Powered by the Scoliosis Research Society

31st International Meeting on Advanced Spine Techniques

31st IMAST

San Diego

CALIFORNIA, USA APRIL 10-13, 2024

FINAL PROGRAM

SRS Scoliosis Research Society

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Corporate Supporters

We are pleased to acknowledge and thank those companies that **provided financial support to SRS in 2023**. Support levels are based on total contributions throughout the year and include the Annual Meeting, IMAST, Global Outreach Scholarships, Edgar Dawson Memorial Scholarships, SRS Traveling Fellowships, and the Research Education (REO) Fund.

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31st IMAST Venue

Marriott Marquis San Diego Marina
333 West Harbor Drive
San Diego, California 92101 USA

Future Educational Events

Annual Meeting

59th Annual Meeting
September 10-14, 2024 | Barcelona, Spain

60th Annual Meeting
September 16-20, 2025 | Charlotte, North Carolina, USA

61st Annual Meeting
October 6-10, 2026 | Sydney, Australia

62nd Annual Meeting
September 14-18, 2027 | New Orleans, Louisiana, USA

International Meeting on Advanced Spine Techniques

32nd IMAST
April 2-5, 2025 | Glasglow, Scotland

33rd IMAST
April 15-18, 2026 | Toronto, ON, Canada

Chair's Message

Dear Delegates and Attendees,

Welcome to beautiful San Diego, California and the 31st International Meeting for Advanced Spine Techniques (IMAST), powered by the Scoliosis Research Society (SRS).

This year's IMAST personifies the meeting's mission to be the premier global forum where professionals treating complex spinal conditions meet to share, discuss and demonstrate groundbreaking research with a focus on innovation.

As always, one of the highlights of this meeting is Cases and Cocktails. This year's topics include Novel Techniques in Complex Thoracolumbar Deformity, Innovation in Pediatric Deformity and Adult and Pediatric Cervical Deformity. We are also hosting a first-ever IMAST keynote speaker Alessandra Sacco, PhD., from Sanford Burnham Prebys, who will cover the topic of cellular senescence.

A don't miss session includes an exclusive AANS/CNS Section on Disorders of the Spine and Peripheral Nerves on the topic of Minimally Invasive Spinal Surgery: Endoscopic to Deformity.

Trends in abstracts this year include aspects of technology, robotics and AI. The new Innovation Award for the most innovative abstract highlights what IMAST is really about – focusing on advancement in the field.

The Instructional Course Lectures features the power of international views on future trends in spine surgery, and include range of compelling topics such as **Session 7A: Anterior Surgery: The Current State of the Art. (link to page 25)**

On Saturday the second IMAST Innovation Day will take place. This day offers an opportunity for SRS stakeholders to meet with key opinion leaders and IMAST attendees. This day is to be used for study group meetings, industry educational events and more. We strongly encourage attendees to stay the extra day and be part of this experience.

We offer a special thank you to our industry partners for their continued support. Plan your schedule accordingly so that you can see all of the latest in the exhibit hall and during the Hands-on Workshops. More information on these can be found beginning on page 132.

Collectively, we have produced what will be a sensational meeting experience that has topics to interest any attendee. See you in San Diego!

Eric O. Klineberg, MD
IMAST Chair

Per D. Trobisch, MD
IMAST Co-Chair

IMAST Mobile App

A mobile app will be available to all delegates during the 31st IMAST. The app is designed to enhance the attendee experience by providing all the information about IMAST in one convenient location that can be accessed from any smart phone or tablet with an internet connection.

To Download the 31st IMAST Mobile App

1. Search for IMAST24 in the App Store or Google Play Store and install
2. Open the downloaded app to begin using the app right away
3. To take full advantage of the app, login with your email address

Once downloaded, delegates can access all static content on the app without an internet connection, including:

- A detailed IMAST agenda, which allows delegates to create a personalized schedule (must login with an email address).
- Exhibitor information including exhibit floor plan, company descriptions and the Hands-On Workshop schedule.
- Maps of meeting space
- An alert system for real-time updates from SRS and breaking news as it happens.
- Session and overall meeting evaluations
- Abstracts

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

Ask a Question in the App

Delegates will be able to ask questions, directly through the mobile app, during all sessions at IMAST

To ask a question:

1. Click on "Agenda" and select the session you are in with the "Ask a Question" feature enabled.
2. Scroll to the bottom of the session information and click "Ask a Question" under Session Engagement. Questions already asked by attendees will be listed.
3. Click "Ask a Question" again and a text box will appear.
4. Type your question in the text box and click "Submit Question". Your question will appear within the question list.
5. If someone has asked a question you would also like answered, you can "up vote" the question by clicking the circular up arrow button to the right of the question in the list. When questions get up voted they will be pushed higher up on the page as the number of votes rise.

Participate in Live Session Polls

Session polls can be found at the bottom of session pages. To participate in one, click "Join Live Poll" at the bottom of the page under Session Engagement. Once you've started a session poll, you can move from question to question by selecting your answers and clicking "Submit" or by clicking on the navigation arrows to the left and right of the Submit button. Moderators will display the live results on screen for the entire audience to view.

Stay Up to Date With SRS During IMAST and Share Your Experiences. #SRSIMAST24

@srs_org @ScoliosisResearchSociety @srs_org @Scoliosis Research Society

General Meeting Information

Meeting Description

The 31st IMAST will offer a meeting experience where leading spine surgeons, innovative researchers and the most advanced spine technologies come together in an international forum to demonstrate and discuss recent advances in spine surgery.

IMAST Mission & Vision Statement

Mission

To freely present, discuss and debate emerging technologies used for the treatment and care of patients with complex spine conditions.

Vision

To be the premier global forum where professionals treating complex spinal conditions meet to share, discuss and demonstrate groundbreaking research with a focus on innovation.

Learning Objectives

Upon completion of IMAST, you should be able to:

1. Assess and evaluate the advantages and disadvantages of robotics, navigation and enabling technology for the treatment of spinal conditions
2. Discuss the impact of osteoporosis on the ability to treat spinal pathologies
3. Examine the different types of anterior approaches for pediatrics scoliosis and assess the limitations of each approach
4. Analyze the operative and nonoperative care of AIS throughout a patient's life, from childhood to adulthood
5. Understand the options for the management of adult spinal deformity using minimally invasive surgical techniques

Target Audience

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

Attire

Business casual (polo or dress shirts, sport coats) are appropriate for IMAST sessions.

Cases & Cocktails Sessions

Cases will be presented by faculty in three concurrent sessions on Wednesday, April 10 from 16:00 - 18:00. Attendees will have the opportunity to discuss cases in small groups with an IMAST faculty member present at each table. Each case presentation will be followed by small group discussions in which each table will debate the various treatment options and determine their action plan. Libations will continue to be served during this time so that all may continue to enjoy a relaxed atmosphere while discussing cases. All registered delegates are welcome and encouraged to attend and participate.

Cases & Cocktail Sessions:

1. **Cases and Cocktails 1:** Novel Techniques in Complex Thoracolumbar Deformity; *supported, in part, by an educational grant from Orthofix/SeaSpine*
2. **Cases and Cocktails 2:** Innovation in Pediatric Deformity (VBT, Apifix, Endoscopic, etc.); *supported, in part, by an educational grant from Highridge Medical*
3. **Cases and Cocktails 3:** Adult and Pediatric Cervical Deformity

We encourage delegates to join us for the Welcome Reception, immediately following the Cases & Cocktails Sessions, from 18:00 - 20:00.

Cell Phone Protocol

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

Charging Tables

Delegates are welcome to use the complimentary charging tables located in the entrance of the Marriott Grand Ballroom Foyer to recharge smartphones and small tablets. Please do not leave your electronic devices or any personal belongings at the charging station unattended.

General Meeting Information

CME Information

CME certificates will be available to pre-registered delegates upon the opening of the meeting at www.srs.org/imast24#cme. Delegates who registered onsite may access their certificates after 30 days.

