the risk for junctional failure in the early postoperative period, however, it did not appear to decrease the incidence of PJK at 5 years.

	PJK (n=9)	PJF (n=4)	Non-PJK/PJF (n=26)	P
<b>Thoracic Kyphosis (T3-T12)</b>				
Pre-Op ( $^\circ$ )	22.0	35.7	30.8	0.24
6wk Post-Op ( $^\circ$ )	38.2	66.4	20.9	0.51
Final Follow-Up ( $^\circ$ )	48.4	N/A	44.6	0.51
<b>Lumbar Lordosis (L1-L5)</b>				
Pre-Op ( $^\circ$ )	30.9	27.2	17.6	0.44
6wk Post-Op ( $^\circ$ )	45.3	47.9	42.7	0.81
Final Follow-Up ( $^\circ$ )	41.8	N/A	42.7	0.81
<b>Sagittal Balance</b>				
Pre-Op (mm)	105.6	112.1	117.3	0.94
6wk Post-Op (mm)	26.5	82.3	41.6	0.04
Final Follow-Up (mm)	88.7	N/A	72.2	0.41
<b>Coronal Balance</b>				
Pre-Op (mm)	23.0	26.0	25.4	0.94
6wk Post-Op (mm)	17.9	21.1	14.7	0.51
Final Follow-Up (mm)	20.3	N/A	16.5	0.41

Comparison of Surgical Correction: PJK, PJF and Non-PJK/PJF Groups

## 133. BMP Use and the Risk of Revision Surgery Following Long Posterolateral Fusions in the Elderly

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United States

### Summary

Revision surgery is a significant source of morbidity in elderly patients treated with long fusions. Unfortunately, this demographic is poorly studied with regard to how to modify these rates. Within this study it was found that elderly patients treated with BMP during 8 level or greater thoracolumbar spine fusions, were significantly less likely to require revision surgery than those who were not treated with BMP. BMP did not significantly decrease revision rates in patients treated with 3-7 level spine fusions.

### Hypothesis

Bone morphogenetic protein (BMP) use will more greatly reduce revision rates when used with longer ( $>7$  level) fusions as compared to shorter (3-7 level) fusions.

### Design

Retrospective review of Medicare claims database.

### Introduction

Revision spine surgery is a significant source of morbidity in the elderly, highlighting the importance of discovering methods to decrease the risk of repeat procedures. The role of BMP in modulating risk of future revision surgery is not well studied in the elderly population. The goal of this study is to assess whether bone morphogenetic protein (BMP) decreases the risk of revision surgery in elderly patients treated with 3-7 level or 8 or greater level fusions.

### Methods

The PearlDiver database (2005-2012) was queried for elderly adult spinal deformity patients treated with a primary thoracolumbar posterolateral fusion of three or more levels. Four mutually exclusive cohorts were created and matched to one another: 1043 patients treated with 8 or greater level fusions with BMP; 1111 patients with 8 or greater level fusions without BMP; 2813 patients with 3-7 level fusions with BMP; and 4770 patients with 3-7 level fusions without BMP. Revision and complication rates were compared. Complications included seroma formation, heterotopic ossification, and post-operative neuritis within 90 days.

### Results

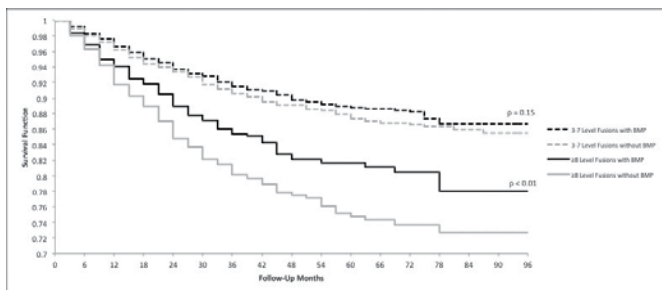
Patients treated with BMP during a 9 or greater level fusion were significantly less likely to require a revision surgery than matched controls (RR 0.75,  $p = 0.015$ ). BMP use was not associated with a decreased risk of revision surgery in 3-7 level fusions (RR 0.89,  $p = 0.20$ ). Patients treated with BMP during 3-7 level fusions were significantly less likely to develop any of the assessed complications ( $p = 0.02$ ). There were no other significant differences in pairwise comparisons of subcohorts of each of the fusion lengths.

### Conclusion

BMP use decreases revision rates in elderly adult spinal deformity patients treated with 9 or greater level fusions, but not in those treated with 3-7 level fusions.



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Survivorship of the four matched cohorts. Log-rank p-values are provided to compare subcohorts of each fusion length.

## 134. Pediatric Patients with Spondylolysis Have High Rates of Vitamin-D Deficiency

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United States

### Summary

While more studies need to be done looking at the effects of treating vitamin D deficiency in patients with spondylolysis, it is important to recognize that these patients have high rates of vitamin D deficiency. For this reason we recommend routine screening of 25-hydroxyvitamin D in patients presenting with spondylolysis.

### Hypothesis

Patients with spondylolysis have high rates of 25-hydroxyvitamin D deficiency.

### Design

Prospective case cohort study of patients with history, physical exam, and positive radiographic, CT, or MRI findings consistent with an acute spondylolysis were included in this study.

### Introduction

The prevalence of 25-hydroxyvitamin D deficiency in the general pediatric population has become increasingly more recognized over the past several years. The objective of this study was to document the 25-hydroxyvitamin D status of patients with confirmed diagnosis of spondylolysis in order to determine if these patients have increased rates of Vitamin D deficiency.

### Methods

After confirming the diagnosis of spondylolysis, patients were prospectively enrolled in this study. Patients' 25-hydroxyvitamin D status was obtained via blood sample. Chart review was used to access demographic data, including gender, age, height, weight, body mass index (BMI), and race. All patient's blood tests were sent to a standard lab for evaluation. By lab criteria, 25-hydroxyvitamin D levels <32 ng/ml were considered deficient, 32-35 ng/ml insufficient, >35 ng/ml were considered normal.

### Results

A total of 40 patients (30 male, 10 female) with a mean age of 14.88 years, and a mean BMI of 22.91 had vitamin D levels drawn after imaging confirmed the diagnosis of spondylolysis. Of these patients, 29 were Caucasian, 3 Hispanic, and 8 African-Americans. The mean 25-hydroxyvitamin D levels was found to be

25.95 ng/ml. Of the 40 patients, only 3 patients (7.5%) were considered to have normal vitamin D levels >35 ng/ml. An additional 6 patients (15.0%) were considered insufficient with values 32-35 ng/ml. And 31 patients (77.5%) were found to have vitamin D deficiency with values <32 ng/ml.

### Conclusion

Pediatric patients presenting with spondylolysis, regardless of race or age, have high rates of 25-hydroxyvitamin D deficiency. Further studies need to be done looking at how the rates of vitamin D deficiency in these patients compare to the general population, as well as how treatment of vitamin D deficiency in these patients affects their outcome.

## 135. Complications with Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS-TLIF) in the Morbidly Obese Population with Degenerative Spondylolisthesis

Eiman Shafa, MD; James D. Schwender, MD

United States

### Summary

We reviewed the peri-operative course of patients with degenerative spondylolisthesis undergoing MIS-TLIF to assess the impact of obesity on the complication rate. Obese and non-obese cohorts were compared. Obesity was correlated with higher in-hospital and six-month post-operative complication rate. Intra-operative complications were low and not significantly different between the two groups.

### Hypothesis

Obesity is an independent risk factor for early peri-operative complication resulting in poorer clinical outcomes in patients with spondylolisthesis treated by MIS-TLIF.

### Design

Retrospective cohort study

### Introduction

Previous studies on degenerative spondylolisthesis report no difference in complication rates or clinical outcome comparing obese and normal weight populations. This study examines the effect of obesity on peri-operative course and outcomes.

### Methods

Retrospective review of 134 patients with degenerative spondylolisthesis undergoing MIS-TLIF between 2010-2012. Patient demographics, peri-operative variables and clinical outcome scores were collected over a minimum of 2 years. Intra-operative, in-hospital, and post-operative (<6 months) complications were assessed. Non-obese (N=65) and obese (N=69) cohorts were grouped by NIH definitions and obese group further subdivided by BMI (I: 30-34, II: 35-39 III: 40 and over).

### Results

There was no difference in intra-operative complications between the two groups (obese = 2.9%, non-obese = 4.6%;  $p=0.362$ ). Incidental durotomy was the only complication; none had sustained sequela. In-hospital complication rate was significantly greater in the obese group (obese = 31.9%, non-obese = 6.2%;  $p<0.001$ ). There was no difference in rate among obese



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subclasses. Genitourinary complications were most common (obese: 11.6%, non-obese 4.6%;  $p < 0.01$ ). Pulmonary, cardiac, and ileus complications were only experienced by obese patients (5.8%, 4.3%, 2.9% respectively). Six-month post-operative complication rate was statistically greater in the obese population (obese= 13%, non-obese= 7.6%;  $p < 0.01$ ). Wound drainage was the most common complication (obese=4.3%, non-obese=0%).

### Conclusion

Obesity poses a unique challenge in treating patients with degenerative spondylolisthesis. In our experience, MIS-TLIF can be safely performed in the obese population despite a higher early post-operative complication rate. No permanent complications were experienced. Knowledge of common complications will help the treatment team appropriately manage obese patients with degenerative spondylolisthesis.

### 136. Cage Subsidence in Lateral Interbody Fusion with Transpoas Approach: Intraoperative Endplate Injury or Late Onset Settling

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Japan

### Summary

93 consecutive patients (184 segments) that underwent lateral interbody fusion (LIF) with transpoas approach were reviewed at one year postoperatively. They were classified into three cage subsidence patterns; intraoperative endplate injury (E), late onset settling (S), and no subsidence (N). The fusion rate of S was significantly lower than E and N. However, subsidence patterns did not significantly affect the clinical outcomes.

### Hypothesis

Intraoperative endplate injury or late onset cage settling may cause poorer results in fusion rate and in clinical outcomes of LIF.

### Design

Retrospective study.

### Introduction

Cage subsidence has been reported as a serious complication of LIF. The purpose is to compare the fusion rate and clinical outcomes at postop. 1 year between the subsidence patterns.

### Methods

93 pts (68.9 yrs, 184 segments) that underwent LIF with transpoas approach with bilateral pedicle screw fixation were enrolled. Diagnoses were 38 adult spinal deformity, 27 spondylolisthesis, 11 adjacent segmental disease, 7 stenosis, and 10 others. All segments were evaluated by CT-MPR immediately postop (within 5 days), 3M, 9M, and 1Y. Cage subsidence over 2mm into the endplates of each segment was identified in the sagittal planes. All segments were classified into three groups according to the subsidence pattern; E (intraoperative endplate injury; identified immediately postop), S (late onset settling; identified after 3M), or N (no subsidence). Patients were classified into Group E (contained at least one E), Group S (contained at least one S), Group ES (contained both of E and S), or Group

N (contained N alone). At POTY, fusion status was evaluated using CT-MPR. VASs and Japanese Orthopaedic Association back pain evaluation questionnaire (JOABPEQ; consisting of five domains) were evaluated as well. The fusion rate of the three subsidence-groups, and VASs and the improvement in five domains of the JOABPEQ of four patient-groups were compared.

### Results

184 segments were classified into 31 E (16.8%), 21 S (11.4%), and 132 N (71.7%). Group E was 20.4%, Group S was 11.8%, Group ES was 4.3%, and Group N was 63.4% of all pts. The fusion rate was 35.5% in E, 23.8% in S, and 54.5% in N. S demonstrated a significantly lower fusion rate than other groups ( $p = 0.01$ ). There was no significant difference in VASs nor in all five domains of the JOABPEQ among the four patient-groups.

### Conclusion

Late onset settling demonstrated a worse fusion rate than intraoperative endplate injury or no-subsidence at POTY. However, there was no significant difference in clinical outcomes among the three patterns.

### 137. Primary Drivers of Cervical Deformity: Prevalence and Effect of Surgical Treatment Strategies on Post-Operative Alignment

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United States

### Summary

Cervical spine deformity surgery, while focusing on optimal correction in cervical alignment, should also take into consideration lower regional and global sagittal deformity. The primary sagittal driver of cervical deformity had been understudied. Analysis showed that thoracic drivers of cervical deformity displayed worse pre-operative alignment, but had greater overall correction in spino-pelvic and cranial alignment. Using primary deformity drivers as a means of classifying cervical deformity is effective in a planning optimal global, not exclusively cervical, correction.

### Hypothesis

Ideal cervical deformity correction can be qualified by using the primary deformity driver

### Design

Retrospective review

### Introduction

Cervical spine deformity (CSD) primary drivers (PD) have yet to be evaluated in relation to pre/postop alignment. This study defines CSD drivers to understand the impact of driver region on postop sagittal realignment.

### Methods

CSD patients (pts)  $\geq 18$  yrs with pre-/post-op (3M) radiographs. PD were classified based on spinal region: CS=cervical; CTJ=cervicothoracic junction;

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TH=thoracic; SP=spino-pelvic. Pts were evaluated if the surgery included the PD apex, based on lowest instrumented vertebra (LIV): CS: LIV≤C7, CTJ: LIV≤T3, TH: LIV≤T12. Cervical alignment modifiers (cSVA, CBVA, mJOA, TS-CL) quantified post-op goals. Groups were compared with ANOVA/Pearson 2, and paired t-tests.

## Results

84 pts met criteria (mean age 63.1yrs, 62% F). Thoracic drivers (n=26) showed the greatest pre-op cervical and global malalignment against other PD: higher TK, PI-LL, T1 Slope C2-T3 SVA, and C0-2 angle ( $p<0.05$ ). Differences in baseline-3M alignment changes were observed between surgical PD groups, in PI-LL, LL, TS-CL, cSVA, C2-T3 SVA ( $p<0.05$  all cases). Main changes were between TH and CS driver groups: TH pts had greater PI-LL ( $4.47^\circ$  vs.  $-0.87^\circ$ ,  $p=0.049$ ), TS-CL ( $-19.12^\circ$  vs.  $-4.30$ ,  $p=0.050$ ), C2-7 SVA ( $-18.12$  vs.  $-4.30$  mm,  $p=0.007$ ), and C2-T3 SVA ( $-24.76$  vs.  $8.50$  mm,  $p=0.002$ ) baseline-3M correction. CTJ drivers also had a trend toward greater LL correction compared to CS drivers ( $-6.00^\circ$  vs.  $0.88^\circ$ ,  $p=0.050$ ). In pts operated at CS driver level, there was a significant difference in the prevalence of 3M TS-CL modifier grades (0=35.7%, 1=0.0%, 2=13.3%,  $p=0.030$ ). There was also a significant difference in the 3M CBVA modifier grade distribution in pts operated at the TH driver level (0=0.0%, 1=35.9%, 2=14.3%,  $p=0.049$ ).

## Conclusion

Characterizing CSD patients by primary driver type reveals differences in pre- and post-operative alignment. Evaluating surgical alignment outcomes based on PD inclusion is important in understanding alignment goals for CSD correction.

### 138. Predictive Model for Patient-Reported Outcomes Scores Following Cervical Spine Deformity Surgical Correction

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## Summary

Predicting outcomes following surgery for cervical deformity correction is particularly important, though most predictive models focus on alignment without consideration for patient-reported outcomes. This study develops a predictive model for myelopathy assessment, a common and validated measure in cervical deformity patients, that incorporates both demographic and operative variables. Screening for these factors at first-visit may aid physicians in patient counseling.

## Hypothesis

Acute post-operative patient-reported outcomes following cervical spine deformity (CSD) correction can be predicted from baseline demographic and surgical variables with high accuracy.

## Design

Retrospective review

## Introduction

Demographic and operative factors impacting clinically-relevant improvement in myelopathy score, a common tool used for assessing CSD success, following surgical correction are lacking. This analysis provides a predictive model for assessing acute improvements in outcomes following CSD surgery.

## Methods

Inclusion: CSD patients  $\geq 18$ yrs with pre/postop (3M) radiographic and HRQL (mJOA=modified Japanese Orthopaedic Association). Univariate logistic regression followed by multivariate regression models with stepwise selection were performed to generate a dataset-specific prediction model. Final prediction model for linear scores (3M mJOA) was selected based on lowest AIC value. Dichotomous outcomes (3M mJOA MCID using published criteria) are presented with AUC and 95% CI.

## Results

84 surgical CSD patients were included (mean age: 63.2yrs, 61.9% F). The final model for predicting increased 3M mJOA scores yielded an AIC = 51.2. The following demographic and operative factors were included in the final model: pre-op mJOA score, BMP-2 use, posterior osteotomy at T1, a prior history of cervical fusion, and baseline thoracic kyphosis ( $p<0.03$  all cases). Likelihood of reaching 3M mJOA MCID was also accurately predicted (AUC=80.5% [94.13-66.77]), based on the following variables: lower LIV and increased baseline mJOA score ( $p<0.04$ ).

## Conclusion

Acute post-operative improvements in myelopathy scores among CSD patients can be predicted with high accuracy using a combination of operative and radiographic parameters. Proper assessment of such factors should be taken at pre-op consultation to optimize patient outcomes.

### 139. Cervical Deformity Surgery Does Not Result in Post-Operative Dysphagia: A Prospective Cohort Study

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## Summary

Cervical deformity (CD) surgery does not result in long term symptomatic dysphagia as measured by SWAL-QOL scores. Prior surgery and increased BMI are associated with lower baseline SWAL-QOL. A history of prior cervical spine surgery was the only operative variable associated with lower SWAL-QOL scores.

## Hypothesis

CD surgery does not result in long-term, symptomatic dysphagia

## Design

Prospective cohort study



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## Introduction

Most studies of dysphagia in the cervical spine have focused on a degenerative patient (pt) population; the rate of dysphagia following surgery for CD is unknown.

## Methods

Pts with CD undergoing surgery from 2013-2015 were prospectively enrolled to evaluate dysphagia. Inclusion criteria were: cervical kyphosis (CK) $>10^\circ$ , cervical scoliosis (CS)  $>10^\circ$ , C2-7 SVA  $>4\text{cm}$  and/or horizontal gaze impairment (chin-brow vertical angle (CBVA)  $>25^\circ$ ). Demographic, operative and radiographic variables were analyzed. SWAL-QOL was used to measure dysphagia. Paired t-test, independent t-tests and bivariate Pearson correlations were performed.

## Results

88 CD pts, aged  $61.52 \pm 10.52$  years, were enrolled. All pts (100%) had 3 mo. SWAL-QOL and 45 (51.1%) had 1 yr SWAL-QOL for analysis. The mean pre-op SWAL-QOL was 78.35 and correlated with NDI ( $r=0.49$ ), mJOA ( $r=0.39$ ) and EQ5D ( $r=0.54$ ). Body Mass Index (BMI) was correlated with to pre-op SWAL-QOL ( $r=0.30$ ) while age, gender, smoking and Charlson Comorbidity Index (CCI) showed no significant correlations. Pts with prior cervical surgery had a lower pre-op SWAL-QOL ( $p=0.04$ ). There was no correlation between pre-op radiographic parameters and SWAL-QOL except for a correlation between C0-C2 angle and the Eat Burden domain ( $r=0.26$ ).

CD surgery did not result in lower SWAL-QOL at 3 mo or 1 yr. Other surgical variables, including estimated blood loss (EBL), anterior or posterior fusion levels, steroid use, pre-operative traction, staged surgery, surgical approach, anterior corpectomy, posterior osteotomy and UIV location, showed no impact on post-op SWAL-QOL.

## Conclusion

While the incidence of early dysphagia in pts undergoing CD surgery is unknown, lower SWAL-QOL scores at 3 months or 1 year was not observed. Pts with prior cervical surgery and higher BMI had a lower baseline SWAL-QOL. A history of prior cervical spine surgery was the only operative variable associated with lower SWAL-QOL scores.