Delegates should log on to the website listed above and enter their last name and the ID# listed on their meeting badge. The system will 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 cme@srs.org for any questions. SRS asks that all CME certificates be claimed no later than December 31, 2024.

Evaluations are available to all attendees at the commencement of the meeting. Evaluations are available in the IMAST 2024 Mobile App.

ACCME Accreditation Statement

The Scoliosis Research Society (SRS) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians.

Credit Designation

The Scoliosis Research Society (SRS) designates this live activity for a maximum of 14.00 *AMA PRA Category 1 Credit(s)*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Emergency & First Aid

The Marriott Marquis San Diego Marina is fully prepared to handle emergency requests and first aid. Contact an SRS Staff person for support. Remember to note all emergency exits within the venue.

E-Point Presentation Kiosks

There are over 60+ E-Point Presentations to view on the E-Point Presentation kiosks located in the Registration area.

Innovation Celebration

Join your colleagues to close out the 31st IMAST. The celebration takes place Friday, April 12 from 16:15 - 18:00 on the South Patio Pool, South Tower, Lower Level. Open to all registered delegates and guests of registered delegates. Tickets are $25 USD for registered delegates and $50 USD for guests and must be purchased in advance. Please stop at the IMAST registration desk to purchase tickets. Dress for the Innovation Celebration is business casual.

Internet Access

Wireless Internet access is available throughout the meeting space of the Marriott Marquis San Diego Marina.

To log on select...

Network = MarriottBonvoy_Conference

Password = IMAST2024

Language

Presentations and course materials will be provided in English.

Lost & Found

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

No Smoking Policy

Smoking is not permitted during any IMAST activity or event.

General Meeting Information

Registration Desk Hours

Location: Marriott Grand Ballroom Entrance, North Tower, Lobby Level

Wednesday, April 10	15:00 - 18:00
Thursday, April 11	07:00 - 18:00
Friday, April 12	07:00 - 15:30

Speaker Ready Room

Presenters may upload their PowerPoint presentations in the Speaker Ready Room.

Location: San Diego Ballroom A, North Tower, Lobby Level

Hours:

Wednesday, April 10	15:00 - 18:00
Thursday, April 11	08:00 - 18:00
Friday, April 12	07:00 - 15:30

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

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 recording 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.

Welcome Reception

All registered delegates are invited to pick up their registration materials and to attend the IMAST Welcome Reception on Wednesday, April 10 from 18:00 - 20:00. The reception will be hosted in the Exhibit area (Marriott Grand Ballroom Foyer), where beverages and light hors d' oeuvres will be served. There is no charge for registered delegates. Registered delegates may purchase guest ticket(s) for the Welcome Reception for $50 USD, per person, at the IMAST registration desk. Dress for the Welcome Reception is business casual.

Meeting Overview

**subject to change*

	Wednesday, April 10	Thursday, April 11	Friday, April 12
Morning		07:00 - 18:00 Registration Open 08:00 - 09:00 Hands-On Workshops* *with breakfast* 09:00 - 09:30 Exhibit Viewing & Refreshment Break* 09:30-11:45 Abstract Session 1: Whitecloud Award Nominated Papers 11:45 - 12:00 Exhibit Viewing & Lunch Pick-Up*	07:00 - 15:30 Registration Open 07:30 - 08:45 Concurrent Sessions (Abstract Sessions 5A - 5D) 08:45 - 09:00 Exhibit Viewing & Refreshment Break* 09:00 - 11:00 Abstract Session 6 & Keynote Address 11:00 - 11:30 Exhibit Viewing* 11:30 - 12:30 Hands-On Workshops* *Lunch Pick-Up (11:15-11:30)*
Afternoon	15:00 - 18:00 Registration Open	12:00 - 13:00 Hands-On Workshops* 13:00 - 13:30 Exhibit Viewing* 13:30 - 15:00 Concurrent Sessions (Sessions 2A & 2B) 15:00 - 15:30 Exhibit Viewing & Refreshment Break* 15:30 - 17:00 Concurrent Sessions (Sessions 3A & 3B) 17:00 - 17:30 Exhibit Viewing* 17:30 - 18:30 Education Session 4	12:30 - 12:45 Exhibit Viewing* 12:45 - 14:15 Concurrent Sessions (Education Sessions 7A & 7B) 14:15 - 14:30 Exhibit Viewing & Refreshment Break* 14:30 - 16:05 Education Session 8
Evening	16:00 - 18:00 Cases & Cocktails Discussion Sessions 18:00 - 20:00 Exhibit Viewing Welcome Reception*		16:15 - 18:00 Innovation Celebration*

**Denotes non-CME session*

Saturday, April 13, 2024: INNOVATION DAY*

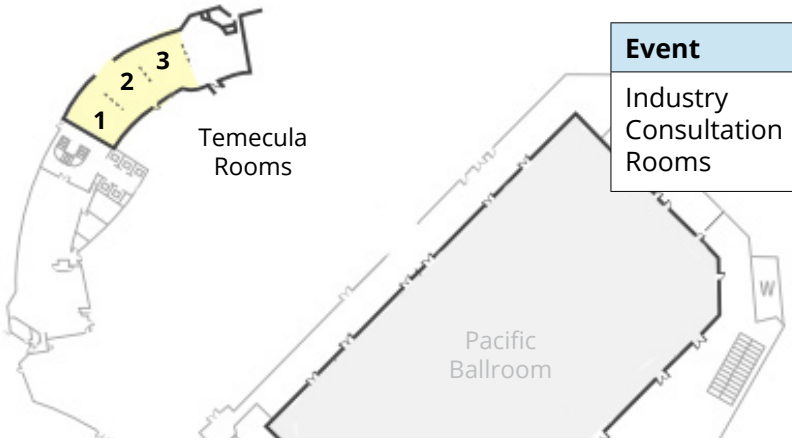
Innovation Day is an opportunity for SRS stakeholders to meet with their key opinion leaders and IMAST attendees. This day is to be used for study group meetings, industry educational events, industry education, etc. More information can be found on the IMAST website.

Meeting Space Floor Plan

North Tower, Lobby Level

Event	Location
Speaker Ready Room	San Diego Ballroom A
Registration	Marriot Grand Ballroom Entrance
Exhibits	Marriott Grand Ballroom Foyer
General Session & Concurrent Sessions	Marriott Grand Ballroom Salons 5-9
Concurrent Sessions	San Diego Ballroom B&C
Cases & Cocktails	Marriott Grand Ballroom Salon 1 Marriott Grand Ballroom Salon 10 Marriott Grand Ballroom Salon 12
Hands-On Workshops	Marriott Grand Ballroom Salon 1 Marriott Grand Ballroom Salon 3 Marriott Grand Ballroom Salon 10 Marriott Grand Ballroom Salon 12
Industry Consultation Rooms	Torrey Pines 1 - 3

North Tower, Ground Level



Event	Location
Industry Consultation Rooms	Temecula 1 - 3

16:00 - 18:00

Cases & Cocktails 1: Novel Techniques in Complex Thoracolumbar Deformity

MARRIOTT GRAND BALLROOM SALON 1

This session is supported, in part, by an educational grant from Orthofix / SeaSpine

Moderator: Gregory M. Mundis Jr., MD
Table Moderators: Michael P. Kelly, MD; Robert K. Eastlack, MD; Jeffrey Hills, MD; Ferran Pellisé, MD, PhD; Eric O. Klineberg, MD & Venu M. Nemani, MD, PhD

Cases & Cocktails 2: Innovation in Pediatric Deformity (VBT, Apifix, Endoscopic, etc.)