SWAL-QOL domains	Baseline (n=88)	3 months follow-up (n=88)	1 year follow-up (n=45)	P between Baseline and 3 mo.
Burden	82.63	77.83	84.30	0.152
Eat Desire	80.10	81.93	84.27	0.509
Eat Duration	71.73	67.03	75.41	0.209
Physical	79.69	80.43	82.76	0.673
Food Selection	79.89	75.97	84.28	0.221
Communication	90.66	87.56	90.26	0.147
Fear Swallow	87.25	84.42	86.11	0.145
Social	90.28	87.05	90.54	0.123
Mental	86.88	80.68	88.37	0.020
Sleep	44.85	56.69	64.24	$<0.001$
Fatigue	45.33	55.20	62.09	0.001
SWAL-QOL Total	78.35	77.26	83.13	0.527
NDI	48.30	44.68	37.15	0.039
mJOA	13.51	13.94	13.79	0.134
EQ5D Score	9.74	9.07	8.53	0.001
EQ5D VAS	68.02	76.66	83.11	$<0.001$

## 140. The Center of Rotation (COR) of Cervical 3-Column Osteotomies (3-CO) for Correction of Cervical Kyphosis

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Germany

## Summary

At the cervical spine and cervicothoracic junction (CTJ) 3-CO represent techniques rarely utilized to treat rigid cervical kyphosis (CK). Due to its scarcity, insight into in-vivo correction kinematics are limited. In practice, a mismatch between the in-vivo and conceptual correction mechanism and geometry was observed. A novel analysis of the COR location in 23 patients that underwent cervical 3-CO established this mismatch between conceptual and in-vivo correction geometry. This is related to difficulties in controlling translation and shortening at the osteotomy site.

## Hypothesis

For a cervical osteotomy a mismatch btw. in-vivo and conceptual COR positions exists

## Design

A series of 53 patients that had 3-CO for CK with  $\geq 1$ yr F/U was studied. Patients were included if preop/postop x-rays and CT-scans were available to measure the kyphosis angle (KA $^\circ$ ), sagittal translation at osteotomy (%) and C2-7 sagittal vertical axis (SVA,mm). Preop and postop CT-scans had to provide comparable sagittal recons for image matching using a digital overlay technique

## Introduction

Objective was to improve understanding of in-vivo 3-CO kinematics

## Methods

To determine the COR, a reference frame with x- and y-axis was assigned to the osteotomy level (Fig.1). The COR is calculated from intersection of perpendicular bisectors connecting 2 identical landmarks on anterior and posterior VB elements on preop and postop images. The COR position was measured and normalized (%) to the AP diameter of the caudal VB. The conceptual COR-X for SPO/PSO is at COR-X= $100\%/100\%$  and the COR-Y is at COR-Y= $0\%/ \approx 50\%$

## Results

Ave. age was 51 yrs, BMI 29, blood loss 1.3L, ASA 2.3. Etiology of CK was AS in 16 pts and various in 7. 14 patients had 3-CO at C4-7, 9 at C7-T1. 12 patients had SPO and 11 PSO including 3 with a Y-type variant, a novel PSO extension. Correction of KA, SVA and translation was  $39^\circ$ , 17% and 4mm ( $p<.01$ ). COR-X was  $3 \pm 50\%$  and COR-Y was  $-26 \pm 55\%$ . Comparing PSO and SPO, a sig. difference existed for COR-X (40% vs. -31%,  $p<.01$ ) and a net difference  $>30\%$  for COR-Y ( $p>.05$ ). COR-X for Y-Type osteotomy was sig. different to COR-X in SPO (26% vs. -31%,  $p=.02$ ) and different to PSO (26% vs. 45%,  $p>.05$ ). COR-Y for Y-Type osteotomy was 40% vs. -10% for SPO and -44% PSO ( $p>.05$ ). Pts with increased preop anterior translation at the osteotomy had sig. increased posterior translation after correction ( $r=.8$ ,  $p=.03$ ). With greater SVA the COR-X was located more anterior ( $r=.8$ ,  $p=.02$ ). Results for COR-X and COR-Y were plotted against the

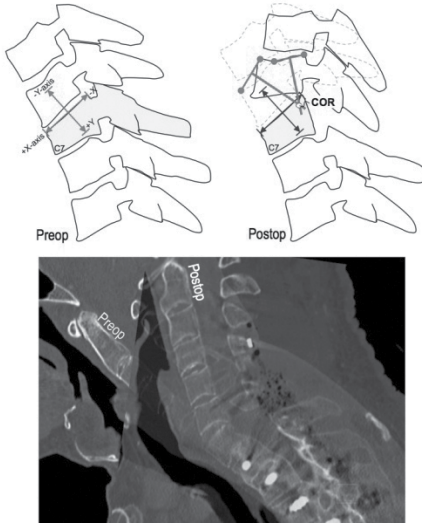


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segmental COR of normals: The COR of 3-CO were shown far off normalcy and conceptual COR for 3-CO

## Conclusion

Translation at the osteotomy influences correction kinematics. Developments that offer a fixed COR during correction can improve accuracy of cervical 3-CO



## 141. Cervical Spine Sagittal Alignment is Different in Standing and Sitting: Are these Changes Predictable?

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### Summary

Sagittal balance is now recognised as an important consideration in spinal deformity surgery. The sitting sagittal profile of the cervical spine and its relationship to other spinopelvic parameters have not been previously defined. Whole spine lateral radiographs in healthy subjects showed significant associations between cervical spine alignment and distal parameters in both sitting and standing positions, with the majority of subjects having different cervical sagittal alignment in both positions. Sitting cervical spine sagittal alignment may thus also merit preoperative attention.

### Hypothesis

Cervical spine sagittal alignment changes between standing and sitting positions, and will have a defined relationship with other spinopelvic parameters.

### Design

A prospective, comparative study with identifying of predictive factors

### Introduction

Despite the recent emphasis on sagittal spine alignment in deformity surgery, the cervical spine remains relatively less understood. With the knowledge that humans spend a substantial amount of time sitting, it is vital to understand the changes that occur in the cervical spine when transitioning from the standing position as well as the relationship between cervical spine sagittal alignment and other spinopelvic parameters.

## Methods

Whole spine sitting and standing radiographs were obtained using a slot scanner for 61 consecutive young patients who were seen in the spine surgery outpatient clinic without any neck symptoms or known cervical spine pathology. Various cervical spine and spinopelvic sagittal alignment parameters were measured and compared. Changes in alignment from a standing position and significant predictors of cervical alignment are identified using chi-squared and paired t-tests.

## Results

5 distinct cervical spine sagittal alignment types were seen, with only 21 and 29.8% of patients having “normal” lordotic cervical spine alignments in standing and sitting positions respectively. Cervical spine alignment was different in sitting and standing positions in 57.4% of patients. Patients with a more lordotic cervical spine have a significantly larger thoracic kyphosis ( $p=0.002$ ) and T1 slope ( $p=0.001$ ). In the sitting position, thoracolumbar angle and pelvic tilt were also significantly associated with different cervical spine subtypes ( $p=0.01$  and  $p=0.02$  respectively).

## Conclusion

Cervical spine sagittal alignment varies across individuals and changes upon sitting. There is interdependence between cervical spine alignment and caudal spinal parameters in both standing and sitting positions. More associations seen between the cervical spine subtypes and distal parameters in the sitting position could be due to physiological adjustments secondary to longer hours of sitting compared to standing.



## 142. Risk Factors For Persistent Axial Neck Pain After Cervical Disc Arthroplasty

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### Summary

We set out to evaluate radiographic and clinical outcomes, and determine risk factors associated with persistent postoperative axial neck pain following cervical disc arthroplasty (CDA). We reviewed all patients undergoing CDA over a five-year period and found a 15.1% rate of persistent posterior neck pain. Multivariate regression found preoperative cervicalgia was the only independent risk factor for persistent postoperative neck pain after CDA, increasing the likelihood by three times.

### Hypothesis

Preoperative neck pain may be associated with persistent axial neck pain after cervical disc arthroplasty (CDA).





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## Design

Retrospective analysis

## Introduction

There is very little literature examining optimal radiographic parameters for placement of CDA, nor is there substantial evidence evaluating the relationship between persistent postop neck pain and radiographic outcomes. We set out to evaluate radiographic and clinical outcomes, and determine risk factors associated with persistent postop axial neck pain following CDA.

## Methods

We performed a retrospective analysis of all patients from a single center, from Aug 2008 to Aug 2012, undergoing CDA. Preop, immediate postop and final follow up films were evaluated.

## Results

285 patients were included, with mean radiographic follow-up of 13.5 months and a 17.2% rate of persistent axial neck pain. The rate of heterotopic ossification (HO) formation per level studied was 22.6% in postop neck pain group, while the rate was significantly lower in the no postop neck pain group (11.7%,  $p=0.03$ ). There was no association between severity of HO and postop neck pain ( $p>0.05$ ). Univariate analysis demonstrated patients with a preop diagnosis of cervicgia were significantly more likely to experience postop neck pain (28.6%,  $p=0.01$ ). There were no differences in preop facet arthrosis, pre- or postop disc height, segmental ROM or anterior-posterior device placement. However, patients with devices more centered coronally between the uncovertebral joints were significantly associated with postop neck pain ( $p=0.03$ ). Multivariate logistic regression found preoperative cervicgia was the only independent risk factor for persistent postoperative neck pain, with odds ratio of 3.02 (1.17-7.83,  $p=0.02$ ).

## Conclusion

We found that persistent axial neck pain is relatively frequent following CDA, and the only independent risk factor was preop cervicgia, increasing the likelihood three times. Univariate analysis found presence of HO and coronal positioning of the device to be associated with postop neck pain; however these radiographic parameters were not found to be independent risk factor in our multivariate regression model.

Multivariate Regression Analysis – Risk of Postoperative Neck Pain After CDA		
	Odds Ratio (95% CI)	P-value
Preoperative cervicgia	<b>3.02 (1.17-7.83)</b>	<b>*0.02</b>
Immediate Postoperative Disc Height	0.65 (0.37-1.14)	0.13
Coronal Position of Implant	0.71 (0.44-1.15)	0.16

Subgroup multivariate logistic regression analysis of single level CDA patients for risk of postoperative neck pain. \*denotes statistically significant  $p$ -value $<0.05$ . We found preoperative neck pain to be the only independent risk factor for developing post-operative axial neck pain after single level cervical disc arthroplasty. CDA = cervical disc arthroplasty, CI = confidence interval, mm = millimeter

## 143. Bimodal Incidence and Causes of Proximal Junctional Kyphosis (PJK) in Adult Spinal Deformity (ASD)

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United States

## Summary

PJK is a well-known complication occurring in patients that undergo surgical correction of ASD. With bimodal incidence, PJK might occur within the first 6 weeks (acute) or beyond 1 yr after surgery (chronic). This study revealed that Acute PJK pts have more co-morbidities, neurologic deficits, depression, and higher lumbar apex corrections with less caudal correction. In addition, aPJK pts had significantly higher peri-operative complication rates, and were more likely to be revised.

## Hypothesis

Acute and chronic PJK occurs with different rates and patients' characteristics.

## Design

Retrospective review of prospectively collected database of consecutive ASD patients.

## Introduction

PJK is a well-known complication occurring in patients (pts) that undergo surgical ASD correction. Acute PJK (aPJK) occurs within the first six weeks, and chronic PJK (cPJK) more than 1 yr after surgery. Both PJK deformities can require surgical treatment. In this study, we aimed to report the incidence of PJK, and contributing factors to either acute or chronic PJK.

## Methods

Pts were included if they were  $>18y$ ,  $\geq 5$  levels fused including the pelvis and 2y f/u. Using Glatte's criteria, pts were stratified according to timing of PJK: aPJK  $<6wk$ , and cPJK  $>1y$ . Pts demographics, radiographic parameters, clinical outcomes (HRQL), operative data, complications and revisions rates were studied using univariate and multivariate analyses to identify independent predictors of aPJK

## Results

176 pts (61.8 yo) were included. 71 pts (40.3%) developed aPJK, and 39 pts (22%) cPJK. Groups were similar in age, baseline deformity, and HRQL. aPJK pts were more likely to have Charlson score  $> 2$  (39.4% vs. 20.5%), depression (34% vs. 16.2%), greater # of co-morbidities (2.7 vs. 2.0), all  $p<0.05$ . aPJK were more likely to have BL abnormal neurologic exam (30% vs. 10.5%), and unable to perform toe-walking test (17% vs. 0%), all  $p<0.05$ . aPJK had higher revision (21 vs. 10.3%), peri-operative complication rate (14.1% vs. 0%) all  $p<0.05$ . Groups underwent similar amounts of sagittal correction, # of level fused, #/type of osteotomies, however, aPJK had more proximal LL apex restoration vs more caudal apex restoration in cPJK. aPJK occurred in 50/70 (71.4%) of posterior only approaches vs. 21/40 (52.5%) in combined

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approaches,  $p < 0.05$ . On multivariate analysis depression (OR: 2.99), and abnormal neurologic exam (OR: 4.15) increased the likelihood of aPJK

## Conclusion

Compared to cPJK, Acute PJK have more co-morbidities, neurologic deficits, depression, and higher lumbar apex corrections with less caudal correction. aPJK pts had significantly higher peri-operative complication rates, and were more likely to be revised

## 144. Early and Late Reoperation Rates and Etiologies Are Similar Between cMIS and HYB Techniques for ASD Correction.

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United States

## Summary

Patients who underwent ASD correction with MIS techniques were identified from a multicenter database. The reoperation rates after a minimum of 2-year follow-up were 27.9% for cMIS and 33.8% for HYB approaches. Early returns to the OR were less common than later reoperations. Junctional failures were more common after HYB technique, while fixation failure was the most common reason for reoperation after cMIS approaches.

## Hypothesis

The rates and reasons for reoperations will vary between cMIS and HYB techniques for ASD correction.

## Design

Multicenter retrospective review

## Introduction

Reoperation after correction of adult spinal deformity (ADS) results in additional cost and morbidity. The rates and etiologies of reoperations may be impacted by the method of ASD correction. We aimed to characterize the reoperation rates and etiologies when performing ASD surgery with cMIS and HYB techniques.

## Methods

A multicenter database was queried. Inclusion criteria for the database included age  $\geq 18$  years, and one of the following:  $CC > 20$ ,  $SVA > 5\text{cm}$ ,  $PT > 20$ ,  $PI-LL > 10$ . Patients with either circumferential MIS (cMIS) or hybrid (HYB) surgery, and  $\geq 3$  spinal levels treated with 2-year minimum follow-up were included for analysis.

## Results

420 patients met inclusion criteria for the database. Of those 165 had complete 2-year data, and a total of 133 met inclusion for this study (65 HYB and 68 cMIS). Junctional failure (15.4%) was the most common reason for reoperation in the HYB group, while fixation failure was the most common reason in the cMIS group (8.8%) (Table 1). There was a higher incidence of PJF than DJF within HYB (12.3% vs. 3.1%), but no significant differences in PJF or DJF rates when compared to cMIS. There were no other differences

between cMIS and HYB when analyzing reasons for reoperation. Early (<30 days) reoperations were less common in both groups (cMIS=1.5%; HYB=6.1%) than late (>30 days) reoperations (cMIS=26.5%; HYB=27.7%), but rates were similar between groups.

## Conclusion

ASD correction with CMIS and HYB techniques result in overall reoperation rates of 27.9% and 33.8%, respectively, at minimum 2-year follow-up. Junctional failures are more common after HYB approaches, while pseudarthrosis/fixation failures happen more often with cMIS techniques. Early reoperations were less common than later returns to the OR in both groups. These reoperation rates compare favorably with open ASD surgery, although the reasons for failure may differ. Further study will be done to evaluate the specific differences between reoperation etiologies when comparing open vs. MIS ASD correction.

Table 1. Reoperation Indications for HYB and cMIS Approaches

	HYB	cMIS	p-value
N	65	68	
Reoperation	22 (33.8%)	19 (27.9%)	0.461
Acute	4 (6.1%)	1 (1.5%)	0.156
Late	18 (27.7%)	18 (26.5%)	0.874
Indications			
Infection	4 (6.1%)	1 (1.5%)	0.156
Neurologic	4 (6.1%)	2 (2.9%)	0.372
Fixation Failure/Pseudoarthrosis	4 (6.2%)	10 (14.7%)	0.169
Fixation Failure	4 (6.1%)	6 (8.8%)	0.559
Pseudo	1 (1.5%)	4 (5.9%)	0.188
Junctional failure	9 (13.8%)	7 (10.3%)	0.529
DJK	2 (3.1%)	4 (5.9%)	0.436
PJK	8 (12.3%)	3 (4.4%)	0.098
CSF Leak	2 (3.1%)	0 (0.0%)	0.145
Bowel/Bladder	1 (1.5%)	0 (0.0%)	0.305

\* =  $p < 0.05$  (significant) Note: Numbers represent count of patients; complications are not mutually exclusive as patients may suffer from more than one complication.

## 145. Proximal Junctional Kyphosis (PJK) Can Be Predicted Following Adult Spinal Deformity (ASD) Surgery: Models Based On Regional Alignment Changes Within the Fusion Area

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United States

## Summary

Surgical treatment of ASD can improve quality of life, however PJK following ASD surgery remains problematic. Numerous risk factors for PJK have been reported; importantly, some of which are controllable by the surgeon. This study developed a model to predict PJK based on surgically modifiable parameters including correction PI-LL mismatch and alignment of the fused segments within the thoracic spine

## Hypothesis

Using parameters controllable during surgery, alignment changes in the proximal junctional segments can be predicted and may be used to predict PJK

## Design

Retrospective review of a prospective multicenter ASD database



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## Introduction

While ASD surgery can improve spinal alignment and quality of life, proximal junctional kyphosis (PJK) occurs at high rates and can negatively affect outcomes. Numerous risk factors for PJK have been reported including parameters that the surgeon can and cannot control. This study aims to develop predictive models of PJK based on parameters controllable during surgery

## Methods

Inclusion criteria were pts with upper instrumented vertebra (UIV) between T7-L1 and fusion to the sacrum/pelvis with mini 2 yr FU. Radiographic analysis included sagittal spino-pelvic parameters and changes of thoracic sagittal alignment within the instrumented construct (TK fused). Regressions between change at the UIV junction and PI-LL and TK fused was built using 75% of the cohort and validated against the 25% remaining. The risk of PJK was computed, and results reported in terms of precision, recall, and accuracy

## Results

123 pts were evaluated. Mean age was 62 yrs, mean 9 levels fused). Most common UIV was T10/T11 (78.9%) and ranged from T8-L1. All sagittal spinopelvic parameters improved postoperatively ( $p < 0.001$ ; Table). Change in PI-LL significantly correlated with PJK angle ( $r = 0.395$ ). The regression model ( $r$ -square: 0.769) led to a mean error of  $-2^\circ$  on the validation cohort. Prediction of the post-op PJK revealed an accuracy of 68% (precision 82%, recall 64%, Table)

## Conclusion

Significant correlations between changes in proximal junctional alignment and PI-LL were noted. Predictive models for PJK based on parameters controllable during surgery revealed an  $r$ -squared of 0.769 and precision of 68%. These findings may be helpful in optimizing surgical planning as the model includes alignment in the fused portions of the thoracic spine. Further work will permit additional model refinement to facilitate improved surgical planning, reduce suboptimal post-op alignment and minimize PJK occurrence

Parameters	Alignment		Model		Validation
	Pre	Post	Predicted	Predictor	Mean error
PI (degree)	56.0 ± 12	-	ΔPJK angle	ΔPI-LL	-2 ± 11
PT (degree)	25.5 ± 10	23.8 ± 10	ΔTK Fused	0.769*	
PI-LL (degree)	21.45 ± 19	5.1 ± 14	* Regression through origin		
T4-T12 (TK) (degree)	-26.6 ± 15	-45.7 ± 16	Predicted		
SVA (mm)	78.3 ± 73	45.4 ± 56	PJK - yes	PJK - no	Precision: 82%
TK Unfused (degree)	-	-30.4 ± 12	49	28	Recall: 64%
NB free vertebra	-	6 ± 1.2	PJK - no	11	35
					Accuracy: 68%

## 146. Interbody Cage Height Affects Subsidence Rate After Transforaminal Lumbar Interbody Fusion

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## Summary

We reviewed patients over age 50 following TLIF with immediate post-operative and follow-up computed tomography (CT) scans available for evaluation of interbody cage subsidence. We found higher number of fusion levels and increased interbody cage height were significantly associated with the occurrence of interbody cage subsidence after TLIF. Our data suggest

a larger interbody cage may ultimately lead to violation of the endplate over time, and the risk of interspace collapse must be considered during intraoperative implant height/size selection.

## Hypothesis

Patients with increased cage height will have higher rates of cage subsidence.

## Design

Retrospective analysis

## Introduction

Various finite element and biomechanical studies have examined construct stability after transforaminal lumbar interbody fusion (TLIF). However, to our knowledge, no clinical or radiographic studies have analyzed interbody cage characteristics and risk factors for subsidence after TLIF.

## Methods

We performed a retrospective review over a ten year period. We included all patients over age 50 following TLIF with immediate post-operative and follow-up computed tomography (CT) scans available for radiographic quantification of interbody cage subsidence. Medical records were reviewed for patient demographic information and surgical data, including number of levels fused, implant material/length/height, and the use of bone morphogenetic protein (BMP).