MARRIOTT GRAND BALLROOM SALON 10

This session is supported, in part, by an educational grant from Highridge Medical

Moderator: Jennifer M. Bauer, MD, MS
Table Moderators: Lindsay M. Andras, MD; Baron S. Lonner, MD; Amer F. Samdani, MD; Stefan Parent, MD, PhD; Mark A. Erickson, MD & Peter O. Newton, MD

Cases & Cocktails 3: Adult and Pediatric Cervical Deformity

MARRIOTT GRAND BALLROOM SALON 12

Moderator: Joshua M. Pahys, MD

Table Moderators: Christopher P. Ames, MD; Michael Ruf, MD; Camilo A. Molina, MD, FAANS; Ilkka J. Helenius, MD, PhD; Christopher M. Bonfield, MD; Mari L. Groves, MD & Rajiv Iyer, MD

18:00 - 20:00

Welcome Reception*

MARRIOTT GRAND BALLROOM FOYER

A hosted reception featuring hors d'oeuvres, cocktails, exhibitor viewing and reunions with colleagues and friends. The Welcome Reception is included in the registration fee for all delegates. Dress for the Welcome Reception is business casual. If you would like to add the Welcome Reception and/ or purchase guest ticket(s), please visit the IMAST Registration Desk.

**denotes Non-CME session/event*

Meeting Agenda

Thursday, April 11, 2024

08:00 - 09:00

Industry Workshops*

MARRIOTT GRAND BALLROOMS SALONS 1, 3, 10 & 12

IMAST delegates are encouraged to attend the Hands-On Workshops (HOWs). Each workshop is programmed by a single- supporting company and will feature presentations on topics and technologies selected by the company. Catering will be served at each Workshop. *Please note: CME credits are not available for Hands-On Workshops.*

For the full schedule, please refer to page 137.

09:00 - 09:30

Refreshment Break & Exhibit Viewing*

MARRIOTT GRAND BALLROOM FOYER

09:30 - 11:45

Abstracts 1: Whitecloud Award Nominated Papers

MARRIOTT GRANDBALLROOM SALONS 5-9

Moderators: Eric O. Klineberg, MD & Per D. Trobisch, MD

09:30 - 09:34 **Paper#1: Rigid Thoracolumbar Orthosis Does Not Improve Outcomes of Acute Adolescent Spondylolysis as Compared with Placebo. Bony Union Predicts Improved Health-Related Quality of Life Outcomes at 2-Year Follow-Up †**
Ella Virkki, MD, PhD; Olli T. Pajulo, MD, PhD; Milja Holstila, MD, PhD; Terhi Kolari, MSc; Ilkka J. Helenius, MD, PhD

09:34 - 09:38 **Paper#2: Core Muscle Strengths, Lumbar Flexibility and Quality of Life in Lenke Type 5 AIS Patients Treated with Either Cobb to Cobb VBT Versus Fusion Compared with Healthy Individuals †**
Celaleddin Bildik, MD; Selen Saygili; Selmin Arsoy; Hamisi M. Mraja, MD; Baris Peker, MD; Halil Gok, MD; Tunay Sanli, MA; Selhan Karadereler, MD; Meric Enercan, MD; Azmi Hamzaoglu, MD

09:38 - 09:42 **Paper#3: LIV Selection in 'Tweener' Patients Treated with MCGR vs. PSF †**
Michael J. Heffernan, MD; Claudia Leonardi, PhD; Brandon Yoshida, MD; Lindsay M. Andras, MD; Tyler Tetreault, MD; Pediatric Spine Study Group; G.Ying Li, MD

09:42 - 09:55 **Discussion**

09:55 - 09:59 **Paper#4: The Hidden Consequences of Advanced Operative Spine Imaging in Children: Increased Lifetime Oncological Risk in Adolescent Idiopathic Scoliosis Patients Treated with Posterior Spinal Fusion Using Intraoperative Computed Tomography & Navigation †**
Bram Verhofste, MD*; Brendan Striano, MD; Alexander Crawford, MD; Andrew Hresko, MD; Andrew Schoenfeld, MD; Andrew Simpson, MD, MBA, MHS; Daniel J. Hedequist, MD*

09:59 - 10:03 **Paper#5: Anterior Scoliosis Correction for the Treatment of Patients with Early Onset Scoliosis †**
M. Darryl Antonacci, MD; Janet L. Cerrone, PA-C; Laury A. Cuddihy, MD; Randal R. Betz, MD

10:03 - 10:07 **Paper#6: Radiation-Free Assessment of the 3D Morphology of the Adolescent Scoliotic Spine: A Feasibility Study in Synthetic (S)CT †**
Lorenzo Costa, MD; Tijl van der Velden, PhD; Tom P. Schlösser, MD, PhD; René M. Castelein, MD, PhD; Peter R. Seevinck, PhD

10:07 - 10:20 **Discussion**

Key: † = Whitecloud Award Nominee – Best Clinical Paper * = Whitecloud Award Nominee – Best Basic Science/Translational Paper

Cast your vote for the Whitecloud Awards on the Mobile App:
1. Select "Polls & Surveys" from the app home screen
2. Select the Whitecloud Awards voting polls
3. Cast your vote!

**denotes Non-CME session/event*

10:20 - 10:24 **Paper#7: Pseudotime Analysis and mRNA-lncRNA-mRNA Network Co-Analysis Reveals Abnormal Bone Marrow Niche Leads to Reduced Osteogenesis and Chondrogenesis of Bone Marrow Mesenchymal Stem Cells in Adolescent Idiopathic Scoliosis Patients ***
Qianyu Zhuang, MD; Yuechuan Zhang, MD; Terry Jianguo Zhang, MD

10:24 - 10:28 **Paper#8: Multi-Segment Growth Guidance Rod can Change Curvature of Spine and Maintain the Growth of Spine in Immature Sheep ***
Kai Li, MD; Xuhong Xue, MD, PhD; Sheng Zhao, MD

10:28 - 10:32 **Paper#9: Development and Validation of an Artificial Intelligence Model to Accurately Predict Spinopelvic Parameters ***
Joseph Linzey, MD, MS; Edward Harake, BS; Jaes Jones, MD, MS; Mark Zaki, MD; Zachary Wilseck, MD; Jacob Joseph, MD; Todd Hollon, MD; Paul Park, MD

10:32 - 10:45 **Discussion**

10:45 - 10:49 **Paper#10: Multi-Center Prospective Cohort of Intractable Chronic Low Back Pain Patients Treated with Restorative Neurostimulation - Outcomes from 5-Year Data †**
Christopher I. Shaffrey, MD

10:49 - 10:53 **Paper#11: Minimization of Lumbar Interbody Fusion by Percutaneous Full-Endoscopic Lumbar Interbody Fusion (PELIF), and Its Minimally Invasiveness Comparison with Minimally Invasive Surgery-Transforaminal Lumbar Interbody Fusion (MIS-TLIF) †**
Kenyu Ito, MD

10:53 - 10:57 **Paper#12: Soft-Tissue Insufficiency as a Predictor for Proximal Junctional Kyphosis and Failure in Patients with Adult Spinal Deformity †**
Bahar Shahidi, PhD; Pearce Haldeman, BS; Eli O'Brien, BS; Brianna Kuhse, BS; Camille Nosewicz, BS; Courtney Moltzen, BS; Tina L. Iannacone, BSN; Robert K. Eastlack, MD; Gregory M. Mundis Jr., MD

10:57 - 11:10 **Discussion**

11:10 - 11:14 **Paper#13: Minimally Invasive Fusionless Bipolar Fixation: A Six Year Follow Up Surgery Results in Severe Neuromuscular Scoliosis †**
Eugenio Dema, MD; Matteo Palmisani, MD; Rosa Palmisani, MD; Lotfi Miladi, MD; Stefano Cervellati, MD; Marco Meli, MD; Laura Zavatti, MD; Naomi Festa, MD; John C. Clohisy, MD

11:14 - 11:18 **Paper#14: Cervical Spinal Cord Signal Changes in the Absence of Apparent Compression Indicate Dynamic Compression - Insights from Load-Bearing Positional Sitting MRI in Patients with Degenerative Cervical Myelopathy †**
J. Naresh-Babu, MS

11:18 - 11:22 **Paper#15: Is Upper Extremity or Lower Extremity Function More Important for Patient Satisfaction? An Analysis of 24-Month Outcomes from the QOD Cervical Myelopathy Cohort †**
Eunice Yang, BS; Praveen V. Mummaneni, MD, MBA; Dean Chou, MD; Mohamad Bydon, MD; Erica F. Bisson, MD MPH; Christopher I. Shaffrey, MD; Oren Gottfried, MD; Anthony L. Asher, MD; Domagoj Coric, MD; Eric A. Potts, MD; Kevin T. Foley, MD; Michael Y. Wang, MD; Kai-Ming G. Fu, MD, PhD; Michael S. Virk, MD, PhD; John J. Knightly, MD; Scott Meyer, MD; Paul Park, MD; Cheerag D. Upadhyaya, MSc; Mark E. Shaffrey, MD; Luis M. Tumialán, MD; Jay D. Turner, MD; Giorgos Michalopoulos, MD; Brandon Sherrod, MD; Regis W. Haid Jr., MD; Andrew K. Chan, MD

11:22 - 11:35 **Discussion**

11:35 - 11:40 **Annual Meeting 2024 Preview**
Ferran Pellisé, MD, PhD

11:40 - 11:45 **IMAST 2025 Preview**
Kristen E. Jones, MD, FAANS & Meric Enercan, MD

Key: † = Whitecloud Award Nominee – Best Clinical Paper * = Whitecloud Award Nominee – Best Basic Science/Translational Paper

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2. Select the Whitecloud Awards voting polls
3. Cast your vote!

**denotes Non-CME session/event*

11:45 - 12:00

Lunch Pick-Up & Exhibit Viewing*
MARRIOTT GRAND BALLROOM FOYER

12:00 - 13:00

Industry Workshops*
MARRIOTT GRAND BALLROOMS SALONS 1, 3, 10 & 12

IMAST delegates are encouraged to attend the Hands-On Workshops (HOWs). Each workshop is programmed by a single- supporting company and will feature presentations on topics and technologies selected by the company. Catering will be served at each Workshop. *Please note: CME credits are not available for Hands-On Workshops.*

For the full schedule, please refer to page 137.

13:00 - 13:30

Break & Exhibit Viewing*
MARRIOTT GRAND BALLROOM FOYER

13:30 - 15:00

Session 2A: Minimally Invasive: Endoscopic to Deformity
MARRIOTT GRANDBALLROOM SALONS 5-9

This session is planned by the AANS/CNS Joint Section on Disorders of the Spine & Peripheral Nerve (DSPN)

Moderators: Dean Chou, MD, & Wilson Z. Ray, MD

13:30 - 13:31 **Introduction**
Dean Chou, MD

13:31 - 13:39 **Eras in Minimally Invasive Spine Surgery**
Michael Y. Wang, MD

13:39 - 13:47 **Awake TLIF**
Praveen V. Mummaneni, MD, MBA

13:47 - 13:55 **Prone Lateral for MIS Deformity**
Juan S. Uribe, MD

13:55 - 14:03 **Endoscopy - Where Are We Now and Where Are We Going**
Christoph P. Hofstetter, MD, PhD

14:03 - 14:08 **Discussion**

14:08 - 14:16 **Limitations of MIS Deformity**
Paul Park, MD

14:16 - 14:24 **Redefining MIS Deformity Algorithm**
Adam S. Kanter, MD

14:24 - 14:32 **Future of Ortho/Neuro Spine Fellowship - One Scheme?**
Michael P. Steinmetz, MD

14:32 - 14:40 **What is Appropriate MIS Spine Surgery for an ASC**
Eric A. Potts, MD

14:40 - 14:45 **Discussion**

14:45 - 14:59 **Debate - L4/5 Spondy with Global Deformity**
Moderator: Charles A. Sansur, MD

Fix the Spondy
Luis M. Tumialán, MD

Fix the Deformity
Christopher I. Shaffrey, MD

14:59 - 15:00 **Conclusion**
Wilson Z. Ray, MD

**denotes Non-CME session/event*

Session 2B: Artificial Intelligence and New Technology Abstracts

SAN DIEGO BALLROOM B&C

Moderators: Gregory M. Mundis Jr., MD & Ferran Pellisé, MD, PhD

13:30 - 13:34 **Paper#16: A Newly Designed Wearable Device with Artificial Intelligence Detects Scoliosis and Monitor Disease Progression**
Guilin Chen, MD; Nan Wu, MD; Hongjun Liu, PhD; Chao Yao, PhD; Xiaojuan Ban, PhD; Terry Jianguo Zhang, MD; Zohaib Sherwani, MD

13:34 - 13:38 **Paper#17: Are 3D-Printed Anatomic Haptic Adolescent Idiopathic Scoliosis Spine Models Better Resident Training Tools when Compared to Conventional Training Modalities**
Selina C. Poon, MD; Haleh Badkoobehi, MD; Cynthia V. Nguyen, MD; Robert H. Cho, MD; Ryan Finkel, MD; Reginald S. Fayssoux, MD

13:38 - 13:42 **Paper#18: Rigo Cheneau Brace for Adolescent Idiopathic Scoliosis: Higher in Brace Correction and Lower Rates of Curve Progression**
Lisa Bonsignore-Opp, MD; Ritt Givens, BS; Rajiv Iyer, MD; Hiroko Matsumoto, PhD; Nicole Bainton, CPNP; Benjamin D. Roye, MD, MPH; Michael G. Vitale, MD, MPH

13:42 - 13:52 **Discussion**

13:52 - 13:56 **Paper#19: Optical-Kinematic Measurement of Spinal Alignment: A Radiation-Free Technique Using Light Field Navigation**
Steven D. Glassman, MD; Erica F. Bisson, MD, MPH; Sigurd H. Berven, MD; Charles Fisher, MD, FRCS(C); Catherine Olinger, MD; Kosei Nagata, MD, PhD; Timothy Chryssikos, MD, PhD; Rafid Kasir, MD; Arun Tirumalai, PhD; David Fiorella, MS; José Gaviria, MS

13:56 - 14:00 **Paper#20: Comparative Analysis of Utilization of Artificial Intelligence in Minimally-Invasive Adult Spinal Deformity Surgery**
M. Burhan Janjua, MD; Peter Tretiakov, BS; Jamshaid Mir, MD; Pooja Dave, BS; Ankita Das, BS; Bailey Imbo, BA; Oluwatobi O. Onafowokan, MBBS, MS; Matthew Galetta, MD; Nathan Lorentz, MD; Stephane Owusu-Sarpong, MD; Justin S. Smith, MD, PhD; Pawel Jankowski, MD; Bassel G. Diebo, MD; Shaleen Vira, MD; Praveen V. Mummaneni, MD, MBA; Robert K. Eastlack, MD; Dean Chou, MD; Paul Park, MD; Rohan Desai, MD; Peter G. Passias, MD

14:00 - 14:04 **Paper#21: Development of an AI Algorithm for Automatic Cobb Angle Measurement in Spinal Deformities - Comparison of Accuracy Among Three Groups of Teaching Data with Deferent Diseases**
Shuzo Kato, MD; Takeo Nagura, MD, PhD; Yoshihiro Maeda, MD; Morio Matsumoto, MD, PhD; Masaya Nakamura, MD, PhD; Kota Watanabe, MD, PhD

14:04 - 14:14 **Discussion**

14:14 - 14:18 **Paper#22: Automatic Prediction of Spinopelvic Parameters from Bi-Planar Radiographs**
Stefan Lang, MS; Kim Ji Hyun, BS; Moritz Jokeit, MS; Frederic Cornaz, MD; Lukas Urbanschitz, MD; Carlos Torrez, MD; Jess Snedeker, PhD; Mazda Farshad, MD, MPH; Jonas Widmer, MSc