## Results

We identified 128 patients with complete CT imaging and average follow-up of 27.2 months. Fifty-five had evidence of implant subsidence at most recent follow up, with average erosion into the superior endplate of the inferior vertebral body of 5.5 mm. The remaining 73 patients had no implant subsidence, with no demographic differences between groups. The most commonly used interbody cage material was polyetheretherketone (PEEK). The number of levels treated ranged from 1 to 4, with the subsidence group having a higher average number of levels fused (2.0 vs 1.7,  $p = 0.05$ ). BMP was used in 67.3% and 65.8% of patients in the subsidence and no-subsidence groups, respectively. Implant height was significantly higher in the subsidence group (12.6 mm) when compared to the no-subsidence group (11.2 mm,  $p < 0.001$ ).

## Conclusion

Our study found higher number of fusion levels and increased interbody cage height (1.4 mm difference between groups) were significantly associated with the occurrence of interbody cage subsidence after TLIF, with an average cage subsidence of more than 5 mm. Our data suggest a larger interbody cage may ultimately lead to violation of the endplate over time, and the risk of interspace collapse must be considered during intraoperative implant height/size selection.

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## 147. Natural History of Proximal Junctional Kyphosis following Posterior Correction and Fusion for Congenital Scoliosis

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### Summary

Proximal junctional kyphosis (PJK) mainly occurred and progressed during the first 3 months after surgery followed by almost no progression or slight improvement.

### Hypothesis

PJK mainly occurred and progressed during the first 3 months after surgery followed by almost no progression or slight improvement.

### Design

A retrospective study.

### Introduction

To investigate the timing, radiographic characteristics, and natural history of post-operative PJK in young children with congenital scoliosis

### Methods

A total of 179 consecutive CS children who underwent posterior instrumentation and fusion were retrospectively reviewed to evaluate timing, radiographic characteristics, and natural history of post-op PJK. From sagittal images, the following values were obtained: proximal junctional angle (PJA), sagittal vertical axis (SVA), pelvic incidence (PI), thoracic kyphosis (TK), lumbar lordosis (LL), and segmental kyphosis (SK). PJK were categorized into 3 types: type 1, ligamentous failure; type 2, bone failure, such as fracture at or above the UIV; and type 3, implant-bone interface failure. Patients with implant bone interface failure, bone failure and increase of PJA more than  $15^{\circ}$  receive brace treatment.

### Results

33 PJK cases were identified out of 179 consecutive patients (18.4%). The average age at surgery was  $6.8 \pm 1.4$  years, and the average follow-up period was  $41.7 \pm 11.47$  months. In PJK group, 87.8% patients developed PJK within 3 months after surgery. Implant-bone interface failure and bone failure were detected in 30.3% and 3.0%, respectively. Thus the remaining 22 patients were classified to ligamentous failure. The average PJA increased from  $7.1^{\circ}$  to  $19.5^{\circ}$  at 3 months after surgery to  $20.6^{\circ}$  at the final follow-up visit in the PJK group. The average PJA increase within the first 3 months accounted for the 86% of the total increased extent of PJA. 10 patients with implant bone interface failure, one patients with bone failure and 5 ligamentous failure patient with a PJA increase more than  $15^{\circ}$  received brace treatment. By the last follow-up visit, PJK was well tolerated and did not require revision surgery.

### Conclusion

PJK were identified in 18.4% of CS children undergoing posterior instrumentation and fusion, and mainly occurred and progressed during the first 3 months after surgery followed by almost no progression or slight improvement.

## 148. Comparative Analysis of Surgical Outcomes of Posterior Vertebral Column Resection by the Age at the Time of Surgery in the Treatment of Congenital Scoliosis: Greater than 10-Year Follow-up

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*Korea*

### Summary

The treatment for congenital scoliosis may include early diagnosis and appropriate surgical management to prevent further progression. However, there is little information reported about the long term follow-up of surgical outcomes that pertain to the timing of surgery for congenital scoliosis in children under age 18 years. This study is to compare the surgical outcomes of posterior vertebral column resection (PVCR) and its long-term effects on the deformity correction for congenital scoliosis in children less than 18 years of age.

### Hypothesis

Early surgical correction of a congenital hemivertebra in children under 10 years of age, before structural changes occur effectively achieves a more satisfactory correction with short fused segments compared to children older than 10 years but under 18 years of age.

### Design

A retrospective study.

### Introduction

Congenital scoliosis due to a hemivertebra usually creates a wedge-shaped deformity, which progresses and causes severe spinal deformity during the growth spurt. Delayed treatment will necessitate long fusion with a high risk of neurologic complications.

### Methods

Forty-five congenital scoliosis patients (N=45) under age 18 at the time of surgery were treated by PVCR and fusion with pedicle screw fixation (PSF). These cases were retrospectively studied and had a minimum 10-year follow-up. We assigned patients into two groups: Group 1 (N = 19) patients who had surgery before 10 years of age, Group 2 (N = 26) those who had surgery after 10 years of age.

### Results

In Group 1, the mean Cobb angle of the main curve was  $44^{\circ}$  before surgery,  $10.2^{\circ}$  after surgery, and  $14.2^{\circ}$  at last follow-up. In Group 2, the mean Cobb angle of the main curve was  $48.7^{\circ}$  before surgery,  $17.2^{\circ}$  after surgery, and  $20.4^{\circ}$  at last follow-up. The mean operative time was 189 min (range: 70 to 405 min) in Group 1 and 245 min (range: 80 to 395 min) in Group 2. The mean estimated blood loss (EBL) was 1285 mL (range: 270 to 3000 mL) in Group 1 and 2376 mL (range: 600 to 6000 mL) in Group 2. The mean fused segments were 3.3 in Group 1 and 4.6 in Group 2. There were 22 complications for PVCR and the overall prevalence of complications was 48.9%.





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## Conclusion

PVCR is an effective procedure for the management of congenital scoliosis under age 18. PVCR and fusion with PSF for congenital scoliosis before the age of 10 years had significantly better deformity correction compared to the group after the age of 10 years and did not cause crankshaft phenomenon. The mean operative time and EBL in children under age 10 were both significantly less compared to children between 10 and 18 years of age.

## 149. The Impact of Prosthetic Rib Treatment on Respiratory Assistance Requirement

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## Summary

Progressive thoracic insufficiency syndrome (TIS) often results in respiratory insufficiency requiring oxygen support or even external respiratory support. Our results reveal that some patients with EOS and TIS, who received early VEPTR treatment, may become completely independent of pulmonary support by two years post-op. The children that improve the level of their ventilator assistance have somewhat smaller pre-operative Cobb angles than those that continue to decline and similar pre-operative Cobb angles to those that remain stable.

## Hypothesis

Patients with an abnormal AVR treated with a prosthetic rib will have improved respiratory status after surgery.

## Design

Prospective comparative study

## Introduction

The Assisted Ventilation Rating (AVR), an ordinal scale ranging from 0 (no assistance) to 4 (fulltime ventilator support), indicates the degree of external respiratory support needed to maintain oxygenation in children with thoracic insufficiency syndrome (TIS). For skeletally immature patients with TIS, a prosthetic rib can be used to improve lung volume and growth. We sought to identify patients with EOS and abnormal initial AVR who underwent early prosthetic rib treatment to determine effect on AVR respiratory status.

## Methods

Pre-op and post-op AVR ratings were prospectively collected from a multicenter study group. Inclusion criteria consisted of patients treated with prosthetic rib under the age of 10 years at initial implant with minimum 2 year follow up data. Patients were excluded if there was no initial AVR assessment or if initial AVR was normal (0). Statistical analysis was performed on groups that had stable, declined, and improved AVR at final follow up.

## Results

A query yielded 77 patients with initial AVR greater than 0. The most frequent primary diagnosis was congenital scoliosis (n=14) and spinal muscle atrophy (n=14). 28 (36%) had a change in AVR from initial to final assessment (Table 1). Average age at time of implant and average pre-op Cobb angle are indicated in Table 1. Of the 19 positive changes, 12 began on full or part time

ventilation support and 7 on supplemental oxygen. Sixteen (84.2%) of these improved to a normal AVR and 3 to part time ventilation support. The positive change group was composed of 25% of the most severe AVR score (4) while the deterioration group (by definition) had no patients at AVR score of 4 at baseline (0%) and the no change group had 19.6%.

## Conclusion

There is evidence that a subset of patients with EOS and TIS, who received early prosthetic rib treatment show complete resolution of pulmonary support at two years. 89% of 79 patients at 2 years did not experience respiratory deterioration. 24% (n=19) had a positive change with over 84% (n=16) of this group no longer requiring support.

Table 1. AVR Change at Minimum 2 years

	No change	Positive change	Negative change
N (%)	49 (64%)	19 (24%)	9 (12%)
Average age (years)	5.5	4	6.7
% of Full time ventilation pre-op	19.6	31.3	0
% of complete respiratory symptom resolution	0	84.2	--
Initial Cobb Angle (°)	58.4	63.5	85.5*

\* p<0.05

## 150. Rib Based Posterior Growing Rod Construct Implantation to Treat Children with Early Onset Scoliosis without Rib Abnormalities: A Prospective Multicenter Study

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United States

## Summary

This prospective, multicenter study of 63 patients evaluated the efficacy of rib based growing rod constructs in preventing further progression of scoliosis without impeding spinal growth in the treatment of children with progressive early onset scoliosis (EOS) without rib abnormalities. 86% of patients had an improvement in scoliosis and 94% of patients had increased spinal height as compared to pre-operatively. Goals of preventing further scoliosis progression and of maintaining normal spine growth were achieved.

## Hypothesis

Rib based growing rod constructs will prevent further progression of scoliosis without impeding spinal growth in the treatment of children with progressive EOS without rib abnormalities.

## Design

Prospective, multi-center, observational cohort study

## Introduction

This study evaluated the efficacy of rib based growing rod constructs in preventing further progression of scoliosis without impeding spinal growth in the treatment of children with progressive early onset scoliosis (EOS) without rib abnormalities.

## Methods

Prospective, multi-center, observational cohort study on patients with EOS treated with rib based growing rod constructs with 2-year follow up. Data were analyzed based on measurements done pre-implant, immediate post-op and at 2-yr f/u.



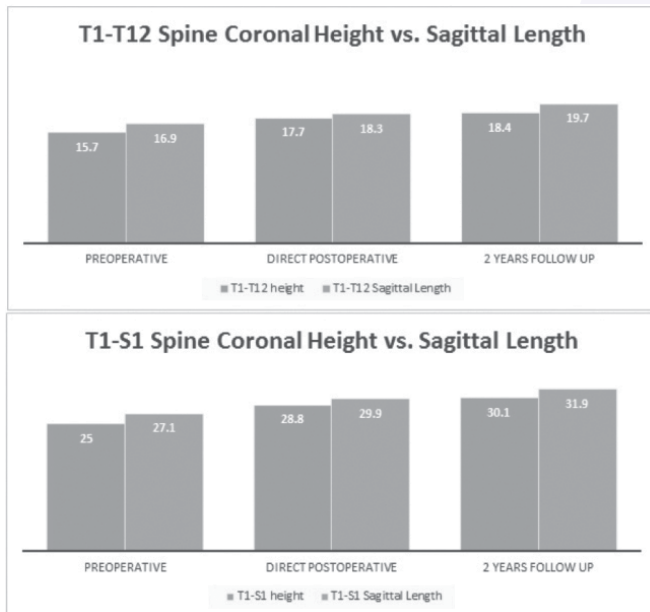
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## Results

63 patients met inclusion: 35 males and 28 females. Mean age at time of implantation was  $6.1 \pm 2.4$  yrs. Etiologies included congenital ( $n=6$ ), neuromuscular ( $n=36$ ), syndromic ( $n=4$ ), and idiopathic ( $n=17$ ). Mean follow up was  $2.2 \pm 0.4$  yrs. Scoliosis ( $72^\circ \pm 18^\circ$ ) decreased after implant surgery ( $47^\circ \pm 17^\circ$ ) followed by slight increase at 2-yr f/u ( $57^\circ \pm 18^\circ$ ),  $p < 0.0001$ . Kyphosis ( $48^\circ \pm 22^\circ$ ) also showed significant decrease after surgery ( $40^\circ \pm 14^\circ$ ) but increased after 2-yrs ( $48^\circ \pm 16^\circ$ ),  $p < 0.0001$ . Spinal height measurements including T1-T12 ( $15.7 \pm 3$ cm) and T1-S1 ( $25 \pm 6$ cm) showed significant increase after surgery ( $17.7 \pm 4$ cm and  $28.6 \pm 6$ cm respectively) and at 2-years ( $18.4 \pm 4$ cm and  $29.1 \pm 5$ cm respectively),  $p < 0.0001$ . The increase in coronal spine height represent 139% of expected age-matched T1-T12 growth and 186% of expected age-matched T1-S1 growth. Similarly, sagittal spinal length (SSL) of T1-T12 and T1-S1 increased from ( $16.9 \pm 2.7$  and  $27.1 \pm 3.9$  respectively) preoperatively to ( $19.7 \pm 3.5$  and  $31.9 \pm 5.1$  respectively) at 2-yrs follow up,  $p < 0.0001$  (Figure 1). SSL of the instrumented segment continued growth from  $25.8 \pm 5.2$  at implantation to  $27.4 \pm 5.3$  at 2-yrs follow up,  $p < 0.0001$ .

## Conclusion

At 2-yr f/u, rib based growing rod constructs was effective in treating EOS without rib abnormalities with 86% demonstrated improved scoliosis and 94% having an increase in spinal height. Rib based growing rod constructs provided greater than 100% of expected age-matched spine growth and the instrumented spinal segment continued to grow during distraction phase.



## 151. Choice of Anchors: Rib vs. Spine: Importance of Proximal Anchor Number

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United States

### Summary

There was no significant difference in curve correction, HRQoL and device migration between patients who received rib and spine-based proximal anchors. However, lower proximal anchor number was associated with an increased risk of proximal device migration in both patient groups.

### Hypothesis

In patients receiving surgery for the treatment of EOS, with either rib or spine-based constructs, there will be a difference in Cobb angle correction, health related quality of life (HRQoL), and complication rate, at 1 year.

### Design

Multi-center prospective cohort study.

### Introduction

Currently, there is significant equipoise regarding the selection and placement of instrumentation when treating EOS patients.

### Methods

106 patients ages 3-9 years with EOS and scoliosis of  $>40$  degrees were enrolled in this study funded by SRS, and supported by both the CSSG and GSSG. 73 (69%) patients received rib-based proximal anchors and 33 (31%) received spine-based proximal anchors. Details regarding proximal anchors, curve correction, HRQoL measured by Early Onset Scoliosis Questionnaire (EOSQ-24), and proximal device migration were prospectively collected. Average follow up for all patients was 1.16 years (rib = 1.025yrs; spine = 1.46yrs).

### Results

No significant difference in curve correction (29% vs 36% correction) or change in EOSQ score (5% vs. -7% change) was noted between rib and spine anchor groups. 11% (8/73) of patients receiving rib-based proximal anchors and 6% (2/33) of patients receiving spine-based proximal anchors experienced proximal device migration, a trend which did not reach statistical significance. There was only one proximal device migration in the group of patients with 5 or more anchors.

### Conclusion

There was no difference in curve correction, change in EOSQ-24 score or device migration between rib-based and spine-based patients. Having 5 or more proximal anchors was protective against proximal device migration - this may have implications in planning future surgical constructs for EOS.



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Device Migration by Anchor-Type						
	Rib			Spine		
	Total	<5 anchors	≥5 anchors	Total	<5 anchors	≥5 anchors
Total N	73	53	20	33	23	10
Device Migration	8 (11%)	7 (13%)	1 (5%)	2 (6%)	2 (9%)	0 (0%)

Device Migration by Anchor Type

## 152. Proximal Junctional Kyphosis in Scheuremann Kyphosis

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### Summary

Proximal junctional kyphosis in Scheuremann kyphosis correction is a major concern. It has been associated with incidence of approx 30%. It is also associated with improper UIV selection below the maximum Cobb upper vertebra and Correction Rate >50%. Our cohort of 62 patients is atypical. There was a high incidence of radiographical PJK (75.8%) but only 4.8% were symptomatic to require revision surgery. Correction rate and spinopelvic parameters didn't influence PJK. Unusually UIV above max Cobb had highest incidence (85.1%).

### Hypothesis

Proximal junctional kyphosis occurs when the upper instrumented vertebra is above the maximum Cobb and more frequently in posterior fusion only (PFO) compared to two stage anterior/posterior fusion (APF).

### Design

Retrospective cohort review

### Introduction

Proximal junctional kyphosis is a major complication of Scheuremann kyphosis deformity (SKD) correction. Risk factors include curve correction rate >50% or improper upper instrumented vertebra (UIV) selection. PJK is defined as an increase in 10 degrees comparing the post-operative and pre-operative XR at the cranial end plate of the UIV to the cranial end plate 2 vertebra above.

### Methods

62 consecutive patients undergoing correction of SKD between 2006-2014 were analyzed. PJK was established. Two groups were stratified Group 1 (PJK+) and Group 2 (PJK-). Comparisons of preoperative data were well matched and spinopelvic parameters examined. Analysis for UIV compared to maximum Cobb level (above, at, below) and type of surgery (APF,PFO). Compared to actual number of cases requiring PJK revision. instrument type was evaluated.

### Results

75.8% PJK incidence (n=47) with POF (51.1) and APF (48.9%). Both groups showed significant differences between preop and postop TK and LL but no significance between Group 1 and 2. Curve Correction Rate and Flexibility was not significant at 50% cut off between groups by Kruskal Wallis non parametric test. UIV above the Maximum Cobb showed 85.1% of PJK cases. 4.8% (n=3) required revision surgery (100% in PFO group). 88.7% used hybrid construct with hooks at top level and screws below.

## Conclusion

Radiological defined PJK shows a high proportion of cases were at risk (75.8%). Of note there was no significant difference whether the case was performed in single stage PFO or two stage APF. However actual revised cases (4.8%) for PJK were only from the PFO group (10% of cases). Interestingly the majority of cases were identified when UIV was above the maximum Cobb. Spinopelvic parameters did not influence PJK.

## 153. The Efficacy and Complications of Posterior-Only Vertebral Column Resection(PVCR) for the Treatment of Severe Congenital Kyphoscoliosis

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### Summary

PVCR for severe kyphoscoliosis has been well studied by many surgeons. However, the etiologies of patients are heterogenous, including post-infectious, neuromuscular and congenital, etc. The aim of this retrospective study to evaluate the efficacy and safety of posterior-only vertebral column resection for the treatment of the treatment of severe congenital kyphoscoliosis. According to our study, PVCR is an ideal procedure for severe rigid congenital kyphoscoliosis. Neurological compromises still remain the biggest challenges. Some methods could be helpful to increase the safety.

### Hypothesis

Congenital kyphoscoliosis has unique characteristics compared to other etiologies of severe kyphoscoliosis. And they should be evaluated when PVCR is chosen for congenital kyphoscoliosis.

### Design

A retrospective study

### Introduction

PVCR for severe kyphoscoliosis has been well studied in previous reports. However, the etiologies of patients are heterogenous, including post-infectious, neuromuscular and congenital, etc. The aim of this retrospective study to evaluate the efficacy and safety of posterior-only vertebral column resection for the treatment of the treatment of severe congenital kyphoscoliosis.

### Methods

66 patients (Male 33, Female 33) with angular congenital kyphoscoliosis (36) or kyphosis (30) treated by PVCR in our hospital were included. The average age was 16.0 years. 8 of them were revision surgeries. 10 patients had intra-spinal anomalies. The patients' radiographs and hospital records were reviewed.

### Results

The mean follow-up is 55.5 months. The mean operation time was 330 minutes. The averaged blood loss was 1171ml. In the kyphoscoliosis group, the segmental scoliosis was 79.3° before surgery, 21.7° post surgery and 23.3° at the latest the follow-up. The segmental kyphosis was 87.1° before surgery, 18.9° post surgery and 21.0° at the latest the follow-up. Trunk shift was corrected from 15.5 mm to 5.5cm. And the sagittal vertical axis was improved from 18.5mm to -5.5mm. In the kyphosis group, the segmental kyphosis was 89.5° before surgery, 20.1° post surgery and 23.6° at the latest the follow-up. And

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the sagittal vertical axis was improved from 34.5mm to 7.5mm. Complications occurred in 7 patients, including 2 incomplete spinal cord injury, 1 root injury, 1 proximal junctional kyphosis and 3 implants failures.

## Conclusion

PVCR is an ideal procedure for severe rigid congenital kyphosis. Neurological compromises and implants failures remain the biggest challenges. Sufficient height of anterior reconstruction, avoidance of the sagittal translation of the upper and lower vertebrae, intra-operative neuromonitoring, and preoperative surgical release of diastematomyelia and tethered cord may help to improve the safety.