14:18 - 14:22 **Paper#23: Leveraging Image Augmentations to Accurately Predict Spinopelvic Parameters in Lumbosacral X-Rays Using a Whole-Spine Artificial Intelligence Model**
Edward Harake, BS; Joseph Linzey, MD, MS; Jaes Jones, MD, MS; Mark Zaki, MD; Zachary Wilseck, MD; Jacob Joseph, MD; Siri S. Khalsa, MD; Todd Hollon, MD; Paul Park, MD

14:22 - 14:26 **Paper#24: Concurrent Radiographic Exam and Bone Mineral Density Assessments in an Upright Stereoradiography System: An Emerging Technology**
Saba Pasha, PhD; Tyler Koski, MD; Craig McMains, MD; Darryl Lau, MD; Christopher I. Shaffrey, MD

14:26 - 14:36 **Discussion**

14:36 - 14:40 **Paper#25: Safety Data for Robotics Coupled with Navigation for Pediatric Spine Surgery: Initial Intraoperative Results of a Prospective Multicenter Registry**
Nicole Welch, BA; Alexa P. Bosco, BA; Jeffrey M. Henstenburg, MD; Craig M. Birch, MD; Grant D. Hogue, MD; M. T. Hresko, MD; Mark A. Erickson, MD; Roger F. Widmann, MD; Jessica H. Heyer, MD; Kirsten E. Ross, MD; Robert F. Murphy, MD; Dennis P. Devito, MD; Daniel J. Hedequist, MD

**denotes Non-CME session/event*

14:40 - 14:44 **Paper#26: Analysis of 5,108 Consecutive Pedicle Screws Placed Utilizing Robotically-Assisted Surgical Navigation in 336 Patients: Surgical Safety and Early Perioperative Complications in Pediatric Posterior Spinal Fusion**
Roger F. Widmann, MD; Jenna L. Wisch, BS; Colson P. Zucker, BA; Olivia Tracey, BA; Tyler Feddema; Florian Miller; Gabriel S. Linden, BA; Mark A. Erickson, MD; Jessica H. Heyer, MD

14:44 - 14:48 **Paper#27: Assessing the Reproducibility of the Structured Abstracts Generated by ChatGBT and Bard Compared to Human-Written Abstracts in the Field of Spine Surgery: A Comparative Analysis of Scientific Abstracts Between Artificial Intelligence and Human**
Dong-Gune Chang, MD, PhD; Hong Jin Kim, MD; Jae Hyuk Yang, MD, PhD; Lawrence G. Lenke, MD; Javier Pizones, MD, PhD; René M. Castelein, MD, PhD; Kota Watanabe, MD, PhD; Per D. Trobisch, MD; Gregory M. Mundis Jr., MD; Seoung Woo Suh, MD, PhD; Se-Il Suk, MD, PhD

14:48 - 15:00 **Discussion**

15:00 - 15:30

Refreshment Break & Exhibit Viewing*
MARRIOTT GRAND BALLROOM FOYER

15:30 - 17:00

Session 3A: Next Generation Technology in Adult Spinal Deformity: Pitfalls and Complications
MARRIOTT GRANDBALLROOM SALONS 5-9

Moderators: Ronald A. Lehman Jr., MD, & Corey T. Walker, MD

15:30 - 15:32 **Introduction**
Ronald A. Lehman Jr., MD

15:32 - 15:41 **Why Robotics/Navigation Has Changed My MIS Deformity Practice**
Corey T. Walker, MD

15:41 - 15:50 **Lessons Learned from Robotics Gone Wrong**
Joseph M. Lombardi, MD

15:50 - 16:00 **Discussion**

16:00 - 16:09 **How AI and Pre-Bent Rods Have Changed My Deformity Planning and Treatment**
Ronald A. Lehman, MD

16:09 - 16:18 **Limitations of AI Planning for MIS Deformity Surgery, We Still Have a Way to Go**
Neel Anand, MD

16:18 - 16:28 **Discussion**

16:28 - 16:37 **Prone Transpsoas Lateral Fusion Has Made Me a More Versatile Deformity Surgeon**
Rodrigo A. Amaral, MD

16:37 - 16:46 **Downfalls of Lateral MIS Deformity Surgery: How to Identify the Best Patient**
Gregory M. Mundis Jr., MD

16:46 - 16:56 **Discussion**

16:56 - 17:00 **Conclusion**
Corey T. Walker, MD

Session 3B: Pediatric and Adult Innovation Abstracts
SAN DIEGO BALLROOM B&C

Moderators: Kota Watanabe, MD, PhD & Brian Hsu, MD

15:30 - 15:34 **Paper#28: 4.5 mm Molybdenum-Rhenium Rods Use in Adult Spinal Deformity Have a 0% Incidence of Rod Fractures at 2-Year Follow-Up: A Multicenter Retrospective Review**
Stephen Enguidanos, MD; Kevin Ammar, MD; Kornelis A. Poelstra, MD; Jason Cormier, MD; Stephen Scibelli, MD; Matthew McGirt, MD; Michael S. Chang, MD; Dave Seecharan, MD; Yi-Ren Chen, MD; Ankit I. Mehta, MD; Francis C. Lovecchio, MD; Han Jo Kim, MD

**denotes Non-CME session/event*

15:34 - 15:38 **Paper#29: Short Posterior Spinal Fusion and Preventive Methods for Proximal Junctional Kyphosis in Adult Spinal Deformity**
Jung-Hee Lee, MD, PhD; Ki Young Lee, MD, PhD; Kyung-Chung Kang, MD, PhD; Won Young Lee, MD; Seong Jin Cho, MD; Cheol-Hyun Jung, MD; Gil Han, MD; Hong-Sik Park, MD; Woo-Jae Jang, MD; Min-Jeong Park, RN

15:38 - 15:42 **Paper#30: Preoperative Radiographic Parameters Versus 24-Month Clinical Success in Decompression and Sagittal Tether Stabilization or TLIF for Degenerative Spondylolisthesis**
Todd Alamin, MD; William F. Lavelle, MD; Louis C. Fielding, MD; Javier Castro, MD; Serena S. Hu, MD

15:42 - 15:52 **Discussion**

15:52 - 15:56 **Paper#31: Radiographic Analysis of Early Changes in Upper Adjacent Segments After Fusion Surgery: OLIF vs PLIF**
JooYoung Lee, MD; Jae Hwan Cho, MD, PhD; Sehan Park, MD; Chang Ju Hwang, MD, PhD; Dong-Ho Lee, MD, PhD

15:56 - 16:00 **Paper#32: One-Third of Surgical Adult Spinal Deformity (ASD) Patients Are Consuming Opioids Pre- and Postoperatively with Significant International Differences: This is a Cultural Issue**
Brett Rocos, MD; Juan Sardi, MD; Jeffrey L. Gum, MD; Anastasios Charalampidis, MD; Stephen J. Lewis, MD, FRCS(C)

16:00 - 16:04 **Paper#33: Single-Level ALIF/ILIF and TLIF Are Associated with Identical Rates of All-Cause Subsequent Lumbar Surgery**
Nakul Narendran, BS; Paal K. Nilssen, BS; David L. Skaggs, MD, MMM; Alexander Tuchman, MD

16:04 - 16:14 **Discussion**

16:14 - 16:18 **Paper#34: The Impact of Revisions on 5-Year Proms: An Analysis from the QOD Spondylolisthesis Data**
Steven D. Glassman, MD; Leah Y. Carreon, MD; Mladen Djurasovic, MD; Andrew K. Chan, MD; Erica F. Bisson, MD, MPH; Mohamad Bydon, MD; Kevin T. Foley, MD; Christopher I. Shaffrey, MD; Eric A. Potts, MD; Mark E. Shaffrey, MD; Domagoj Coric, MD; John J. Knightly, MD; Paul Park, MD; Michael Y. Wang, MD; Kai-Ming G. Fu, MD, PhD; Jonathan R. Slotkin, MD; Anthony L. Asher, MD; Michael S. Virk, MD, PhD; Panagiotis Kerezoudis, MD, MS; Jian Guan, MD; Dean Chou, MD; Regis W. Haid Jr., MD; Praveen V. Mummaneni, MD, MBA