## 154. Open Versus Minimally Invasive Approach (MIS) in Placement of Pedicle Screws at the Upper-Instrumented Vertebra (UIV) and the Effect on the Incidence of Proximal Junctional Kyphosis (PJK); A Prospective Randomized Controlled Study

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United States

## Summary

Proximal junctional kyphosis (PJK) continues to be a common problem following posterior spinal fusion in adult spinal deformity (ASD) surgery. In order to study the effect of preserving the posterior tension band, we prospectively randomized 43 patients to MIS versus open placement of pedicle screws at the upper-instrumented vertebra (UIV). At two years, the MIS group had a lower mean proximal junctional angle, lower rate of PJK and PJK revision, and no increase in major complications.

## Hypothesis

MIS approach in placement of pedicle screws at the UIV will decrease PJK incidence.

## Design

Prospective, randomized, controlled study

## Introduction

PJK is a common complication (~30%) following posterior spine fusion for adult spinal deformity, which often necessitates revision surgery. It has been theorized that disruption of the posterior tension band could be a contributing factor.

## Methods

43 eligible patients were randomized into MIS and open arms. 30 patients (MIS=15, Open=15) completed 2 yr f/u at the time of this review (1 died, 4 lost to f/u, and 8 have <2 yrs f/u). In the open arm, the UIV was exposed and instrumented using a free-hand technique; in the MIS arm, the instrumentation was placed subcutaneously without performing any dissection at that segment. PJK was defined as a proximal junctional angle (PJA) 10° greater than the corresponding preoperative measurement or >20° overall.

## Results

Gender (19F, 11M), age (60.1, range: 44-74), months of follow up (28.8, 23-48), number of comorbidities (2.3 SD 1.3), baseline and immediate postoperative radiographic measurements, number of levels fused, number of 3 column osteotomies, use of iliac crest bone graft, and estimated blood loss were not significantly different between the two groups. Operative time was significantly longer for MIS (466 min) than Open (375 min), p<0.001. Length of hospital stay, major complication rate, and reoperation rate were not significantly different. Mean PJA at 2 yrs for MIS was 7.4° (1-33) and for Open was 9.0° (2-35). In the MIS group, 4 patients developed PJK, 1 requiring revision; in the open group, 6 developed PJK, 2 requiring revision. After adjusting, the odds of developing PJK were 0.015 (p=0.063) and those of revision were 0.12 (p=0.2) times less for MIS than Open. Table 1

## Conclusion

MIS placement of pedicle screws at the UIV had a lower trend for the incidence of PJK or revision surgery at two years in this prospective, randomized study. Longer follow up and a larger number of patients may be required to clarify the benefit of this approach.

Table 1: Demographics, Surgical parameters, and outcomes between cohorts with minimally invasive versus open instrumentation of the upper instrumented vertebrae

	Approach	Mean	SD	Confidence Interval	P Value
Age	MIS	59.1	6.9	55-62	
	Open	61.1	9.8	55-67	
Operative Time	MIS	466	68.5	426-505	P=0.2
	Open	375	63.6	340-410	
ERL	MIS	419	79.6	388-449	P=0.0005
	Open	2430	1311	1768-3336	
Number of levels fused	MIS	2.103	0.52	1.742-2.464	
	Open	2.267	1.031	1.862-2.651	P=0.19
PJA at 2 years	MIS	9.2	0.56	8.9-9.5	
	Open	9.2	0.41	9.0-9.4	
Proximal Junction Angle	MIS	9.2	0.40	9.0-9.4	P=0.5
	Open	6.6	6.7	2.9-10.3	
PJA at 2 years	MIS	3.0	7.1	-1.0-6.9	
	Open	4.8	7.0	2.2-7.4	P=0.08
Length of Stay	MIS	7.4	11.5	1.0-13.8	
	Open	9.0	10.8	3.0-15.0	P=0.36
PJA for those with PJK	MIS	8.2	2.0	4.1-12.3	
	Open	6.3	1.4	3.5-7.1	P=0.00
3 Column Osteotomies	MIS	7.2	1.8	6.2-8.2	
	Open	6.8	1.4	6.1-7.5	P=0.00
Minor Complication	MIS	20.3	3.1	12.3-28.2	
	Open	23.3	3.8	17.2-29.3	P=0.2
Major Complication	MIS	21.5	6.2	17.0-29.3	
	Open	21.5	6.2	17.0-29.3	P=0.2
Reoperation	MIS	6	40%		
	Open	4	27%		P=0.44
PJK	MIS	10	33%	0.6	
	Open	9	60%	2.1	P=0.14
PJK Revision	MIS	5	33%		
	Open	14	47%	0.19	P=0.67
PJK Revision	MIS	4	27%		
	Open	3	20%	0.24	P=0.62
PJK Revision	MIS	4	27%		
	Open	6	40%	0.60	P=0.44
PJK Revision	MIS	1	6.7% (25% of PJK)		
	Open	2	13% (33% of PJK)	0.37	P=0.54

## 155. Analysis of Patients with Cerebral Palsy Requiring Reoperation after Spinal Fusion: Associated Risk Factors and Impact on Quality of Life

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United States

## Summary

Patients with cerebral palsy (CP) undergoing spinal fusion experience a high rate of reoperation, although this has not been previously quantified. This



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report seeks to establish the rate of and major reasons for reoperation in this population. We report an 11.4% reoperation rate with 68% due to infection and 32% to instrumentation failure. Patients with larger preoperative deformity and kyphosis were at highest risk. Reoperation resulted in lower health related quality of life (HRQoL) scores.

### Hypothesis

The reoperation rate in patients with CP is high and results in lower HRQoL scores.

### Design

Retrospective review of a prospective data set.

### Introduction

Patients with CP undergoing spinal fusion experience a high rate of reoperation, although this has not been previously quantified. This report seeks to establish a rate of and major reasons for reoperation and the effect of reoperation on HRQoL as well as explore potential risk factors.

### Methods

A prospectively collected multicenter database was retrospectively reviewed to identify patients with CP who had undergone spinal fusion and had at least a 2 year follow-up. Of 193 patients identified, 20 patients underwent a total of 22 reoperations. We compared patients who underwent reoperation (Y) to those who did not (N) with respect to preoperative, intraoperative, and postoperative factors.

### Results

Of the 22 total reoperations, 15 (68%) were for infection and 7 (32%) were instrumentation related. The majority of infections were deep (14/15, 93%). Of the 7 instrumentation related reoperations, 2 were for junctional kyphosis, 3 were for instrumentation prominence, and 2 were for instrumentation failure. The magnitude of primary deformity (Y=91 degrees, N=82 degrees,  $p<0.01$ ) and those with kyphosis as the primary surgical indication (23.5% of patients with kyphosis as the primary indication underwent reoperation versus 9.1% of patients with scoliosis,  $p=0.03$ ) were at highest risk for a reoperation. These patients had lower scores postoperatively on the CP child total domain ( $p<0.01$ ).

### Conclusion

Spinal fusion for patients with CP carries a significant rate of reoperation which appears to lower HRQoL scores. Infection, proximal junctional kyphosis, and instrumentation prominence/failure are the most common reasons for reoperation. At highest risk are those patients undergoing surgery primarily for kyphosis and those with larger overall Cobb angles.

## 156. Are Severely Underweight Patients with Cerebral Palsy at a Higher Risk for Complications and Poorer Outcomes Following Posterior Spinal Fusion for Scoliosis?

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### Summary

We evaluated the effects of patient weight on outcomes and complications for cerebral palsy patients undergoing posterior spinal fusion for scoliosis. The severely underweight groups (%BMI<5% and %BMI<1%) fared better than expected. Other than percent blood volume loss, there was no difference with regards to radiographic/clinical outcomes, or complications for severely underweight vs. normal weight CP patients two years postop. Both underweight groups significantly increased their %BMI postoperatively compared to the normal weight group which remained unchanged.

### Hypothesis

Severely underweight cerebral palsy (CP) patients have poorer outcomes and increased complications with scoliosis surgery compared to normal weight CP patients.

### Design

Retrospective review of a prospectively collected multicenter database

### Introduction

A considerable portion of CP patients have poor oral intake/nutrition resulting in severely low percentile body mass index (%BMI). This study evaluated if severely underweight (UW) CP patients have increased complications and poorer outcomes compared to normal weight (NL) CP patients after posterior spinal fusion (PSF) for scoliosis.

### Methods

89 patients with minimum 2 year follow-up after PSF were identified and placed into two groups: severely underweight (UW)=%BMI<5% (n=42) and Normal (NL)=%BMI: 5-85% (n=47). Pre-op gross motor function classification system levels were similar for both groups.

### Results

The coronal/sagittal Cobb, curve flexibility and pelvic obliquity were similar for both groups pre-op and at 2 years. Significantly more UW vs. NL patients were orally fed vs. via feeding tube (62% vs 36%,  $p=0.02$ ). UW had a higher percentage estimated blood volume lost (%EBVL), (UW: 104% vs. NL: 77%,  $p=0.04$ ). There was no difference between UW and NL groups for: transfusions, length of stay (LOS), readmissions, reoperations, infection, complications, and mortality at 2 years. CP child outcome scores were similar for both groups preop and at 2 years. A separate analysis of patients with %BMI<1% (n=31), also showed no differences vs. the NL group. UW patients' %BMI significantly increased from preop to 2 years, while NL had no change.

### Conclusion

The severely underweight CP group (%BMI<5% and BMI<1%) fared better than expected compared to normal weight CP patients after PSF for scoliosis.



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Severely underweight vs. normal weight CP patients had similar radiographic results and outcome scores preop and 2 years postop. There was no difference with regards to LOS, complications, infection, reoperation, readmission, and mortality for severely underweight vs. normal weight CP patients at 2 years postop. Underweight groups showed significant increases in %BMI at 2 years.

	Severely Underweight N=42	Normal Weight N=47	P value
Sex: Male	64.5%	48.9%	0.15
GMFCS-V	73.8%	74.4%	0.6
Oral feeding only	61.9%	36.2%	0.02
Preop Major Cobb	86.1°	79.1°	0.06
2yr PO Major Cobb (% correction)	27.8° (67.2%)	28.6° (63.5%)	0.2
Preop Pelvic Obliquity	26.5°	21.0°	0.07
2yr PO Pelvic Obliquity (% correction)	6.1° (69.1%)	5.6° (65.8%)	9.6
Length of Stay (days)	11.9	11.4	0.3
Length of ICU (days)	6.6	5.9	0.59
Intubation days	3.9	3.1	0.53
EBL (mL)	2112mL	1930mL	0.6
%EBVL	10.4%	76.8%	0.04
Required transfusion	100%	91%	0.24
Postop Surgical Site Infection	14.3%	14.9%	0.9
GI related complication	30.9%	29.8%	0.9
Avg Preop %BMI	0.6%	40.6%	<0.001
Avg 2yr PO %BMI	8.3%	32.5%	0.01
%BMI change from preop to 2yr PO	p=0.05	p=0.8	

GMFCS-V: Gross motor function classification system level 5  
 2yr PO: 2 years postoperative  
 ICU: Intensive Care Unit  
 EBL: Estimated Blood volume  
 %EBVL: percentage estimated blood volume lost  
 %BMI: percentile body mass index  
 GI: gastrointestinal  
 Avg: average

## 157. Minimally Invasive Surgery for Neuromuscular Scoliosis: Preliminary Results and Complications

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France

### Summary

Fusionless surgery in neuromuscular scoliosis has a high rate of complications. We used an alternative technique to perform a strong and stable construct and reviewed radiographic results and complications of 95 cases operated from 2011 to 2015. This technique provided 65.00% correction of spinal deformities and 84.31% of pelvic obliquity with only 22.10% global complication rate.

### Hypothesis

A strong bipolar construct extended to the pelvis using minimally invasive fusionless surgery can reduce complication rate in neuromuscular scoliosis.

### Design

Retrospective review.

### Introduction

Conservative treatment is not efficient in neuromuscular scoliosis. Growing rod techniques are more and more used but with high complication rate. We reported the preliminary results of an original fusionless technique.

### Methods

95 patients underwent the same fusionless surgery. Age at initial surgery was 11+6y. Mean follow-up was 2+4y. Diagnoses included 57 cerebral palsy, 21 spinal muscular atrophy, 10 muscular dystrophy, 7 other neurological etiologies. Cobb angle, pelvic obliquity, T1-S1 height and thoracic kyphosis were measured before and after initial surgery, after each lengthening and at final follow-up. Per operative and post operative complications were retrospectively reviewed. The technique relies on a bipolar bilateral sliding construct from T1 to the pelvis by a minimally invasive approach. Mean interval between two rod lengthening procedure was 1y+2. No post operative bracing was used. No final arthrodesis surgery was performed at last follow-up.

### Results

At last follow-up, mean Cobb angle improved from 85.86° (range 25° to 149°) to 30.05° (range 5.6° to 70.46°) which correspond to 65% correction.

Mean pelvic obliquity improved from 29.31° (range 0° to 60.45°) to 4.6° (range 0 to 14.7°) which correspond to 84.31% correction. Mean T1-S1 length increased from 28.85cm to 36.55cm. Mean preoperative hyper kyphosis was reduced from 71.94° to 31, 67°. Complications have occurred in 21 patients (22.10%) included 5 implants related, 7 wounds infections (4 superficial, 3 deep), 1 neurological per operative alert, 2 superior mesenteric artery syndromes, and 6 pulmonary infections. 8 patients (8.4%) had unplanned procedure.

### Conclusion

Our preliminary results showed that in patients with neuromuscular scoliosis this original fusionless technique is safe and effective, providing a significant correction of spinal deformities and pelvic obliquity with low complication rate. It preserves spinal and thoracic growth and improves the quality of life of the patients.





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## 158. Impact of Spinal Deformity and Surgery on Health-Related Quality of Life in Cerebral Palsy

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United States

### Summary

In a prospective longitudinal cohort study of scoliosis associated with cerebral palsy (CP), severity of deformity was negatively correlated with HRQoL; HRQoL was improved at 24 months with spinal fusion.

### Hypothesis

Fusion for scoliosis associated with cerebral palsy (CP) will improve HRQoL.

### Design

Prospective cohort

### Introduction

Spinal fusion for scoliosis associated with CP is associated with high costs and complications, and the evidence that surgery leads to meaningful benefits has not been established with any rigor. The aim of this study was to determine if corrective spinal fusion improves health related quality of life in children with CP.

### Methods

Children with CP (GMFCS levels III, IV & V) & scoliosis that met criteria for posterior spinal fusion were enrolled at 10 centers in the US & Canada. Participants elected either spinal fusion (SF) or observation (OBS). Demographic, clinical data (GMFCS level, magnitude of deformity, co-morbidities), and HRQoL (CPCHILD Questionnaire) were collected at baseline, 12 months and 2 years. Change (from baseline) in total CPOCHILD scores was the primary outcome, with 5% change being the minimal clinically important difference (MCID).

### Results

144 SF and 17 OBS subjects had complete baseline and 2yr data. At baseline, both groups were comparable in age, sex, GMFCS level, and co-morbid status, and CPOCHILD scores ( $50.6 \pm 14.7SD$  v.  $52.6 \pm 9.7SD$ ;  $p=0.45$ ). However, the SF group had larger deformity ( $83^\circ \pm 24^\circ$  v.  $65^\circ \pm 17^\circ$ ) ( $p=0.001$ ).

At baseline, there was a small negative correlation between Cobb angle and CPOCHILD subscales CE (Comfort & Emotions) ( $r=-0.17$ ;  $p=0.045$ ); and QoL ( $r = -0.21$ ;  $p=0.013$ ) domains. At 2 years, deformity was reduced by 64% in SF and increased by 13% in OBS. Total CPOCHILD score improved in SF group by 5.9% (95% CI 3.6 to 8.1;  $p<0.001$ ) & in 5 of 6 domains. OBS scores were unchanged (+1.6%; 95% CI: -5.7 to 8.9;  $p=0.65$ ).

### Conclusion

Increased magnitude of spinal deformity in CP is associated with lower parental reports of HRQoL, as measured by the CPOCHILD. Corrective spinal fusion surgery in CP leads to significant (and > MCID) improvement in HRQoL. In comparison those who chose not have surgery saw their curves increased by an avg. of 13% with HRQoL remaining unchanged. This is first prospective comparative

study showing evidence of benefit of spinal fusion surgery for this population using a validated measure of meaningful outcomes.

	SF	OBS	p value
Subjects meeting inclusion criteria	144	17	-
Baseline Cobb (degrees)	83	65	0.001
Baseline CP CHILD	50.6 (SD $\pm$ 14.7)	52.6 (SD $\pm$ 9.7)	0.454
Pre to 2y Cobb change (degrees)	- 54	+ 13	<0.0001
Change in CP CHILD (pre-op to 2y)	5.9%, $p<0.001$	1.6%, $p=0.65$	0.256

## 159. Accuracy of Percutaneous Screws Inserted Under Intra-operative Cone-beam Computed Tomography and Navigation

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United Kingdom

### Summary

Intra-operative cone-beam computed tomography coupled with stereotactic navigation can be used to insert percutaneous Jamshedi needles without fluoroscopy reducing surgeon radiation exposure to zero. In open navigation cases, accuracy can be double checked using anatomical landmarks. This check is not possible with purely percutaneous techniques and hence there has been concern over accuracy of screws inserted in this way. This paper demonstrates that percutaneous screws inserted under navigation is extremely accurate with a malposition rate of 0.4%.

### Hypothesis

Percutaneous pedicle screws inserted under Intra-operative cone-beam computed tomography and navigation is accurate with a low rate of malposition

### Design

This is a retrospective review of prospectively collected data from a single surgeon case series of 61 patients (including 21 degenerative scoliosis and 20 spondylolisthesis), who underwent navigated percutaneous pedicle screw insertion from April 2013 to October 2015.

### Introduction

Percutaneous pedicle screw placement under fluoroscopy is widely used by minimally invasive surgeons in deformity and degenerative spinal surgery. However radiation exposure to the surgeon can be quite considerable and there is concern regarding the risks of this cumulative exposure. Intra-operative cone-beam computed tomography coupled with stereotactic navigation can be used to insert percutaneous Jamshedi needles without fluoroscopy. Guidewires are placed down the trocar and screws then inserted. Fluoroscopy is used only to check trocar/Jamshedi needle position prior to guide wire insertion and after screw placement. Surgeon radiation exposure is effectively reduced to zero. In open navigation cases, surgeons can check accuracy by double checking anatomical landmarks. This check is not possible with purely percutaneous techniques and hence there has been concern over accuracy of screws inserted in this way.

### Methods

All postoperative x-rays in the patient sample were analysed for screw placement accuracy and the need for pedicle screw revision analysed. It is standard practice

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at our institute to perform a CT scan at 12 months in order to check the presence of fusion. Hence all patients from April 2013 to September 2014 also had their CT scans analysed for accuracy of the pedicle screws.

## Results

A total of 451 pedicle screws and 16 iliac bolts were inserted. Only 2 screws (0.4%) were malpositioned of which only one required revision. The latter was a case of a very narrow L3 pedicle measuring 3.5mm in diameter and a small portion of the thread of a 5.5mm screw was exposed medially causing nerve root irritation.

## Conclusion

Intra-operative cone-beam computed tomography and navigation allows safe and accurate insertion of percutaneous pedicle screws whilst reducing radiation dose to the surgical team and operating theatre personnel.

## 160. The Clinical Spectrum of PROMIS Physical Function Scores Over Time in Patients with Operative Lumbar Pathology

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### Summary

Patient reported outcome measures provide critical information on assessing the effectiveness of care delivered. Several prior studies have identified problems with legacy disease specific and generalized PROMs (NDI, ODI, SF-36, etc). PROMIS physical function domain scores have been shown to be valid, accurate, and have low ceiling and floor effects in the spine patient population. This study analyzes scores of patients with operative lumbar pathology and their response over time from the preoperative period to twelve months postop.

### Hypothesis

PROMIS PF CAT scores are an effective tool to measure outcomes in response to treatment in the spine patient population

### Design

Retrospective review of prospectively collected data.

### Introduction

The PROMIS PF item bank has been previously shown to be a valid and accurate method of assessing patient reported outcomes in the spine patient population. This study attempts to understand how PF CAT scores vary over time with treatment.

### Methods

PRO scores at a single university spine center from October, 2013 to April, 2015 were included for analysis. All patients had a primary complaint of lumbar pathology. Both lumbar fusion and non-fusion operative patients were included in this study for analysis. PF CAT scores were mapped over time at intervals from the preoperative period to 12 months post op.