16:18 - 16:22 **Paper#35: Lumbar Vertebral Body Tethering: Single Center Outcomes and Reoperations in a Consecutive Series of 106 Patients**
Alan Stein, MD; Amer F. Samdani, MD; Alexander J. Schupper, MD; Zan Naseer, MD; Ronit Shah, BS; Sabrina Zeller, MD; Joshua M. Pahys, MD; Solomon Samuel, D. Eng.; Alejandro Quinonez, BS; Steven W. Hwang, MD

16:22 - 16:26 **Paper#36: Effects of Natural Standing on Biomechanical and Diffusion Properties of Unfused Lumbar Intervertebral Discs in AIS Patients 5 Years After Fusion. A Serial MRI Post Contrast Diffusion Study in Supine and Standing**
J. Naresh-Babu, MS

16:26 - 16:36 **Discussion**

16:36 - 16:40 **Paper#37: Improvement in Axial Rotation with Bracing Reduces Risk of Curve Progression in Patients with Adolescent Idiopathic Scoliosis**
Michael Fields, MD; Christina C. Rymond, BA; Matan Malka, BA; Ritt Givens, BS; Matthew Simhon, MD; Hiroko Matsumoto, PhD; Gerard F. Marciano, MD; Afrain Z. Boby, MS, BS; Benjamin D. Roye, MD, MPH; Michael G. Vitale, MD, MPH

16:40 - 16:44 **Paper#38: Initial Outcomes of Posterior Dynamic Distraction Device Compared to Vertebral Body Tethering for Adolescent Idiopathic Scoliosis**
A. Noelle Larson, MD; Julia Todderud, BS; Geoffrey F. Haft, MD; Ron El-Hawary, MD; John T. Anderson, MD; Ryan E. Fitzgerald, MD; Timothy Oswald, MD; Gilbert Chan, MD; Baron S. Lonner, MD; Michael C. Albert, MD; Dan Hoernschemeyer, MD; Todd A. Milbrandt, MD, MS

**denotes Non-CME session/event*

16:44 - 16:48 **Paper#39: Tissue Response Following Implantation with the Posterior Dynamic Distraction Device in Adolescent Idiopathic Scoliosis**
Olivia K. Richard, DVM; Aléthéa Liens, PhD; DesiRae Muirhead, MD; Ron El-Hawary, MD; Klaus Weber, PhD

16:48 - 17:00 **Discussion**

17:00 - 17:30

Break & Exhibit Viewing*
MARRIOTT GRAND BALLROOM FOYER

17:30 - 18:30

Session 4: Enabling Technologies in Spine Surgery: Are We Ignoring Patient Safety with Quick Adoption?
MARRIOTT GRAND BALLROOM SALONS 5-9

Moderators: Ferran Pellisé, MD, PhD, & Rajiv K. Sethi, MD

17:30 - 17:35 **Enabling Technologies: What to Do When Things Go Bad**
Rajiv K. Sethi, MD

17:35 - 17:40 **Robotics in Spine Surgery: What's Next? Are There Safety Concerns?**
Brandon B. Carlson, MD, MPH

17:40 - 17:45 **How Do We Measure Intra-Operative Failure of CT Based Navigation, Robotics, or Augmented Reality Technology?**
Jesse Shen, MD, PhD

17:45 - 17:50 **Discussion**

17:50 - 17:55 **Tips and Tricks: How Do I Notice Inaccuracy Before It's Too Late?**
Phillip K. Louie, MD

17:55 - 18:00 **When Should I Rely on Enabling Technologies?**
Ferran Pellisé, MD, PhD

18:00 - 18:05 **When Should I Not Rely on Enabling Technologies?**
Eric O. Klineberg, MD

18:05 - 18:10 **Implementation of New Enabling Technologies and How Not to Fall Behind**
David L. Skaggs, MD, MMM

18:10 - 18:15 **Discussion**

18:15 - 18:30 **Panel Discussion: How Do We Discuss Major Complications Associated with Enabling Technology Openly with Industry and Educate Surgeons at the Same Time?**
Mark A. Erickson, MD, Eric O. Klineberg, MD, Ronald A. Lehman, MD, Lawrence G. Lenke, MD, Ferran Pellisé, MD, PhD, & David W. Polly Jr., MD

**denotes Non-CME session/event*

07:30 - 08:45

Session 5A: Pediatric Scoliosis Abstracts

MARRIOTT GRAND BALLROOM SALON 1

Moderators: Michael P. Kelly, MD & Barron S. Lonner, MD

07:30 - 07:34 **Paper#40: Behavior of the Un-Instrumented Lumbar Curve Following Selective Thoracic Tether**
Ritt Givens, BS; Christina C. Rymond, BA; Firoz Miyanji, MD; Juan Carlos Rodriguez-Olaverri, MD; Kevin Smit, MD; Ron El-Hawary, MD; Stefan Parent, MD, PhD; Walter H. Truong, MD, FRCS(C); Benjamin D. Roye, MD, MPH; Michael G. Vitale, MD, MPH; Pediatric Spine Study Group

07:34 - 07:38 **Paper#41: The Fate of the Broken Tether: How Do Curves Treated with Vertebral Body Tethering (VBT) Behave After Tether Breakage?**
Tyler Tetreault, MD; Tiffany N. Phan; Tishya Wren, PhD; Michelle C. Welborn, MD; John T. Smith, MD; Ron El-Hawary, MD; Kenneth M. Cheung, MD, MBBS, FRCS; Kenneth D. Illingworth, MD; David L. Skaggs, MD, MMM; Pediatric Spine Study Group; Lindsay M. Andras, MD

07:38 - 07:42 **Paper#42: Outcomes in Patients with Tether Rupture After Anterior Vertebral Tethering for Adolescent Idiopathic Scoliosis: The Good, The Bad, and The Ugly**
John T. Braun, MD; Sofia Federico; David F. Lawlor, MD; Brian E. Grottkau, MD

07:42 - 07:52 **Discussion**

07:52 - 07:56 **Paper#43: Which Lenke Type Curve is Most Appropriate for Vertebral Body Tethering in Adolescent Idiopathic Scoliosis?**
Abel De Varona Cocero, BS; Camryn Myers, BA; Fares Ani, MD; Constance Maglaras, PhD; Themistocles S. Protopsaltis, MD; Juan Carlos Rodriguez-Olaverri, MD

07:56 - 08:00 **Paper#44: Anterior Vertebral Body Tethering Shows Clinically Comparable Shoulder Balance Outcomes to Posterior Spinal Fusion in Lenke 1 and 2 Adolescent Idiopathic Scoliosis**
James Meyers, BA; Lily Q. Eaker, BA; Amer F. Samdani, MD; Firoz Miyanji, MD; Michael Herrera, BS; Ashley Wilczek, BA; Ahmet Alanay, MD; Caglar Yilgor, MD; Dan Hoernschemeyer, MD; Suken A. Shah, MD; Peter O. Newton, MD; Harms Study Group; Baron S. Lonner, MD

08:00 - 08:04 **Paper#45: What Predicts a Successful Result for Vertebral Body Tethering?**
Julia Todderud, BS; Todd A. Milbrandt, MD, MS; D. Dean Potter, MD; A. Noelle Larson, MD

08:04 - 08:08 **Paper#46: The Link Between a Growth Mindset and Health-Related Quality of Life in AIS Patients on Brace Treatment**
Joelle L. Wang, MPsych(Clinical); Nicole Lee, PhD; Matilda Kwek, MD; Kevin B. Lim, MD, FRCS(Orth), MBA; Patrick C. Hsieh, MD, MBA, MSc; Dhiraj V. Sonawane, MS (Orth)