### Results

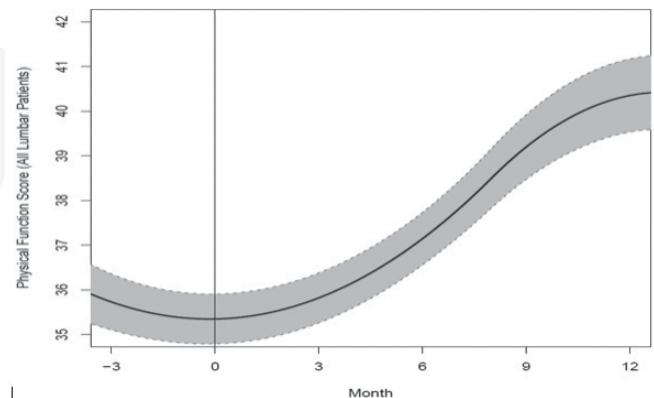
A total of 870 unique patients were identified, representing 5659 PROMIS PF CAT scores recorded for purposes of this study. The predicted PF CAT scores (+ 95% confidence intervals) were mapped over time from preop to 12

months post op for all lumbar spine patients and separately for the fusion and decompression alone patient groups (Figure 1 and 2). Age-adjusted percentile rank of scores were also mapped over time for the same patient groups (Figure 3 and 4). The mean PFCATs for all lumbar patients were 35.4, 35.8, 37.2, and 40.4 at time points 0, 3, 6, and 12 months, respectively. The lumbar decompression alone group started at a higher physical function score and improved more rapidly than the fusion group.

## Conclusion

To our knowledge, this is the first study to describe the overall trend of PF CAT scores over time following treatment, as well as the age-matched percentiles of PROMIS scores. Starting in the preoperative setting. This data also provides a unique perspective for patients to visualize their current progress in the treatment process as it relates to other patients with lumbar pathology at similar stages of treatment.

FIGURE 1 - PF CAT scores over time based on procedure date in all lumbar surgery patients.



## 161. Surgical Correction of the Severe Rigid Pelvic Obliquity with PVCR in Neglected Congenital Scoliosis.

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### Summary

11 pts who had severe rigid pelvic obliquity due to neglected congenital scoliosis with significant coronal and sagittal imbalance were corrected with thoracolumbar/lumbar PVCR with a mean of 1,82 (1-3) vertebratomy. 4 pts who had concomitant intraspinal abnormality (SCM type1) were treated simultaneously at the same stage with the osteotomy. PVCR provided %86 (60-100) correction in pelvic obliquity, %67,1 (28-100) correction in coronal balance and %64,5 (25-100) correction on the sagittal plane.

### Hypothesis

Severe rigid pelvic obliquity due to neglected congenital scoliosis can be corrected with PVCR

### Design

Retrospective



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## Introduction

The correction of rigid severe pelvic obliquity in neglected congenital scoliosis is technically challenging. The purpose of this study is to evaluate the efficacy of thoracolumbar/lumbar PVCR on the correction of the pelvic obliquity and significant coronal and sagittal plane deformity.

## Methods

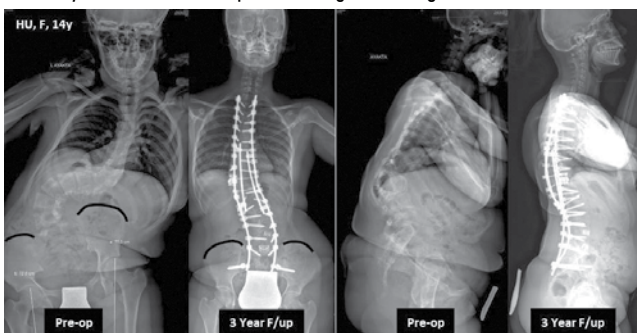
11 pts (8F,3M) with severe rigid pelvic obliquity, significant coronal and sagittal imbalance due to neglected congenital scoliosis who were surgically treated were included. In the surgical technique, pelvic obliquity was corrected with gradual compression maneuvers which were performed above and below the vertebrectomy level on the side in which pelvis was lower than the contralateral side. Correction of the pelvic obliquity also provided the correction of coronal and sagittal plane deformity. Correction of the pelvic obliquity was confirmed with intraop control x-rays in all pts. Radiological evaluation included pelvic obliquity angle, Cobb angles of curves, coronal and sagittal parameters.

## Results

Mean age was 15,6(11-30) and mean f/up was 4,1(2-9) years. Osteotomy levels were between; T11-L1 in 2 pts; T12-L1 in 2 pts; L1-L2 in 2 pts; L2-L3 in 2 pts; L4 in 3 pts. 4 pts with concomitant intraspinal abnormality (SCM type1) were treated simultaneously at the same stage with the osteotomy. Mean preop pelvic obliquity of 21,8° was corrected to 2,2° with %86(60-100) correction rate. Mean preop coronal balance was corrected from 74,5mm to 19,5mm, mean preop 69 mm of trunk shift was corrected to 15,9mm with %78(64-92) correction rate. Mean preop SVA was corrected from 64,1mm to 20,7mm (Table). Three pts had dural tear during surgery.

## Conclusion

It is possible to correct the rigid, severe pelvic obliquity and significant coronal and sagittal plane deformity due to neglected congenital scoliosis with PVCR. The amount and level of resection is important in the surgical planning. This is the first study which showed that PVCR can correct rigid severe pelvic obliquity and provide satisfactory correction on both planes in neglected congenital scoliosis.



	Preop	F/up	%Correction	p
PT (°)	18,4 (3-61)	10,5 (0-42)	60 (31-100)	0,007*
MT (°)	49,4 (25-80)	28,9 (2-60)	50,1 (22-95)	0,008*
TL/L (°)	73,3 (34-110)	30,8 (4-69)	60,3 (35-91)	0,005*
Shoulder Height (mm)	48,8 (25-105)	14,8 (0-34)	68,9 (43-100)	0,003*
Coronal Balance (mm)	74,5 (35-158)	19,5 (0-41)	67,1 (28-100)	0,003*
Trunk Shift (mm)	69 (33-128)	15,9 (3-41)	78 (64-92)	0,003*
Pelvic Obliquity (°)	21,8 (19-32)	2,2 (0-6)	86 (60-100)	0,003*
Sagittal Balance-SVA(mm)	64,1 (28-112)	20,7 (0-61)	64,5 (25-100)	0,003*

Statistical analysis: Wilcoxon signed rank test  
PT: Proximal Thoracic, MT: Main Thoracic, TL/L: Thoracolumbar/Lumbar

## 162. Long-Term Results of Spine Stapling for AIS

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United States

## Summary

Long-term studies of AIS, treated with growth modulation, are few. We retrospectively reviewed 13 consecutive patients (15 curves) treated with Nitinol staples (NS) for growth modulation. This is the longest follow-up reported, avg 61 mos (37-95). Follow-up was at least to skeletal maturity. 8 patients improved, 4 curves progressed <5 deg, and 3 progressed to fusion. NS were safe and possibly changed natural history in 10 of 13 patients. In many, NS probably functioned more as an internal brace.

## Hypothesis

Spine stapling is a safe and effective way to modulate growth of the spine in skeletally immature children, even with long-term follow-up.

## Design

Retrospective review of a consecutive case series, with follow-up to skeletal maturity and beyond.

## Introduction

Spinal stapling, which utilizes the patient's growth to attain curve correction, is a technique with little data on long-term outcomes. This study follows AIS patients to skeletal maturity and beyond (3-8 years) to evaluate long-term results of growth modulation using NS.

## Methods

After IRB approval, a retrospective chart and radiographic review was performed on 14 consecutive AIS patients treated with spine stapling between 2005 and 2008. Radiographs and charts were reviewed to attain standard radiographic, surgical, and follow-up data.

## Results

13 pts with 15 curves were included, 10 were Risser 0 and 3 were Risser 1. One, not progressing, was excluded due to lack of follow-up to skeletal maturity. The avg follow-up was 61 mos (37-95 mos). Avg preop curve size was 34.8(28-43). The avg OR time was 195 min (114-294 min) and EBL was 114 mL (25-500 mL). The number of levels stapled per curve was 5.67 (4-7). The avg first postop erect Cobb was 23.7(8-35). Avg improvement first erect film was 10.8 (0-24). Analysis revealed 3 groups. Group one: 8 curves showed improvement with an avg 7.3(4-13). Group two: 4 curves showed progression less than 5. Group three: 3 patients with 3 curves progressed to fusion. There was one staple dislodgement that was revised thoroscopically. No other complications were noted.

## Conclusion

Nitinol staples were safe long term. Only three patients went to fusion in this high risk group. Growth modulation, though present in some, was inconsistent. In many, the NS had initial correction, but initial correction was lost over time, and NS possibly acted more as an internal brace. As growth modulation technologies continue to evolve, long-term studies such as this one are critical to improve safety and efficacy.



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## 163. Spinal Surgery in Achondroplasia: Outcome Analysis and Risk Factors for Impending Neurologic Deficit

John Heydemann, MD; Oussama Abousamra, MD; Tyler Kreitz, MD; Kenneth J. Rogers, PhD; Colleen Ditro, RN; Suken A. Shah, MD; William Mackenzie, MD  
United States

### Summary

Children with achondroplasia who underwent surgical decompression and fusion for neurologic symptoms were compared to a matched control group that did not need surgery. All 26 patients who had surgery had neurologic complaints preoperatively and 21/26 resolved postoperatively. Thoracolumbar kyphosis was a significant radiographic parameter associated with increased risk of neurologic deficit. Unresolved thoracolumbar kyphosis by age 10 may be an indication for increase surveillance or even discuss prophylactic surgery as these children have an increased propensity for neurologic deficit.

### Hypothesis

There is no difference in neurologic status and sagittal spinal parameters after thoracolumbar decompression and fusion.

### Design

Retrospective review of single institution data with follow up questionnaires

### Introduction

This study reports the outcomes after decompression, sagittal realignment and fusion in children with achondroplasia and thoracolumbar kyphosis.

### Methods

Records of children with achondroplasia who had spinal surgery (thoracolumbar decompression and fusion) were identified. Lateral standing spine radiographs (at preop, postop and last visits) were reviewed. Thoracic kyphosis TK, lumbar lordosis LL, thoracolumbar kyphosis TLK: T10-L2, pelvic incidence PI, T1 pelvic angle TPA and sagittal balance SVA were measured. Clinical evaluation included neurologic symptoms and signs, hip flexion contractures and postoperative complications. Preoperative measurements were compared to a matched control group of children with achondroplasia who did not have surgery. In addition, the Oswestry Disability Index (ODI) and Scoliosis Research Society-22 (SRS-22) were collected.

### Results

Records of 315 children were reviewed, 26 children had surgery with mean follow up of 5.1 (2-14.1) years. TK, LL and TLK improved significantly and were stable over follow up (Table1, Figure). No significant change was noted for PI, TPA and SVA. Preoperatively, all children had neurologic deficits. Three children had revision surgery because of persistent neurologic deficits (two of them had pseudarthrosis). At the last visit, 5 children were unchanged, 21 improved and none worsened.

A control group of 196 children who had x-rays after age 5 years was identified. Data of the last available visit were compared with preop data of the surgical group. TLK was significantly higher in the surgical group (Table2).

### Conclusion

In children with achondroplasia, correction of thoracolumbar kyphosis and improvement in the neurological status were achieved after spinal decompression,

realignment and fusion. Apart from a higher TLK, no difference in the spinopelvic parameters was found between the surgical and nonsurgical group.

	Surgical group 26 children						p values	
	Preop		Postop		LFU		Preop vs. Postop	Postop vs. LFU
Thoracic Kyphosis	Mean 14	SD 24	Mean 28	SD 16	Mean 30	SD 17	0.025	0.543
Lumbar Lordosis	Mean 55	SD 27	Mean 41	SD 20	Mean 41	SD 17	0.059	0.990
Thoracolumbar Kyphosis	Mean 42	SD 33	Mean 10	SD 9	Mean 10	SD 10	0.0001	0.930
Sacral Slope	Mean 47	SD 15	Mean 44	SD 16	Mean 44	SD 13	0.395	0.879
Pelvic Tilt	Mean 1	SD 14	Mean 2	SD 20	Mean 7	SD 19	0.838	0.356
Pelvic Incidence	Mean 48	SD 20	Mean 44	SD 19	Mean 49	SD 19	0.454	0.358
T1 Pelvic Angle	Mean 3	SD 18	Mean -2	SD 18	Mean 3	SD 21	0.364	0.443
Sagittal Balance (mm)	Mean 20	SD 46	Mean 13	SD 46	Mean 12	SD 41	0.589	0.989

Table1: Sagittal spinopelvic measurements perioperatively and during follow up. SD: standard deviation.

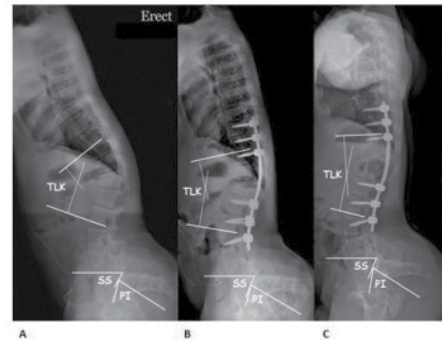


Figure: Lateral standing spine radiograph

A: Preoperatively at age 15.3 years; TLK=60°, SS=62°, PI=72°.

B: Postoperatively; TLK=26°, SS=64°, PI=74°

C: Last follow up at age 21 years; TLK=18°, SS=66°, PI=70°

	Surgical Group (26 Children)		Control Group (196 Children)		p values
	Mean	SD	Mean	SD	
Age (years)	13.2	4.3	11.2	4.9	0.82
Thoracic Kyphosis	14	24	18	12	0.422
Lumbar Lordosis	55	27	64	17	0.099
Thoracolumbar Kyphosis	42	33	14	12	0.0003
Sacral Slope	47	15	53	12	0.106
Pelvic Tilt	1	14	-4	13	0.097
Pelvic Incidence	48	20	49	16	0.969
T1 Pelvic Angle	3	18	-8	9	0.003
Sagittal Balance (mm)	20	46	-6	28	0.009

Table2: Comparison between the surgical and control group. SD: standard deviation.

## 164. Selection of Lowest Instrumented Vertebra for Thoracolumbar Kyphosis in Ankylosing Spondylitis

Guoquan Zheng; Yan Wang, MD; Zheng Wang, MD, PhD; XueSong Zhang, MD  
China, People's Republic of

### Summary

We compared the radiographic and clinical data between patients with different lowest instrumented vertebra (LIV). There was no significant difference on corrective and fixed effect between different groups, but the S1 screw-related complications were remarkable. Thus, we suggest taking 2nd caudal vertebra below distal osteotomized vertebra(OV) as LIV, restricting the instrumentation of S1 and carrying out pedicle subtraction osteotomy(PSO) above L4.

### Hypothesis

When PSO is performed at the level of L2 or L3, the instrumentation could be limited to the 2 caudal vertebra that follow, extending the fixation to more vertebra or to the sacrum could not improve the stability of the instrumentation and the fusion rate.

### Design

Retrospective study.

### Introduction

Although most of AS kyphosis cases are treated by pedicle subtraction osteotomy, few studies have focused on the selection of the LIV relative to distal OV.



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## Methods

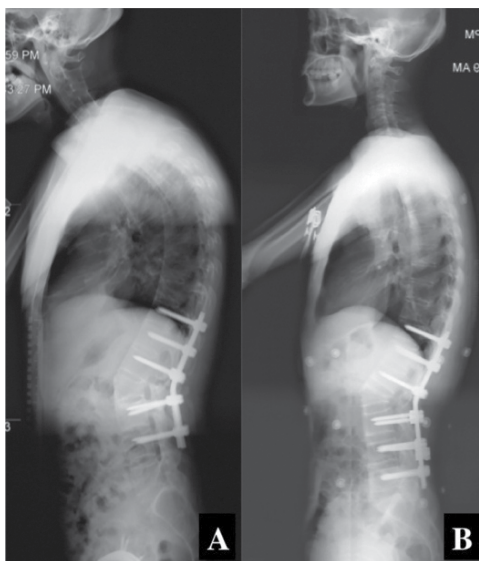
We reviewed all AS kyphosis cases surgically treated at our institution between 2010 and 2013. Patients were divided into groups based on the relative position of LIV and distal OV: Group OV+2, the LIV was the second vertebra below OV; Group OV+3, the LIV was the third vertebra below OV; Group OV+4, the LIV was the fourth vertebra below OV. The preoperative and 2-year postoperative radiographic parameters and clinical data of the former two groups were compared. Additionally, if the LIV was S1, patients were included in Group S1, and those remaining were included in Group Non-S1 (the LIV was L5 or above).

## Results

None of the patients presented fixation failure. Groups OV+2 and OV+3 had similar magnitudes of kyphosis ( $P>0.05$ ) and SVA corrections ( $P>0.05$ ) at the last follow-up. There was no difference in the incidence of proximal junctional kyphosis (PJK) between groups ( $P>0.05$ ). Between Groups S1 and Non-S1, the incidence of PJK and the magnitudes of kyphosis and SVA corrections were not significantly different ( $P>0.05$ ). The lumbosacral VAS and the incidence of pressure sores in Group S1 were higher than in Group Non-S1 ( $P<0.05$ ).

## Conclusion

When PSO is performed at the level of L2 or L3, the instrumentation can be limited to the 2 caudal vertebra that follow. Extending the fixation to more vertebra or to the sacrum does not appear to improve the stability of the instrumentation and the fusion rate, and it is not suitable to carry out PSO at L4.



Radiographs of two patients with single-level PSO at L2. A) Patient with the LIV at L4 (OV+2); B) patient with the LIV at L5 (OV+3)

## 165. Surgical Versus Nonsurgical Treatment of Lumbar Degenerative Kyphosis

*Jung Sub Lee, MD, PhD; Tae Sik Goh, MD; Jong Ki Shin, MD; Seung Min Son, MD Korea*

### Summary

In this prospective study, surgical candidates with LDK were enrolled at three spine centres. Treatment was performed by pedicle subtraction osteotomy or nonsurgical care. Outcomes were measured using a Visual Analog Scale of back pain, the Oswestry disability index, and the 32-item short-form health survey, which consists of physical component summary and mental component summary scores, and using radiologic outcomes and treatment-related complications. LDK patients that underwent surgery showed significantly greater improvement in all outcome variables than patients treated non-surgically.

### Hypothesis

Surgery is widely performed for lumbar degenerative kyphosis (LDK), but its effectiveness as compared with nonsurgical treatment has not been demonstrated.

### Design

Prospective study

### Introduction

Surgical treatment theoretically restores and preserves sagittal balance, and thus, should lead to better functional and radiologic outcomes. However, the majority of previous studies conducted on this topic were retrospective and of small scale, and thus, clear information on the therapeutic outcomes of the surgical treatment in LDK is not available. Moreover, it is not known whether surgical treatment produces better outcomes than nonsurgical treatment in LDK. Here, we report and compare the 2-year outcomes of LDK patients treated surgically or non-surgically and analyse the relative efficacies of treatments.

### Methods

This prospective study was designed to evaluate the efficacy of surgical treatment for LDK. Treatment was performed by pedicle subtraction osteotomy or nonsurgical care. Outcomes were measured using a VAS of back pain, the ODI, and the SF-36, which consists of physical component summary and mental component summary scores, and using radiologic outcomes and treatment-related complications.

### Results

Of 126 patients with LDK were treated during the reference period, and 116 that fully complied with the above-mentioned inclusion and exclusion criteria were allocated to the surgical group (54 patients) or the nonsurgical group (62 patients). The study showed a significant effect favouring surgery for VAS, ODI, PCS, and MCS scores, and radiologic outcomes. However, the complication rate was high in the surgical group. Analysis showed a significant advantage for surgery at 6 months postoperatively in terms of ODI and SF-36 scores, and these changes remained significant at 2 years.

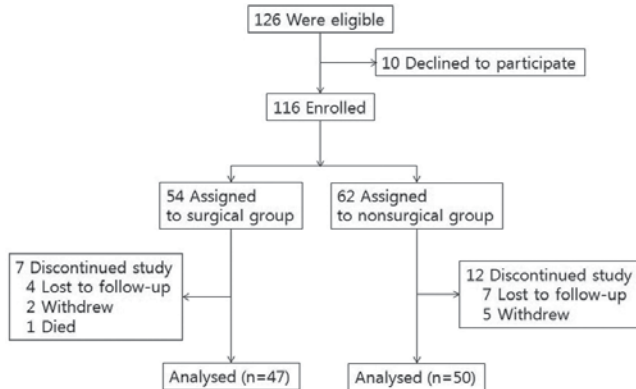
### Conclusion

In this study, we evaluated the surgical treatment of LDK patients and compared outcomes with those of conservative treatment over a follow-up of



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24 months. Surgical patients showed significantly greater improvements in pain and functional outcomes than patients treated non-surgically. However, the complication rate was significantly higher for surgical treatment.



## Subjects

### 166. How Does Case Type, Length of Stay, and Comorbidities Affect Medicare DRG Reimbursement for Minimally Invasive Surgery (MIS) for Deformity?

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United States

#### Summary

Hospital DRG coding and reimbursement is a separate system from physician professional CPT coding, billing and collecting and reimbursement. There exist several distinct differences that significantly affect hospital reimbursement. For example: Deformity coding was critical and resulted in reimbursement losses of 24% to 42% if not coded properly. We present these differences and most importantly how case type, length of stay, and concomitant medical comorbidities effect hospital reimbursement in spinal deformity surgery for MIS deformity techniques.

#### Hypothesis

DRG coding affects proper reimbursement for MIS deformity cases.

#### Design

The Inpatient PPS PC Pricer (CMS.gov) was used to collect reimbursement data from 2015 for MIS surgical deformity procedures DRG s at our hospitals.

#### Introduction

We investigated Medicare DRG based reimbursement for MIS deformity procedures in our study group hospitals based on length of stay and presence of comorbid conditions (CC).

#### Methods

DRG based reimbursement was obtained for MIS anterior, posterior and circumferential 1-level and multi-level fusion for listhesis and deformity cases with and without CC from 12 institutions throughout the US. The 3 most

common MIS procedures were analyzed to compare reimbursement based on DRG coding: 1. Fusion via anterior or posterior only; 2. Fusion anterior with fixation posterior percutaneous (no dorsal fusion); 3. Fusion Combined anterior and posterior.

#### Results

The number of levels fused does not affect the reimbursement for all cases. Cases 1 and 2 without CC, 3-day stay reimbursed \$41,404 vs 8-day reimbursed \$42,808. Cases 1 and 2 with CCs, 3-day stay reimbursed \$54,476 vs 8-day stay reimbursed \$55,881. Case 3 without CC, 3-day stay reimbursed \$47,992 vs 8-day stay reimbursed \$49,397. Case 3 with CC, 3-day reimbursed \$61,806 vs 8-day reimbursed \$63,212. The increased payment for an 8-day stay was \$1,405 or \$281 per day. If a deformity case 1 or 2 is coded incorrectly as a degenerative case the decrease in payment was \$9,769 lower (-24%) with no CC and \$22,841 lower (-42%) with CC.

#### Conclusion

Regardless the direct costs, Medicare DRG based reimbursement was the same for single and multi-level MIS deformity cases. The use of posterior percutaneous fixation without dorsal fusion resulted in a 13-16% lower reimbursement compared with the addition of a posterior arthrodesis. Coding a deformity case as degenerative by the hospital resulted in 24-42% lower DRG based reimbursement. In today's challenging environment it is important that physicians and hospitals better understand procedure and coding issues in order to be able to continue to offer complex spinal surgeries cost effectively to our patients.

Table 1. Comparison of Medicare Reimbursements for 3-Day and 8-Day Hospital Stay

Case Type	3-Day	8-Day	Increase from 3 to 8 Days
Cases 1&2	\$41,404	\$42,808	\$1,404
with CC	\$54,476	\$55,881	\$1,405
Cases 1&2 NOT coded as deformity	\$31,635	\$33,040	\$1,405
Case 3	\$47,992	\$49,397	\$1,405
with CC	\$61,806	\$63,212	\$1,406

### 167. High Pelvic Incidence Predicts Alignment Failure in Patients Undergoing 3-Column Osteotomy

Gregory M. Mundis, Jr., MD; Virginie Lafage, PhD; Christopher P. Ames, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Frank J. Schwab, MD; Eric O. Klineberg, MD; Themistocles S. Protopsaltis, MD; Behrooz A. Akbarnia, MD; Bassel G. Diebo, MD; Han Jo Kim, MD; Vedat Deviren, MD; International Spine Study Group

United States

#### Summary

Patients with high pelvic incidence (HPI) require greater lordosis to achieve spinopelvic harmony. This patient group provides a challenge when surgical reconstruction is required. We found that patients with HPI have more sagittal plane deformity preoperatively and fail to achieve a well aligned spine more frequently than low PI. 3CO resection angle is smaller in HPI than mid/low PI. Surgeons develop and execute an appropriate surgical plan in high PI patients to avoid malalignment.

#### Hypothesis

Patients with high pelvic incidence will be at risk for alignment failure after 3CO



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## Design

Retrospective review of multicenter database

## Introduction

A high pelvic incidence (HPI) presents a unique surgical challenge when addressing patients with adult deformity. We investigate the effect of HPI on radiographic outcomes with 3-column osteotomy (3CO).

## Methods

A retrospective review of a multicenter 3CO database. Single lumbar 3CO and baseline/1-year x-ray were included. Groups include low (LPI), medium (MPI) and high PI by 1 standard deviation from mean. Theoretical LL (tLL) was calculated for all groups based on Schwab PI-LL formula with respect to PI outliers:  $tLL=LPI+10$ ,  $tLL=MPI$ , and  $tLL=HPI-10$ . The offset is the difference b/w tLL and pre- or post-LL. Well-aligned (WA) were classified via Vialle et al. Groups comparison: anova for continuous variable, chi-square for categorical.

## Results

491 pts were available for review, 362 met inclusion. 34 - LPI ( $PI < 42^\circ$ ), 274 MPI ( $PI 42-75$ ) and 54 HPI ( $>75$ ). Preop, all differed radiographically. HPI had more sagittal deformity despite larger LL. All required equal tLL correction. 3CO resection angle was greatest for LPI (30.4), MPI (25.2) then HPI (21.3°,  $p=0.013$ ). LPI and MPI both achieved tLL goal with satisfactory PT, SVA, and TPA (Table). HPI fell 13° shy of tLL and failed to achieve realignment (PT 36.6°; SVA 85 mm, TPA 35.6°;  $p=0.000$ ). All groups saw change in LL and PI-LL. No difference in global alignment between groups. Of the entire cohort only 50% were WA postop. The distribution of WA varied for all (LPI 61.8, MPI 52.6, HIP 29.6%;  $p=0.003$ ). Postop WA-HPI had similar regional parameters but worse global alignment preop than postop malaligned patients (SVA 179 v 128 mm,  $p=0.027$ ; TPA 52 v 43,  $p=0.01$ ).

## Conclusion

Patients with HPI were less likely to reach postop alignment with 3CO. A lower resection angle is a likely contributor to alignment failure. This may reflect a lack of recognition of need for greater lordosis, as well as technical difficulty in achieving the higher degree of lordosis these patients require. Surgeons need to be meticulous in surgical planning to achieve appropriate resection angles.

	LPI	MPI	HPI	p value
Pre L1-S1	12.49	21.24	38.84	0.000
Pre tLL	45	57.4	74.6	0.000
Pre Offset	32.5	36.1	35.7	0.577
Pre PI-LL	22.8	36.1	45.8	0.000
Pre PT	21.4	31.9	43.1	0.000
Pre PI	35	57.4	84.6	0.000
Pre SVA (C7 mm)	84.7	140.4	163.4	0.000
Pre TPA	21.8	36.2	48.8	0.000
<i>No difference was found for age, BMI, sex, # levels fused, OR time, EBL, or level of 3CO</i>				
Post L1-S1	46.6	51.5	61.1	0.000
Post Offset LL	-1.6	5.76	13.43	0.000
Post PI-LL	-10.6	5.75	23	0.000
Post PT	12.9	23.2	36.6	0.000
Post SVA (C7 mm)	-1.5	38.1	85	0.000
Post TPA	7.8	19.7	35.6	0.000

## 168. National Trends for Primary and Revision Lumbar Disc Arthroplasty Throughout the United States from 2005-2013

Comron Saifi, MD; Alex Ha, MD; Alejandro Cazzulino, BA; Joseph Lawrence Laratta, MD; Charla R. Fischer, MD; Mark Weidenbaum, MD; Lawrence G. Lenke, MD; Ronald A. Lehman, Jr., MD

United States

## Summary

Given the increasing focus on health care utilization and value-based care, it is essential to determine the number of primary and revision lumbar disc arthroplasty (LDA) per year throughout the United States. Additionally patient demographics and economic data associated with primary and revision LDA are critical to understanding and improving health care utilization. We analyzed data from the National Inpatient Sample database to infer trends in the incidence and related outcomes of LDA nation-wide.

## Hypothesis

We will be able to determine national trends in the incidence and outcomes of primary and revision lumbar disc arthroplasty.

## Design

Retrospective database review

## Introduction

Given the increasing focus on health care utilization and value-based care, it is essential to determine the number of primary and revision lumbar disc arthroplasty (LDA) per year throughout the United States. Additionally patient demographics and economic data associated with primary and revision LDA are critical to understanding and improving health care utilization.

## Methods

The data utilized in this study was collected between 2005-2013 across 44 states from the National Inpatient Sample (NIS) database on patients who underwent either primary or revision LDA. Demographic and economic data were obtained. The NIS database represents a 20% sample of discharges from U.S. hospitals, which is weighted to provide national estimates.

## Results

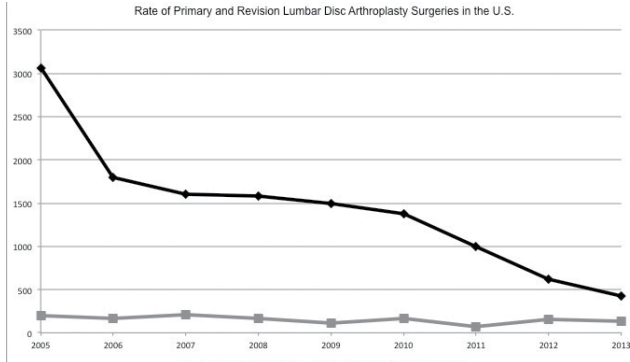
The total number of primary LDA has progressively decreased 86% from 3,059 in 2005 to 420 in 2013. The mean total cost, including hospital and physician related costs, of LDA increased 33% from 2006 to 2013 from \$17,747 to \$23,804 with a mean of \$22,310 per case over the nine-year study period. The mean LOS decreased from 2.8 days in 2005 to 2.3 days in 2012. The mean routine discharge of 90% did not vary significantly based on year. The number of revision procedures similarly declined 65% from 205 in 2007 to 71 in 2011. The mean national revision burden, the ratio of revision procedures to the sum of primary and revision procedures, was 10% (range 6% to 24%). The mean cost of revision LDA ranged from \$12,752 to \$22,282 over the study period. The mean LOS after the revisions was 3.4 days.

## Conclusion

Over the course of this study (2005-2013), primary and revision LDA progressively declined in the U.S. by 86% and 65%, respectively. The total costs for primary LDA increased by 33% between 2006 and 2013. Over this

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time period the national revision burden throughout the United States has risen significantly from 6% to 24%.



## 169. Timing of Preoperative Lumbar Corticosteroid Injection Does Not Affect Postoperative Infection Rate

Scott C. Wagner, MD; Jonathan Seavey, MD, MS; George Balazs, MD  
United States

### Summary

There is some debate in the literature regarding the effect of lumbar corticosteroid injection (CSI) on local immune suppression and increased risk of wound infection following surgery. We examined over 10,000 patients undergoing lumbar spine surgery and found that preoperative CSI within two, three, four, six or 12 weeks had no effect on postoperative wound infection rates.

### Hypothesis

Lumbar steroid injections performed close to the time of surgery would increase the rate of wound infection

### Design

Retrospective review

### Introduction

There has been some suggestion that lumbar corticosteroid injections (CSI) may predispose to post-operative wound infection after spinal surgery due to a local immunosuppressive effect, but the effect of injection timing on post-operative infection has never been studied. We compared post-operative infection rates in surgical patients receiving pre-operative lumbar injections within 14, 21, 28, 42 and 90 days prior to surgery.

### Methods

The Military Health System Management and Reporting Tool (M2) database was searched for all patients who had undergone a single lumbar surgery with a pre-operative lumbar steroid injection (epidural, facet). Encounter date, diagnosis, associated CPT code and demographic information were recorded. Information on days from injection to surgery, infection rate, and days from surgery to infection were captured where applicable.

### Results

The search identified 10,863 patients, with 172 patients having a post-operative wound infection (1.58%). The median number of days for the development of infection after surgery was 21 (range 1-1915 days). From

the total study population, 1738 patients were identified having undergone a lumbar steroid injection prior to a single lumbar surgery. The post-operative wound infection rate in the injection group was not significantly higher than the no-injection group (1.9% vs 1.5%,  $p>0.05$ ). There were no significant differences identified in patients receiving CSI within 14, 21, 28, 42 or 90 days prior to lumbar surgery.

### Conclusion

We found that post-operative infection rate was not significantly increased in patients receiving lumbar corticosteroid injections within 14, 28, 42 or 90 days prior to lumbar surgery. These findings suggest that any theoretical immunosuppressive effect of local CSI does not significantly increase the risk of infection after surgery. Lumbar corticosteroid injections may be performed as temporizing pain management measures prior to surgery without increasing the risk of wound infection.

## 170. Delayed Post-Operative Foot Drop in Lumbar Spine Surgery-Natural History of Recovery, Correlation with Type of Surgery and Type of Pathology

Saumyajit Basu, MD; Sri Krishna Chaitanya Kondety, MS; Tarun Suri, MS; Amitava Biswas, MS; Sandeep Kesharwani, MS; Kiran Tapal, MS; Trinanjan Sarangi, MD

United States

### Summary

12 patients of delayed post-operative foot drop, resulting from lumbar fusion procedures were retrospectively analysed for neurological improvement, relation with the type of surgery and type of primary pathology. 85% patients recovered more than 2 grades by the end of 2 years & no relation with the primary pathology and type of surgery was found

### Hypothesis

Patients with delayed post-operative foot drop improve gradually with conservative treatment

### Design

Retrospective analysis

### Introduction

The natural history of recovery & relation with type of surgery/primary pathology of delayed post-operative foot drop is not clearly documented. Most authors consider it as result of post-operative nerve root stretch resulting in vascular insufficiency. The purpose of this study is to observe the natural history of recovery & its relation with type of surgery and type of spinal pathology.

### Methods

All Patients who underwent lumbar fusion from 2001 to 2013 (single centre), developing delayed post-operative foot drop (12 hours -5 days) were included in the study. 12 patients were identified from a database of 1950 patients with a mean age of 49.8 years with a minimum follow up of 24 months (24-140 months) and the recovery is correlated with the primary pathology (degenerative spine/lytic/dysplastic spondylolisthesis) and surgery performed (PLF/TLIF).



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## Results

The average preoperative motor power was 3.9(MRC grade EHL/ADF) and time of development of deficit is 1.8 days. Neurological improvement at 1 month, 6 months, 1 year & last follow-up was 2.2, 3.2, 3.4 & 3.7. Maximum recovery was observed between 1 month and 6 months (1 grade). Permanent neurological damage without recovery was seen in 2, only 1 grade improvement seen in 1 patient. 6 patients had preserved L5 dermatome sensation (isolated motor weakness), out of which 5 patients improved by more than 2 grades. Only one patient had complication in the form of intraoperative dural tear which was sutured. There is no significant difference in the recovery patterns in patients in relation to primary pathology and type of surgery ( $p=0.2$ ).

## Conclusion

Delayed post-operative foot drops mostly occur between 1-3 days. Maximum improvement seen between 1-6 months. The incidence doesn't increase in patients with intraoperative dural injury/other complications. There is no correlation between the type of surgery, type of spinal pathology and amount of reduction. Most of them (85%) recover more than 2 grades by the end of 2 years

NAME	AGE	SEX	DIAGNOSIS	OPERATION	DATE	PRE-OP MOTOR	POST-OP MOTOR	PRE-OP SENSATION	POST-OP SENSATION	PRE-OP FOOT DROP	POST-OP FOOT DROP	PRE-OP PAIN	POST-OP PAIN	PRE-OP GAIT	POST-OP GAIT	PRE-OP INPATIENT MORTALITY	POST-OP INPATIENT MORTALITY	PRE-OP MAJOR COMPLICATION	POST-OP MAJOR COMPLICATION	PRE-OP TOTAL HOSPITAL CHARGES	POST-OP TOTAL HOSPITAL CHARGES
ABHIRAM	35	M	L5/S1 DISC PROTRUSION	DISC RESECTION	2012	4	4	+	+	0	0	0	0	0	0	0	0	0	0	0	0
ADARSH	35	M	L5/S1 DISC PROTRUSION	DISC RESECTION	2012	4	4	+	+	0	0	0	0	0	0	0	0	0	0	0	0
ADARSH	35	M	L5/S1 DISC PROTRUSION	DISC RESECTION	2012	4	4	+	+	0	0	0	0	0	0	0	0	0	0	0	0
ADARSH	35	M	L5/S1 DISC PROTRUSION	DISC RESECTION	2012	4	4	+	+	0	0	0	0	0	0	0	0	0	0	0	0
ADARSH	35	M	L5/S1 DISC PROTRUSION	DISC RESECTION	2012	4	4	+	+	0	0	0	0	0	0	0	0	0	0	0	0
ADARSH	35	M	L5/S1 DISC PROTRUSION	DISC RESECTION	2012	4	4	+	+	0	0	0	0	0	0	0	0	0	0	0	0
ADARSH	35	M	L5/S1 DISC PROTRUSION	DISC RESECTION	2012	4	4	+	+	0	0	0	0	0	0	0	0	0	0	0	0
ADARSH	35	M	L5/S1 DISC PROTRUSION	DISC RESECTION	2012	4	4	+	+	0	0	0	0	0	0	0	0	0	0	0	0
ADARSH	35	M	L5/S1 DISC PROTRUSION	DISC RESECTION	2012	4	4	+	+	0	0	0	0	0	0	0	0	0	0	0	0
ADARSH	35	M	L5/S1 DISC PROTRUSION	DISC RESECTION	2012	4	4	+	+	0	0	0	0	0	0	0	0	0	0	0	0
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# PAPER ABSTRACTS

## Hypothesis

Post-op infections involving *P acnes* present, and are treated, differently from other infections. Knowledge of the bacteria may aid in its recognition and appropriate treatment.

## Design

Retrospective review of all patients treated for AIS during a 5-year period (2010-2014) at our institution, with a minimum of 1-year follow-up after the index surgery. Of 315 patients, any patient with a postoperative infection following their index surgery was included. Primary outcome was infection, and the surgical and antibiotic treatments for infection were reviewed.

## Introduction

Post-op *P acnes* infections have been well described in shoulder literature, but there is considerably less information available in spine surgery. We are reporting our experience with infections following surgery for AIS, which includes a trend of *P acnes* as the most common bacterium isolated.

## Methods

Charts of AIS patients with post-op infections were reviewed for details of the index surgery, time to presentation of the infection, presenting signs/symptoms, microbiology details, details of surgical and antibiotic treatment, and outcomes.

## Results

Ten post-op infections occurred after 315 cases for AIS during this period. Eight involved *P acnes*; the average time to presentation was 30 months, and most commonly presented with mild pain and swelling. The 2 cases involving other bacteria were due to MSSA, with an average time to presentation of 3 weeks, and both presented with drainage. All *P acnes* patients were treated with instrumentation removal and antibiotics. The most common antibiotic utilized was penicillin, usually for an 8-week period.

## Conclusion

*P acnes* was the most commonly isolated bacteria in our patients with post-op infections following surgery for AIS. The usual signs/symptoms were mild pain and swelling in the area of the prior surgery. *P acnes* typically presented considerably later than other infections. Treatment with debridement, instrumentation removal, and at least 8 weeks of antibiotics was universally successful. This study highlights the need to recognize and treat *P acnes* when there is clinical suspicion for infection after surgery for AIS.

## 173. Utility of Supine Lateral Radiographs in the Assessment of Segmental Instability in Degenerative Lumbar Spondylolisthesis

Foster Chen, MD; Wwojin Cho, MD, PhD; Louis Amorosa, MD  
United States

## Summary

The most widely used radiographic examination for lumbar spondylolisthesis involves standing lateral images taken in neutral/flexion/extension, however it is now being recognized that the relaxed supine position may produce a greater amount of reduction in the listhesed segment. We have added supine lateral radiographs to our routine examination (standing neutral/flexion/

extension lateral radiographs) for symptomatic lumbar spondylolisthesis. In this retrospective study we found that this additional examination showed increased amounts of segmental instability seen in spondylolisthesis.