08:08 - 08:18 **Discussion**

08:18 - 08:22 **Paper#47: Changes in Diaphragm Intrusion and Thoracic Dimensions After Posterior Spinal Fusion in Patients with Neuromuscular Scoliosis**
Gregory Benes, BS; Peter G. Gabos, MD; Gregory Redding, MD; Joann Hunsberger, MD; Patrick J. Cahill, MD; Harms Study Group; Paul D. Sponseller, MD, MBA

08:22 - 08:26 **Paper#48: Intra-Operative Skin Traction in Posterior Spinal Fusion for Non-Ambulatory Pediatric Scoliosis**
Grace H. Coughlin, BS; Suken A. Shah, MD; Jennifer M. Bauer, MD, MS

08:26 - 08:30 **Paper#49: Documenting the Variation of Proximal Foundation Constructs and Their Correlation with Unplanned Return to the Operating Room in Children with Magnetically Controlled Growing Rods**
Bahar Shahidi, PhD; Fernando Rios, MD; Hazem B. Elsebaie, MD, FRCS; Bailee Monjazeb, BA; William Kerr, BS; Joshua M. Pahys, MD; Steven W. Hwang, MD; Amer F. Samdani, MD; Lindsay M. Andras, MD; Matthew E. Oetgen, MD; Peter O. Newton, MD; Burt Yaszay, MD; Peter F. Sturm, MD; Michael G. Vitale, MD, MPH; Paul D. Sponseller, MD, MBA; Gregory M. Mundis Jr., MD; Behrooz A. Akbarnia, MD; Pediatric Spine Study Group; Jason Bernard, FRCS (Orth); Anna 0. Sawa, MS

**denotes Non-CME session/event*

08:30 - 08:34 **Paper#50: The Role of Enabling Technology in Growth-Friendly Spine Surgery**
Daniel Gabriel, BS; Sydney Lee, BA; Shanika De Silva, PhD, MS; Daniel J. Hedequist, MD; Craig M. Birch, MD; Brian D. Snyder, MD, PhD; M. T. Hresko, MD; Grant D. Hogue, MD

08:34 - 08:45 **Discussion**

Session 5B: Lumbar Degenerative Abstracts

MARRIOTT GRAND BALLROOM SALON 3

Moderators: Phillip Louie, MD & Jason Bernard, MD, MBBS, FRCS(Orth)

07:30 - 07:34 **Paper#51: Comparison of Unilateral Versus Bilateral Pedicle Screw Fixation (U/BPSF - TLIF) Transforaminal Lumbar Interbody Fusion in Lumbar Degenerative Disorders - An Analysis of 1098 Cases**
Vigneshwara M. Badikillaya, MD; Sharan T. Achar, MS; Sajan K. Hegde, MD

07:34 - 07:38 **Paper#52: Lumbar Disc Arthroplasty Leads to Increased Subsequent Facet Injections Compared to Anterior & Lateral Lumbar Interbody Fusions**
Nakul Narendran, BS; Paal K. Nilssen, BS; Christopher Mikhail, MD; Alexander Tuchman, MD; David L. Skaggs, MD, MMM

Paper #53: Moved to an E-Point Presentation

07:38 - 07:52 **Discussion**

07:52 - 07:56 **Paper#54: Outcomes of Minimally Invasive Decompression Alone Versus Fusion in Patients with Predominant Back Pain**
Pratyush Shahi, MBBS, MS; Tejas Subramanian, BS; Omri Maayan, BS; Nishtha Singh, BS; Sumedha Singh, MBBS, MD; Chad Simon, BS; Kasra Araghi, BS; Avani S. Vaishnav, MBBS; Tomoyuki Asada, MD; Olivia Tuma, BS; Eric Mai, BS; Yeo Eun Kim, BS; Joshua Zhang, BS; Cole Kwas, BS; Max Korsun, BS; Myles Allen, MBchB; Eric Kim, BS; James E. Dowdell, MD; Evan D. Sheha, MD; Sravisht Iyer, MD; Sheeraz Qureshi, MD; Karim A. Shafi, MD

07:56 - 08:00 **Paper#55: Hypertension and High Post-Operative Diastolic Pressure Shown to Be Significant Risk Factors in Onset of Postoperative Lumbar Epidural Hematoma**
Samuel Ezeonu, BA; Juan Rodriguez Rivera, BS; Alyssa Capasso, BS; Nicholas Vollano, MBS; Constance Maglaras, PhD; Tina Raman, MD

08:00 - 08:04 **Paper#56: Effects of Anti-Osteoporotic Therapies on Lumbar Interbody Fusion in Postmenopausal Osteoporotic Females**
Lei Kuang, MD

08:04 - 08:08 **Paper#57: Commonly Used Patient-Reported Outcome Measures (PROMS) Do Not Adequately Reflect Patient-Perceived Changes in Health Status Following Lumbar Decompression**
Avani S. Vaishnav, MBBS; Jung Mok, MD; Eric Mai, BS; Kasra Araghi, BS; Myles Allen, MBchB; Cole Kwas, BS; Tomoyuki Asada, MD; Nishtha Singh, BS; Chad Simon, BS; Yeo Eun Kim, BS; Olivia Tuma, BS; Joshua Zhang, BS; Max Korsun, BS; Eric Kim, BS; Sravisht Iyer, MD; Sheeraz Qureshi, MD; Philip K. Louie, MD

08:08 - 08:18 **Discussion**

08:18 - 08:22 **Paper #58: Review of Intraoperative Management and Outcomes of Incidental Durotomy in Minimally Invasive Spine Surgery**
Chad Simon, BS; Jung Mok, MD; Tomoyuki Asada, MD; Kasra Araghi, BS; Eric Mai, BS; Olivia Tuma, BS; Max Korsun, BS; Avani S. Vaishnav, MBBS; Yeo Eun Kim, BS; Joshua Zhang, BS; Cole Kwas, BS; Myles Allen, MBchB; Nishtha Singh, BS; Eric Kim, BS; Sheeraz Qureshi, MD; Sravisht Iyer, MD

08:22 - 08:26 **Paper#59: Vancomycin Efficacy in Reducing Surgical Site Infection in Posterior Spinal Fusion Surgery**
Aditya Joshi, BS; James Baber, MBChB, MPH; Amit Jain, MD; Khaled M. Kebaish, MD; Hamid Hassanzadeh, MD

**denotes Non-CME session/event*

08:26 - 08:30 **Paper#60: Predictors of Delayed Clinical Benefit and Deterioration in Back Pain Following Surgical Treatment for Low Grade Spondylolisthesis an Analysis from QOD**
Shawn Adams, MD; Mladen Djurasovic, MD; Steven D. Glassman, MD; Andrew K. Chan, MD; Erica F. Bisson, MD, MPH; Mohamad Bydon, MD; Kevin T. Foley, MD; Christopher I. Shaffrey, MD; Eric A. Potts, MD; Mark E. Shaffrey, MD; Domagoj Coric, MD; John J. Knightly, MD; Paul Park, MD; Michael Y. Wang, MD; Kai-Ming G. Fu, MD, PhD; Jonathan R. Slotkin, MD; Anthony L. Asher, MD; Michael S. Virk, MD, PhD; Vivian Le, MPH; Dean Chou, MD; Regis W. Haid Jr., MD; Praveen V. Mummaneni, MD, MBA; Leah Y. Carreon, MD

08:30 - 08:34 **Paper#61: Predictors of Oswestry Disability Index (ODI) Deterioration at 5 Years After Surgery for Grade 1 Spondylolisthesis: A QOD Study**
Christine Park, MD; Deb Bhowmick, MD; Christopher I. Shaffrey, MD; Erica F. Bisson, MD, MPH; Anthony L. Asher, MD; Domagoj Coric, MD; Eric A. Potts, MD; Kevin T. Foley, MD; Michael Y. Wang, MD; Kai-Ming G. Fu, MD, PhD; Michael S. Virk, MD, PhD; John J. Knightly, MD; Scott Meyer, MD; Paul Park, MD; Cheerag D. Upadhyaya, MSc; Mark E. Shaffrey, MD; Luis M. Tumialán, MD; Andrew K. Chan, MD; Dean Chou, MD; Regis W. Haid Jr., MD; Praveen V. Mummaneni, MD, MBA; Mohamad Bydon, MD; Oren Gottfried, MD