## Hypothesis

The inclusion of supine lateral radiographs increases the amount of segmental instability seen in single-level lumbar spondylolisthesis compared to standard standing neutral/flexion/extension lateral radiographs.

## Design

Retrospective consecutive case series

## Introduction

Evaluating segmental instability is critical to the management of lumbar spondylolisthesis. Standing flexion-extension lateral radiographs are routinely obtained as it is believed to demonstrate the forward-backward motion of the segment; however recent studies with MRI and CT have shown that the relaxed supine position can facilitate the reduction of the anterolisthesed segment.

## Methods

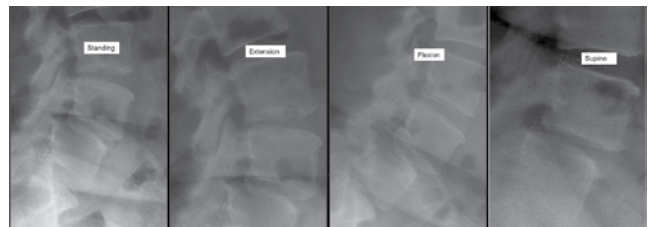
Supine lateral radiographs have been added to the routine evaluation (standing neutral/flexion/extension lateral radiographs) of symptomatic spondylolisthesis at our institution. In this study, 27 patients with this series of radiographs were included. The amount of listhesis was measured and compared on each radiograph: Standing neutral lateral ("neutral"), Standing flexion lateral ("flexion"), Standing extension lateral ("extension"), and Supine lateral ("supine").

## Results

27 patients (25 female, 2 male), with a mean age of 58 were included in this study. The mean mobility seen with flexion-extension was 5.25%. The mean mobility seen with flexion-supine was 9.3%. This difference was significant in paired t-test ( $p < 0.0001$ ), and independent of age and BMI. The maximal mobility was seen comparing flexion and supine radiographs in 20 patients, and comparing neutral and supine radiographs in 5 cases. Extension demonstrated more subluxation in one case. Only three cases demonstrated more reduction in extension than in supine.

## Conclusion

The supine radiograph demonstrates more reduction of anterolisthesis than the extension radiograph. The supine radiograph is technically easy for both the facility and for patient comfort, can be a valuable tool in the evaluation of spondylolisthesis. It is much less expensive than MRI or CT. This study suggests that we may skip the extension radiograph when evaluating instability in spondylolisthesis patients, as extension is painful for some patients.





# PAPER ABSTRACTS

## 174. National Trends for Primary and Revision Anterior and Lateral Lumbar Interbody Fusion Throughout the United States from 2004-2013

Comron Saifi, MD; Alex Ha, MD; Alejandro Cazzulino, BA; Kola Jegede, MD; Charla R. Fischer, MD; Joseph Lawrence Laratta, MD; Yongjung Jay Kim, MD; Mark Weidenbaum, MD; Lawrence G. Lenke, MD; Ronald A. Lehman, Jr., MD  
United States

### Summary

We hypothesized that the number of anterior/lateral lumbar interbody procedures has increased over the past decade. Demographic and economic data associated with these procedures is critical to optimizing health care utilization. We utilized the National Inpatient Sample database to investigate national trends in these procedures.

### Hypothesis

The national incidence of anterior/lateral lumbar interbody procedures has increased over the past decade.

### Design

Retrospective database review

### Introduction

For this study our group hypothesized that the number of anterior/lateral lumbar interbody procedures including anterior lumbar interbody fusions (ALIF), and lumbar lateral interbody fusion (LLIF) has increased over the past decade. Demographic and economic data associated with primary and revision anterior/lateral lumbar interbody cases is critical to optimizing health care utilization.

### Methods

The data were collected between 2004-2013 across 44 states from the National Inpatient Sample (NIS) database on patients who had undergone primary or revision ALIF, and LLIF. Demographic and economic data were obtained. The NIS database represents a 20% sample of discharges from U.S. hospitals, weighted to provide national estimates.

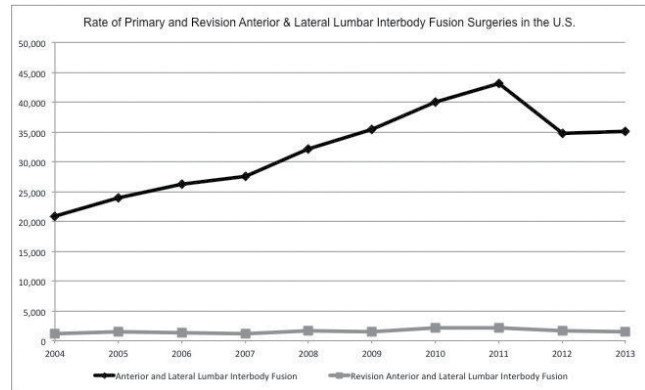
### Results

An estimated 319,730 and 15,938 patients underwent primary and revision ALIF/LLIF procedures, respectively, throughout the U.S. during the study period. The total number of these operations has progressively increased 69% from 20,900 to 35,195 over the ten-year study period. The mean total cost of these surgeries increased 26% from \$30,561 to \$38,614. The mean LOS decreased from 5.0 to 3.7 days. The mean routine discharge of 74% did not vary significantly. The mean national revision burden, the ratio of revision procedures to the sum of primary and revision procedures, was 4.8%. The mean cost of revision anterior/lateral lumbar spine interbody surgeries was \$38,898. The mean LOS after the revisions was 5.0 days.

### Conclusion

From 2004 to 2013 there was an increase in primary anterior/lateral interbody lumbar surgeries by 69% throughout the U.S., and an increase in total costs for primary anterior/lateral interbody surgeries by 26%. This is likely driven in part by an increasing interest in LLIF procedures. LOS has progressively decreased over the same time period to 3.7 and 4.4 days for

primary and revision cases, respectively. The mean national revision burden has remained constant at 4.8%



## 175. Is there a Correlation Between Gross Motor Function Classification System (GMFCS) Level and Scoliosis in Patients with Cerebral Palsy? A Systematic Review.

Abdul Gaffar Dudhniwala, MRCS, FRCS (Orth); Lara E. McMillan, BS, Medical Student; Sashin Ahuja, FRCS

United Kingdom

### Summary

Gross Motor Function Classification System (GMFCS) is an established assessment tool for classifying cerebral palsy (CP). Prevalence of scoliosis is associated with poor motor function in CP patients. Correlation between GMFCS level and scoliosis can help to identify early those who develop scoliosis by providing them higher surveillance. This can also assist in providing timely intervention to those whose curve progression is rapid.

### Hypothesis

Correlation between GMFCS level and scoliosis in CP patients can be used as an adjunct to identify scoliosis risk amongst CP patients.

### Design

Systematic Review

### Introduction

Gross motor function classification system (GMFCS) is now an established standardized assessment tool for classifying cerebral palsy (CP) children to levels I-V according to their gross motor function skills. Studies predating GMFCS have shown scoliosis prevalence to be associated with poor motor function. Prevalence of other secondary musculoskeletal complications is associated with increased GMFCS level.

### Methods

Publications sourced using Full text journals, EMBASE, Ovid Medline, JSTOR, SCOPUS and Web of Science search for all years of terms/subject headings: gross motor function classification system or GMFCS and scoliosis.

### Results

Children with GMFCS I-II have minimal overall scoliosis incidence and almost no scoliosis risk. Those with GMFCS IV-V there is increased overall scoliosis risk and their curves are moderate or severe. Prevalence: GMFCS, when

# PAPER ABSTRACTS

dichotomised as levels I-II and III-V, as a significant determinant of scoliosis amongst CP young adults with odds ratio of 5.1 (95% CI: 0.025, p=0.025); higher GMFCS III-V was related to increased scoliosis prevalence. Rate of scoliosis progression increased with GMFCS level, and the maximum Cobb angle increase rate was significantly different among the different GMFCS groups (p=0.0153). The progression rate has been  $>3.4^{\circ}$  / year in children with GMFCS of IV-V. Scoliosis progression also occurred at higher rates amongst non-ambulant children than amongst ambulant children.

## Conclusion

GMFCS IV-V CP children should receive greatest spine-surveillance to monitor scoliosis emergence and progression in order to provide early interventions if necessary, thereby avoiding risks associated with treating high-grade curves. Patients with lower GMFCS levels are less likely to develop scoliosis or experience rapid or severe curve progression so could be monitored with fewer radiographs, thereby reducing radiation exposure and avoiding surveillance clinic visits.

## 176. In Patients with Nonidiopathic Spinal Deformity, Risk of Surgical Site Infection can Range from 2.0% to 54.8% - Results of a Novel Risk Severity Score

Jeanne Franzone, MD; Hiroko Matsumoto, PhD; WG Stuart Mackenzie; Michael Troy, BS; Kody K. Barrett, BA; Brendan Striano; Michael P. Glotzbecker, MD; John M. Flynn, MD; David L. Skaggs, MD, MMM; David Price Roye, MD; Michael G. Vitale, MD, MPH

United States

## Summary

Pre-operative anemia, neuromuscular disease, non-ambulatory status, pulmonary disease and same-day non-spine procedures increase the risk of surgical site infection (SSI) following spinal fusion in non-idiopathic patients.

## Hypothesis

In pediatric patients undergoing spinal fusion for treatment of non-idiopathic scoliosis, clinical findings, laboratory values and procedural decision increase the risk of SSI.

## Design

Risk Severity Score (RSS) based on multicenter case control.

## Introduction

Predicting SSI following spinal fusion is essential to reduce patient harm and burden. The aim of this study is to develop a RSS reflecting the probability of developing SSI within 90 days of surgery in pediatric patients with nonidiopathic spinal deformity undergoing spinal fusion.

## Methods

This is a multi-center study to develop an SSI predictive model for children with nonidiopathic spinal deformity who underwent primary or revision spinal fusion between Jan 2006 and Dec 2011. Patient characteristics, preoperative laboratory results, and clinical data were collected. The CDC's case definition was used to identify SSI within 90 days of surgery.

## Results

Of 867 patients reviewed, etiologies included neuromuscular (52.9%), congenital (19.2%), syndromic (21.6%) and other (6.4%). The overall SSI rate was 8.8%. Our model identified 5 clinical risk factors for developing SSI (see Table 1). Using this model, it can be determined that a patient without any factors has a risk of 2.0%, while a patient with all factors has a risk of 54.8%.

## Conclusion

A RSS to predict the probability of SSI within 90 days of spinal fusion in children with nonidiopathic spinal deformity shows increased risk based on neuromuscular etiology, non-ambulatory status, pulmonary comorbidity, preoperative hemoglobin, and a same-day non-spine procedure. This RSS will be useful when considering operations in children with nonidiopathic scoliosis, and will improve shared decision making with families during preoperative counseling.

	Odds Ratio	p value
Hemoglobin < 13 g/dL	2.29	0.002
Neuromuscular Etiology	1.91	0.087
Non-Ambulatory	2.73	0.004
Pulmonary Comorbidity	1.52	0.100
Same-day Non-spine Procedure	3.21	0.006

Risk Factors for SSI after Spinal Fusion in Nonidiopathic Scoliosis Patients















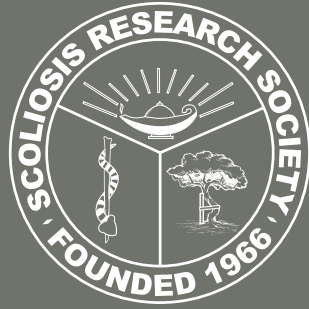
# EXHIBITS & WORKSHOPS

IMAST2016

23<sup>RD</sup> INTERNATIONAL MEETING ON  
ADVANCED SPINE TECHNIQUES

JULY 13-16, 2016  
WASHINGTON, D.C., USA





**The Scoliosis Research Society  
gratefully acknowledges Orthofix  
for their support of the Newsletter,  
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# EXHIBIT HALL FLOORPLAN

## IMAST Exhibit Hall

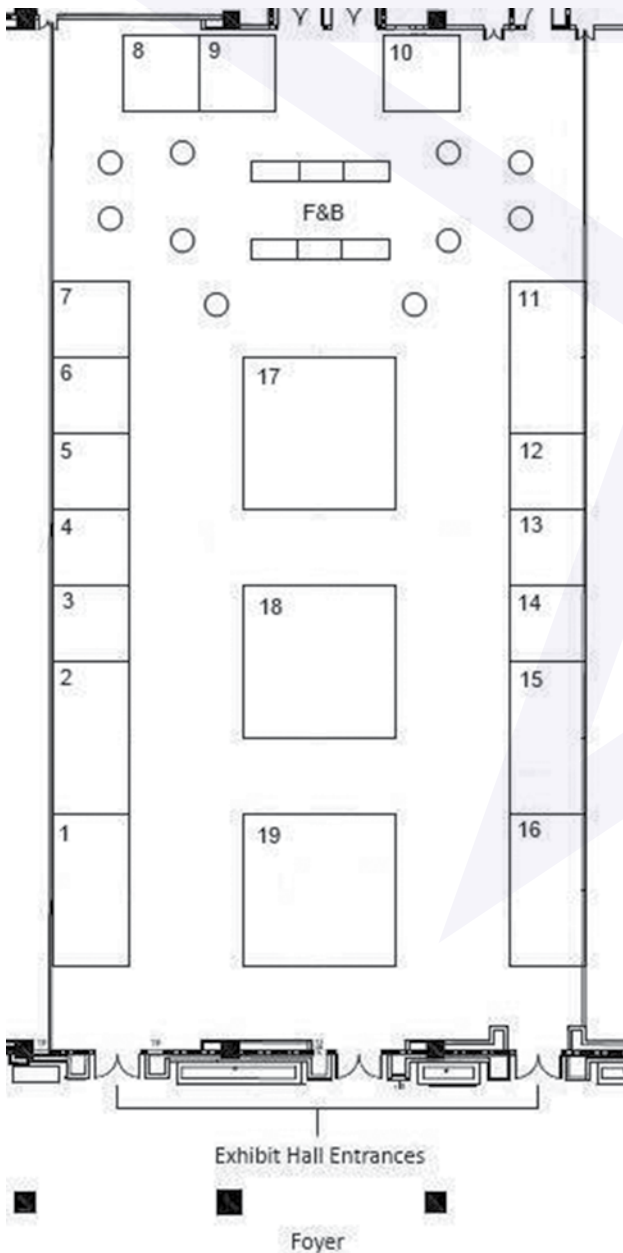
The IMAST Exhibit Hall is located in Salon 6 of the Marriott Marquis.

### Hours:

Wednesday, July 13 14:00-21:00

Thursday, July 14 8:15-17:30

Friday, July 15 8:00-17:00



Company	Booth Number
Alphatec Spine	15
Benevenue Medical	9
DePuy Synthes	1
Diers Medical	4
EOS Imaging	5
Globus Medical	19
K2M	18
LDR Spine	8
Mazor Robotics	11
Medicrea USA	6
Medtronic	17
Misonix	13
NuVasive	16
Orthofix	3
OrthoPediatrics	7
Paradigm Spine	10
SpineGuard	12
Stryker Spine	14
Zimmer Biomet	2





# EXHIBIT DESCRIPTIONS

## ALPHATEC SPINE, INC

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Carlsbad, CA 92008 USA  
+1-800-922-1356  
[www.alphatecspine.com](http://www.alphatecspine.com)

Alphatec Spine, Inc., a wholly owned subsidiary of Alphatec Holdings, Inc. (Nasdaq:ATEC), is a global provider of spinal fusion technologies. The Company's mission is to combine innovative surgical solutions with world-class customer service to help improve outcomes and patient's quality of life. The Company and its affiliates market products in the U.S. and internationally via a direct sales force and independent distributors.

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[www.diersmedical.com](http://www.diersmedical.com)

DIERS Medical Systems is an innovative company offering a radiation-free system for assessment of the spine and trunk. Using surface topography, the DIERS formetric system can provide a 3-D reconstruction of the spine as a static measurement or while the spine is in motion. The addition of lower extremity video analysis and foot pressure measurements from the integrated treadmill turns the spine system into a fully functional gait lab.

The DIERS formetric system provides reliable outcomes data for clinicians who treat patients with scoliosis, kyphosis, neuromuscular disorders, gait abnormalities, adult degeneration, spinal fusions, and can even be used in patients with total joint replacement or sports medicine.

DIERS proudly supports the Spine and Surface Topography Study Group (SSTSG.org), consisting of top researchers interested in the use of surface topography to evaluate trunk and spine deformity in new and innovative ways.

Visit the company website at: [www.diersmedical.com](http://www.diersmedical.com)

## EOS IMAGING

10 rue Mercoeur  
75011 Paris, France  
+331 55 25 60 60

The EOS imaging system is a low and micro dose orthopedic imaging solution developed by a team of engineers, orthopedic surgeons and radiologists. An EOS exam captures full-body, weight bearing images at a significant dose reduction. The sterEOS workstation does not only offer a global assessment of balance and posture, it also provides 3D measurement tools which automatically calculate over 100 clinical parameters. The patient's 3D data is used by orthopedic surgeons for diagnosis, surgical planning, control and follow-up. Radiologists can create 3D models in-house using sterEOS or use [EOS3Dservices.com](http://EOS3Dservices.com). The 3D data can also be used in our cloud-based, 3D surgical planning platform which helps to select and position implants. The EOS system, sterEOS workstation and hipEOS surgical planning software have been 510(k) cleared by US FDA

# EXHIBIT DESCRIPTIONS

## **GLOBUS MEDICAL, INC.**

Company 2560 General Armistead Avenue  
Audubon, PA 19403 USA  
+1-610-930-1800  
[www.globusmedical.com](http://www.globusmedical.com)

Globus Medical, Inc. is a leading musculoskeletal implant company based in Audubon, PA. The company was founded in 2003 by an experienced team of professionals with a shared vision to create products that enable surgeons to promote healing in patients with musculoskeletal disorders. Additional information can be accessed at [www.globusmedical.com](http://www.globusmedical.com).

## **K2M INC.**

600 Hope Parway SE, Leesburg  
Virginia 20175 USA  
+1 866-526-4171  
[www.k2m.com](http://www.k2m.com)

K2M Group Holdings, Inc. is a global medical device company focused on designing, developing and commercializing innovative complex spine and minimally invasive spine technologies and techniques used by spine surgeons to treat some of the most difficult and challenging spinal pathologies. K2M has leveraged these core competencies to bring to market an increasing number of products for patients suffering from degenerative spinal conditions. These technologies and techniques, in combination with a robust product pipeline, enables the company to favorably compete in the global spinal surgery market.

## **LDR SPINE**

13785 Research Boulevard - Suite 200  
Austin, TX 78750 USA  
+1-512-344-3444  
[www.ldr.com](http://www.ldr.com) — [www.CervicalDisc.com](http://www.CervicalDisc.com)

LDR Holding Corporation is a global medical device company focused on designing and commercializing novel and proprietary surgical technologies for the treatment of patients suffering from spine disorders. LDR's primary products are based on its exclusive VerteBRIDGE® fusion and Mobi® non-fusion technology platforms and are designed for applications in the cervical and lumbar spine.

## **MEDICREA**

50 Greene Street, 5th Floor  
New York, NY 10013 USA  
+1-646-490-2360  
[www.medicrea.com](http://www.medicrea.com)

MEDICREA is a pioneer and global leader in the manufacturing of customized implants for personalized spinal surgery with the development of a comprehensive process incorporating the software analysis of each patient, the pre-surgical planning of the surgical strategy, and the production of customized spinal osteosynthesis rods (UNiDTM rod) and morphologically adapted 3D printed implants. We enjoy an excellent and ever-improving reputation that allows us to develop unique scientific partnerships with some of the most visionary and creative spine surgeons.

## **MEDTRONIC**

710 Medtronic Parkway  
Minneapolis, MN, 55432 USA  
+1-763-514-4000  
[www.medtronic.com](http://www.medtronic.com)

As a global leader in medical technology, services and solutions, Medtronic improves the lives and health of millions of people each year. We use our deep clinical, therapeutic and economic expertise to address the complex challenges faced by healthcare systems today. Visit us at booth 17 to see how we can take healthcare Further, Together. Learn more at [Medtronic.com](http://Medtronic.com).

## **MISONIX, INC.**

1938 New Highway  
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+1-631-694-9555  
Email: [sales@misonix.com](mailto:sales@misonix.com)  
[www.misonix.com](http://www.misonix.com)

Misonix, Inc. is a world leader in developing ultrasonic surgical devices for hard and soft tissue removal. Our Misonix BoneScalpel™ is a unique ultrasonic osteotome that is rapidly being adopted by leading hospitals around the world. It encourages bone dissections en-bloc while sparing elastic tissues, and has been reported to reduce blood loss, use of cell savers and time for bone work. BoneScalpel has been used extensively for bone removal in the cervical, thoracic and lumbar spine, including osteotomies such as facetectomy, SPO, Ponte osteotomy, PSO, and VCR.



# EXHIBIT DESCRIPTIONS

## MAZOR ROBOTICS INC.

189 South Orange Ave, Suite 1850  
Orlando, FL 32801 USA  
+1-407-591-3463  
[www.mazorrobotics.com](http://www.mazorrobotics.com)

Mazor means healing, or cure, in Hebrew, and our number one mission is to help heal patients in need. We strive for this mission each day by leading and innovating global spine and brain surgery with our one-of-a-kind Renaissance® Guidance System and complementary products. Furthermore, we are elevating the art of spine and brain surgery from typical freehand procedures to leading-edge, effective, state-of-the-art procedures, to define the future of surgical technology – today.

## NUVASIVE

7475 Lusk Blvd.  
San Diego, CA 92121 USA  
[www.nuvasive.com](http://www.nuvasive.com)

NuVasive is a global medical device company focused on transforming spine surgery by empowering surgeons with technology to approach procedures in the least disruptive way possible and restore the vitality of life for those that suffer from debilitating spinal conditions. Through its minimally invasive, procedurally-integrated solutions, the Company is expanding the boundaries of modern healthcare with technologies and surgeon training designed to provide reproducible and clinically-proven surgical outcomes that are redefining the success factors of spine surgery like never before. Addressing a variety of pathologies up and down the spine, from complex spinal deformity to degenerative spinal conditions, NuVasive's highly differentiated solutions include access instruments, implantable hardware and increasingly expert software systems like its game-changing iGA™ surgical planning and reconciliation technology that centers on achieving the global alignment of the spine. NuVasive believes its integrated approach and expertise can fundamentally evolve spine care by delivering improved patient experiences, and better economics for healthcare systems. With \$811 million in revenues as of the end of 2015, NuVasive has an approximate 1,600 person workforce in more than 40 countries around the world. For more information on the Company, please visit [www.nuvasive.com](http://www.nuvasive.com).

## ORTHOFIX, INC.

3451 Plano Parkway  
Lewisville, TX 75056  
+1-214-937-2200  
[www.orthofix.com](http://www.orthofix.com)

Orthofix International N.V. is a diversified, global medical device company focused on improving patients' lives by providing superior reconstructive and regenerative orthopedic and spine solutions to physicians worldwide. Headquartered in Lewisville, TX, the company has four strategic business units that include BioStim, Biologics, Extremity Fixation and Spine Fixation. Orthofix products are widely distributed via the company's sales representatives, distributors and its subsidiaries. In addition, Orthofix is collaborating on research and development activities with leading clinical organizations such as the Musculoskeletal Transplant Foundation, the Orthopedic Research and Education Foundation and the Texas Scottish Rite Hospital for Children. For more information, please visit [www.orthofix.com](http://www.orthofix.com).

## ORTHOPEDIATRICS

2850 Frontier Dr  
Warsaw IN 46582 USA  
+1-574-268-6379  
[www.orthopediatrics.com](http://www.orthopediatrics.com)

At OrthoPediatrics® we have a cause to improve the lives of children with orthopedic conditions. As the only global medical device company focused exclusively on pediatric orthopedics, we have 16 surgical systems for Trauma, Limb Deformity, Spine, and Sports Medicine. OrthoPediatrics is the true end-to-end provider for surgical solutions in pediatric orthopedics, and in collaboration with world-class pediatric orthopedic surgeons, we are dedicated to delivering the best products for children. We are committed to providing and supporting superior clinical education through partnerships with professional societies as well as training and educational initiatives globally to advance the field of pediatric orthopedics.

# EXHIBIT DESCRIPTIONS

## PARADIGM SPINE, LLC

505 Park Avenue, Floor 14  
New York, NY 10022 USA  
+1-212-367-7274  
[www.paradigmspine.com](http://www.paradigmspine.com)

Paradigm Spine, LLC was founded in 2005 to be a leader in the field of non-fusion spinal implant technology. The Company has offices in New York and Germany, and sells its four core medical device products in more than 45 countries worldwide. Paradigm Spine, LLC has successfully received FDA PMA approval of the coflex® Interlaminar Stabilization® device in the United States in October of 2012. The coflex® technology has been implanted in more than 100,000 patients, and is selling in over 45 countries. The core market for coflex® is degenerative lumbar spinal stenosis patients. coflex-F® is an interspinous stabilization device that offers an alternative to pedicle screw fixation as an adjunct to intervertebral fusion in cases of degenerative disc disease with or without mild instabilities in the lumbar spine. The DSS® Stabilization Systems provides semi-rigid and rigid stabilization for customized spine stabilization. It is intended to treat patients suffering from degenerative disc disease, spondylolisthesis, kyphosis, stenosis, pseudarthrosis, and traumatic injuries of the spine. DCI™ is a tissue sparing, motion preserving cervical implant. It provides stable, controlled motion in the cervical spine allowing the spine to be functionally dynamic.

## SPINEGUARD, INC.

1388 Sutter Street  
Suite 510  
San Francisco, CA 94109 USA  
+1-415-512-2500  
[www.spineguard.com](http://www.spineguard.com)

SpineGuard provides tools equipped with DSG™ (Dynamic Surgical Guidance) Technology to enhance spinal surgery. Devices built with DSG Technology give real-time audio and visual feedback to improve the accuracy of pedicle screw placement, without the need for ancillary equipment. The PediGuard® probes are the only devices with built-in DSG capability. These devices have assisted spine surgeons in accurately placing pedicle screws in over 45,000 spinal procedures around the world. Please visit [www.spineguard.com](http://www.spineguard.com) for more information.

## STRYKER'S SPINE DIVISION

2 Pearl Court  
Allendale, NJ 07401 USA  
+1-201-749-8000  
[www.stryker.com](http://www.stryker.com)

Stryker is one of the world's leading medical technology companies and, together with our customers, we are driven to make healthcare better. The Company offers a diverse array of innovative products and services in Orthopaedics, Medical and Surgical, and Neurotechnology and Spine that help improve patient and hospital outcomes. Stryker is active in over 100 countries around the world. Please contact us for more information at [www.stryker.com](http://www.stryker.com).

## ZIMMER BIOMET

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[www.zimmerbiomet.com](http://www.zimmerbiomet.com)

Zimmer Biomet was created to redefine musculoskeletal healthcare, and to help improve the lives of those we serve. Our singular goal is to help achieve exceptional outcomes for patients, healthcare professionals, investors, our Team Members, and the communities in which we work. By focusing the strengths of two great companies, Zimmer Biomet is uniquely positioned to accelerate the pace of innovation and to drive growth. This simple but powerful philosophy is summarized by our tagline, "Your progress. Our promise." It reminds us that, together, we can achieve more when we work together in pursuit of our shared goals.



# HANDS-ON WORKSHOPS

IMAST delegates are encouraged to attend the Hands-On Workshops (HOW) on Wednesday, Thursday and Friday afternoons, at lunch on Thursday and Friday and during breakfast on Thursday and Friday mornings. Each workshop is programmed by a single-supporting company and will feature presentations on topics and technologies selected by the company (as of May 2016). \*Please note: CME credits are not available for Hands-On Workshops.

	Wednesday July 13, 2016	Thursday July 14, 2016	Friday July 15, 2016
Morning		7:30-8:30	7:30-8:30
		Medtronic - Salon 14	Medtronic - Salon 14
		Misonix - Salon 15	
		Benvenne Medical - Judiciary Square	
Lunch		12:30-13:30	12:05-13:05
		K2M - Salon 14	K2M - Salon 14
		NuVasive - Salon 15	DePuy Synthes - Salon 15
		Globus Medical - Judiciary Square	Orthofix - Judiciary Square
		Zimmer Biomet - Mt. Vernon Square	Zimmer Biomet - Mt. Vernon Square
Afternoon	17:00-19:00	17:30-18:30	
	K2M - Salon 14	K2M - Salon 14	
	NuVasive - Salon 15	DePuy Synthes - Salon 15	
		NuVasive - Judiciary Square	



# HOW DESCRIPTIONS

## Wednesday, July 13 – 17:00-19:00

### K2M

Room: Salon 14

*Adolescent Idiopathic Scoliosis: Getting the Right Contour*

PRESENTERS: Peter O. Newton, MD; Harry L. Shufflebarger, MD; Laurel C. Blakemore, MD

### NuVasive

Room: Salon 15

*Surgical Solutions for Achieving Global Sagittal Alignment with Intraoperative Assessment Technology*

PRESENTERS:

NUVAPanning™ – Serena Hv, MD

Deformity TLIF – Justin Smith, MD and Tyler Koski, MD

XLIF® ACR® & ALIF ACR® – Juan Uribe, MD

Cervical ACR® – Bobby Kalantar, MD

## Thursday, July 14 – 7:30-8:30

### Medtronic

Room: Salon 14

*The Ante-psoas Approach to Managing Adult Degenerative and Deformity Spinal Conditions: Considerations in Patient Selection, the Surgical Technique, and the Latest in Biologics Options*

PRESENTERS: Sigurd H. Berven, MD and Peter Whang, MD

In this workshop attendees will learn about accessing L2 to L5, and even L5-S1, from the oblique lateral position. Utilizing an oblique lateral trajectory away from the posterior nerves within the psoas muscle, the OLIF25™ procedure is an alternative to approaches dependent on neuromonitoring to traverse the psoas muscle, and OLIF51™ obviates the need for patient repositioning to access L5-S1. This workshop incorporates indications and applications of a comprehensive surgical access platform, interbody, fixation and biologic options.

### Misonix

Room: Salon 15

*Ultrasonics in Spine Surgery: Bonescalpel Hands-On Workshop*

PRESENTER: Suken A. Shah, MD

### Benvenue Medical

Room: Judiciary Square

*Multi-Expandable, ALIF-Sized Implant for TLIF*

PRESENTER: Richard G. Fessler, MD, PhD

## Thursday, July 14 – 12:30-13:30

### K2M

Room: Salon 14

*Adult Scoliosis and PJK: Present and Future Strategies for Management and Prevention*

PRESENTERS: Oheneba Boachie, MD; Gregory M. Mundis, MD; Han Jo Kim, MD

### NuVasive

Room: Salon 15

*Anterior Column Realignment (ACR®) with Computer-assisted Surgery*

PRESENTERS:

NuvaMap™ O.R. – Rajiv Sethi, MD

ALIF ACR® – Christopher Shaffrey, MD

XLIF® ACR® – Serena Hu, MD

### Globus Medical

Room: Judiciary Square

*Visualized Lateral Access to Help Minimize Neural Complication*

PRESENTER: Joseph R. O'Brien, MD, MPH

### Zimmer Biomet

Room: Mt. Vernon Square

*Surgeon Preservation and Patient Safety, the Use of Power in the OR*

PRESENTERS: David L Skaggs, MD, MMM

An educational review of the benefits and use of power within several aspects of a spinal fusion procedure.



# HOW DESCRIPTIONS

## Thursday, July 14 – 17:30-18:30

### K2M

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Room: Salon 14

*Correcting & Maintaining Sagittal Alignment in AIS - Current Concepts*

PRESENTERS: Oheneba Boachie, MD; Benny T. Dahl, MD, PhD, DMSci; Martin Gehrchen, MD, PhD; Matthew Cunningham, MD, PhD

### DePuy Synthes

---

Room: Salon 15

*Simplifying Complex Spine: Correction Techniques in Adult Deformity*

PRESENTERS: Daniel E. Gelb, MD; Munish C. Gupta, MD; Heiko Koller, MD

This workshop is designed for surgeons experienced with open deformity procedures seeking exposure to new techniques for instrumented adult deformity correction with a focus on goals for spinal alignment in adult deformity surgery, complication avoidance and revision strategies. The session will include technique discussions with case examples.

### NuVasive

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Room: Judiciary Square

*MAGEC®: Best Practices*

PRESENTERS: Suken A. Shah, MD and Peter Strum, MD, MBA

## Friday, July 15 – 7:30-8:30

### Medtronic

---

Room: Salon 14

*Optimal Sagittal Alignment in Adult Deformity*

PRESENTERS: Lawrence G. Lenke, MD and Christopher I. Shaffrey, MD

This course will feature presentations on the clinical relevance of restoring sagittal balance, and the principles of spinal deformity correction techniques and technologies. Discussion will include radiographic assessment, strategic surgical planning, and the treatment of sagittal imbalance through osteotomies, VCR, and the utilization of spinal implants.

## Friday, July 15 – 12:05-13:05

### K2M

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Room: Salon 14

*Treating Adult Degenerative Deformity with a Minimally Invasive Far Lateral Technique*

PRESENTERS: Pierce D. Nunley, MD; Michael Wang, MD; Robert S. Lee, BSc, MBBS, MRCS, FRCS

### DePuy Synthes

---

Room: Salon 15

*Advanced Techniques in Treating AIS*

PRESENTERS: Darrell S. Hanson, MD; Peter O. Newton, MD

This workshop is designed for surgeons interested in advanced techniques for treating AIS from an expert panel. This session will include an overview of the latest available technology and techniques for treating complex deformity in the adolescent population, including a new implant-based reduction and derotation system. The session will include technique discussions with case examples.

### Orthofix

---

Room: Judiciary Square

*Phoenix® CDX™ Minimally Invasive Spinal Fixation System for MIS Deformity*

PRESENTER: Harvinder Bhatti, MD

### Zimmer Biomet

---

Room: Mt. Vernon Square

*Avoidance and Management of PJK and DJK*

PRESENTERS: Amer Samdani, MD; Justin Smith, MD, PhD

A detailed look at management of PJK and DJK within the pediatric and adult spinal fusion patient population.

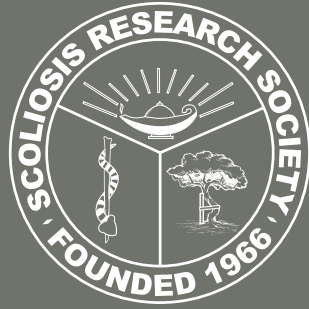
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IMAST2016

23<sup>RD</sup> INTERNATIONAL MEETING ON  
ADVANCED SPINE TECHNIQUES

JULY 13-16, 2016  
WASHINGTON, D.C., USA





**The Scoliosis Research Society  
gratefully acknowledges DePuy Synthes  
and Zimmer Biomet for their overall  
support of SRS.**



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# ABOUT SRS

## 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 37 orthopaedic surgeons to an international organization of more than 1,250 health care professionals.

## Mission Statement

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

## Membership

SRS is open to orthopaedic surgeons, neurosurgeons, researchers and allied health professionals who have a practice that focuses on spinal deformity.

*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 to researchers in all geographic locations who are willing to commit to a clinical practice which includes at least 20% spinal deformity. Candidate Fellows stay in that category for five years, during which time they must meet all of the requirements and demonstrate their interest in spinal deformity and in the goals of the Society. After five years, those who complete all requirements are eligible to apply for Active Fellowship in the Society. Candidate Fellowship does not include the right to vote or hold office. Candidate Fellows may serve on SRS committees.

*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: <http://www.srs.org/professionals/membership>

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- Networking
- Education

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## Programs and Activities

SRS is focused primarily on education and research and include the Annual Meeting, the International Meeting on Advanced Spine Techniques (IMAST), Hands-On Courses, Worldwide Conferences, a Global Outreach Program, the Research Education Outreach (REO) Fund which provides grants for spine deformity research, and development of patient education materials.

## Website Information

For the latest information on SRS meetings, programs, activities and membership please visit [www.srs.org](http://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](http://www.srs.org).

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SCOLIOSIS RESEARCH SOCIETY presents



# 24th IMAST

## INTERNATIONAL MEETING ON ADVANCED SPINE TECHNIQUES

# JULY 12-15, 2017 SOUTH AFRICA



52<sup>ND</sup>  
ANNUAL MEETING &  
COURSE 2017  
SEPTEMBER 6-9  
PHILADELPHIA PA USA

# MEETING OVERVIEW

## Wednesday, July 13, 2016

8:00 - 14:00	Board of Directors Meeting; Exhibit Set-Up	
14:00 - 21:00	Delegate Registration Open	Meeting Level 2 Foyer
15:00 - 16:45	Special Symposia 1A-B	Salon 7-10; Salon 12-13
17:00 - 19:00	*Hands-On Workshops	Salon 14; Salon 15
19:00 - 21:00	Welcome Reception	Exhibit Hall — Salon 6

## Thursday, July 14, 2016

7:30 - 18:00	Registration Open	
7:30 - 8:30	*Hands-On Workshops with Breakfast	Salon 14; Salon 15; Judiciary Square
8:15 - 8:45	Breakfast & Exhibit Viewing	Exhibit Hall — Salon 6
8:45 - 10:15	General Session	Salon 1-5
10:15 - 11:00	Refreshment Break & Exhibit Viewing	Exhibit Hall — Salon 6
11:00 - 12:15	Concurrent Sessions 2A-C: Abstract Session & Debate Series	Salon 1-5; Salon 7-10; Salon 12-13
12:30 - 13:30	Lunch & Exhibit Viewing *Hands-On Workshops	Exhibit Hall — Salon 6 Salon 14; Salon 15; Mt. Vernon Square, Judiciary Square
13:45 - 14:45	Concurrent Session 3A-D: ICLs & Two-Minute Point Presentations	Salon 1-5; Salon 7-10; Salon 12-13; Shaw/Ledroit Park
14:45 - 15:00	Walking Break & Exhibit Viewing	Exhibit Hall — Salon 6
15:00 - 15:55	Concurrent Sessions 4A-D: Abstract Sessions, Complication Series & Two-Minute Point-Presentations	Salon 1-5; Salon 7-10; Salon 12-13; Shaw/Ledroit Park
15:55 - 16:15	Refreshment Break & Exhibit Viewing	Exhibit Hall — Salon 6
16:15 - 17:15	Concurrent Sessions 5A-D: Abstract & Roundtable Sessions	Salon 1-5; Salon 7-10; Salon 12-13; Shaw/Ledroit Park
17:15 - 17:30	Walking Break	
17:30 - 18:30	*Hands-On Workshops with Beverages & Snacks	Salon 14; Salon 15; Judiciary Square

## Friday, July 15, 2016

7:30 - 16:45	Registration Open	Level 2 Foyer
7:30 - 8:30	*Hands-On Workshops with Breakfast	Salon 14
8:00 - 8:40	Breakfast & Exhibit Viewing	Exhibit Hall — Salon 6
8:40 - 9:40	Concurrent Sessions 6A-C: Abstract Sessions, Debate Series	Salon 1-5; Salon 7-10; Salon 12-13
9:40 - 10:30	Refreshment Break & Exhibit Viewing	Exhibit Hall- Salon 6
10:30 - 11:55	Concurrent Sessions 7A-C: Abstract Sessions & Video-Based Session	Salon 1-5; Salon 7-10; Salon 12-13
12:05 - 13:05	Lunch & Exhibit Viewing *Hands-On Workshops	Exhibit Hall — Salon 6 Salon 14; Salon 15; Mt. Vernon Square, Judiciary Square
13:15 - 14:15	Concurrent Sessions 8A-E: Roundtable Sessions & Two-Minute Point Presentations	Salon 1-5; Salon 7-10; Salon 12-13; Shaw/Ledroit Park; Chinatown
14:15 - 14:30	Walking Break & Exhibit Viewing	Exhibit Hall — Salon 6
14:30 - 15:30	Concurrent Sessions 9A-D: Abstract Sessions, Debate Series & ICLs	Salon 1-5; Salon 7-10; Salon 12-13; Shaw/Ledroit Park
15:30 - 15:45	Walking Break	
15:45 - 16:45	Concurrent Sessions 10A-E: ICLs & Two-Minute Point Presentations	Salon 1-5; Salon 7-10; Salon 12-13; Shaw/Ledroit Park; Chinatown
16:45 - 17:00	Membership Info Session	Salon 14
19:00 - 22:00	Course Reception	Smithsonian National Zoological Park

## Saturday, July 16, 2016

8:15 - 11:30	Registration Open	Level 2 Foyer
8:15 - 8:45	Breakfast Exhibits Closed	Salon 6
8:45 - 9:45	Concurrent Sessions 11A-C: ICLs	Salon 1-5; Salon 7-10; Salon 12-13
9:45 - 10:00	Walking Break	
10:00 - 11:00	Session 12: Debates Series	Salon 1-5
11:00 - 11:30	Walking Break & Lunch Buffet	Level 2 Foyer
11:30 - 13:00	Session 13: Lunch with the Experts	Salon 1-5
13:00	Adjourn	

\*Denotes Non-CME Session