08:34 - 08:45 **Discussion**

Session 5C: Adult Spinal Deformity Abstracts

MARRIOTT GRAND BALLROOM SALON 10

Moderators: Rajiv K. Sethi, MD & Ronald A. Lehman Jr., MD

07:30 - 07:34 **Paper#62: Fused Spinopelvic Angles: Determining The Overcorrection Threshold to Prevent Proximal Junctional Kyphosis**
Jung-Hee Lee, MD, PhD; Ki Young Lee, MD, PhD; Kyung-Chung Kang, MD, PhD; Won Young Lee, MD; Seong Jin Cho, MD; Gil Han, MD; Cheol-Hyun Jung, MD; Hong-Sik Park, MD; Woo-Jae Jang, MD; Min-Jeong Park, RN

07:34 - 07:38 **Paper#63: Normalized Total Psoas Area Predicts Early Postoperative Mobility and Perioperative Complications After Complex Adult Spinal Deformity Surgery**
Takashi Hirase, MD; Myles Allen, MBchB; Chukwuebuka Achebe, BS; Hiroyuki Nakarai, MD; Han Jo Kim, MD; Francis C. Lovecchio, MD

07:38 - 07:42 **Paper#64: Forward Global Sagittal Alignment of The Cranium Relative to The Hips Drives Surgical Complexity and is Associated with a More Adverse Perioperative Course**
Christopher Lai, BS; Sarthak Mohanty, BS; Fthimnir Hassan, MPH; Caroline Taber, BS; Jaques Williams, MD; Nathan J. Lee, MD; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman Jr., MD; Lawrence G. Lenke, MD; Jennifer K. Hurry, MASc; Marco Meli, MD; Naomi Festa, MD

07:42 - 07:52 **Discussion**

07:52 - 07:56 **Paper#65: Can Patient Specific Precontoured Rod Instrumentation Reduce The Rate of Proximal Junctional Kyphosis for Adult Spinal Deformity? A Propensity Score Matched Analysis.**
Michael Fields, MD; Nathan J. Lee, MD; Mark Herbert, BS; Gabriella Greisberg, BS; Matan Malka, BA; Cole Morrissette, MS; Zeeshan M. Sardar, MD; Lawrence G. Lenke, MD; Joseph M. Lombardi, MD; Ronald A. Lehman Jr., MD

07:56 - 08:00 **Paper#66: Post-Operative Hyperextension Bracing Has The Potential to Reduce PJK: A Propensity Matched Analysis of Braced Versus Non-Braced Cohorts**
Robert K. Merrill, MD; Francis C. Lovecchio, MD; Bo Zhang, BS; John C. Clohisy, MD; Anthony Pajak, BS; Jerry Y. Du, MD; Gregory Kazarian, MD; Austin Kaidi, MSc; Rachel L. Knopp, MPH; Izzet Akosman, BS; Jonathan Elysee, MS; Justin Samuel, BS; Hiroyuki Nakarai, MD; Alex Dash, BS; Kasra Araghi, BS; Han Jo Kim, MD

08:00 - 08:04 **Paper#67: Utility of Computerized Tomography Hounsfield Unit Measurements to Predict Proximal Junctional Kyphosis in Adult Spinal Deformity Patients with Long Constructs**
Josephine R. Coury, MD; Justin Reyes, MS; Gabriella Greisberg, BS; Matan Malka, BA; Joseph M. Lombardi, MD; Lawrence G. Lenke, MD; Ronald A. Lehman Jr., MD; Zeeshan M. Sardar, MD

**denotes Non-CME session/event*

08:04 - 08:08 **Paper#68: Intraosseous Injection of Bone Morphogenetic Protein-2 at The Uppermost Instrumented Vertebra for Prevention of Proximal Junctional Kyphosis Following Long Segment Fusion in Adult Spinal Deformity: A Preliminary Report**
Jung-Hee Lee, MD, PhD; Ki Young Lee, MD, PhD; Kyung-Chung Kang, MD, PhD; Won Young Lee, MD; Seong Jin Cho, MD; Gil Han, MD; Cheol-Hyun Jung, MD; Hong-Sik Park, MD; Woo-Jae Jang, MD; Min-Jeong Park, RN

08:08 - 08:18 **Discussion**

08:18 - 08:22 **Paper#69: Does the New Lenke Modular Radiographic Classification of Adult Idiopathic Scoliosis (ADIS) Reliably Dictate Preferred Treatment?**
Christopher Mikhail, MD; Fthimnir Hassan, MPH; Andrew Platt, MD; Stephen Stephan, MD; Gerard F. Marciano, MD; Lawrence G. Lenke, MD

08:22 - 08:26 **Paper#70: Radiological Features and Postoperative Outcomes in Patients of Degenerative Lumbar Scoliosis with Pelvic Obliquity: The Application of an Novel Classification**
Junyu Li, MD; Xie Bowen, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Yan Zeng, MD; Weishi Li, MD; Bo Zhang, BS; John C. Clohisy, MD; Anthony Pajak, BS

08:26 - 08:30 **Paper#71: Detecting Perioperative Body Composition Changes in Elective Spine Surgery Through Bioimpedance Analysis**
Alex Coffman, BS; Catherine Olinger, MD; Cassim Igram, MD; Sarah Ryan, MD

08:30 - 08:34 **Paper#72: A Regularized Linear Regression Equation Predicts Cranial SVA-Hip Alignment Without Full Body Radiographs**
Sarthak Mohanty, BS; Fthimnir Hassan, MPH; Christopher Lai, BS; Christopher Mikhail, MD; Stephen Stephan, MD; Andrew Platt, MD; Joshua Bakhsheshian, MD; Zeeshan M. Sardar, MD; Joseph M. Lombardi, MD; Lawrence G. Lenke, MD

08:34 - 08:45 **Discussion**

Session 5D: Cervical Degenerative/Deformity Abstracts

MARRIOTT GRAND BALLROOM SALON 12

Moderators: David M. Sciubba, MD, MBA & Qianyu Zhuang, MD

07:30 - 07:34 **Paper#73: Novel Risk Factors and a Radiological Predictor Model for The Progression of Proximal Junctional Kyphosis in Osteoporotic Vertebral Compression Fracture with Kyphosis Following Posterior Corrective Surgery**
Junyu Li, MD; Yinghong Ma, MD; Junjie Ma, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; Yan Zeng, MD

07:34 - 07:38 **Paper#74: Guttering Osteotomy for Removal of Retro-Corporeal Compressive Pathology During Anterior Cervical Discectomy and Fusion**
Dong-Ho Lee, MD, PhD; Chang Ju Hwang, MD, PhD; Jae Hwan Cho, MD, PhD; Sehan Park, MD

07:38 - 07:42 **Paper#75: Intraoperative C2 Slope Thresholds for Optimal Functional & Clinical Outcomes in Cervical Deformity Correction**
Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Ankita Das, BS; Stephane Owusu-Sarpong, MD; Matthew Galetta, MD; Nathan Lorentz, MD; Oluwatobi O. Onafowokan, MBBS, MS; Justin S. Smith, MD, PhD; M. Burhan Janjua, MD; Bassel G. Diebo, MD; Peter G. Passias, MD; Paul Park, MD; Rohan Desai, MD; Renaud Lafage, MS; Virginie Lafage, PhD

07:42 - 07:52 **Discussion**

07:52 - 07:56 **Paper#76: Range of Horizontal Gaze Following Multilevel Posterior Cervical Fusion Across the Cervicothoracic Junction**
Clayton Hoffman, BS; Michael Nocek, BA; Zohaib Sherwani, MD; Vikas V. Patel, MD; Shahbaaz Sabri, MD; David C. Ou-Yang, MD; Christopher J. Kleck, MD

07:56 - 08:00 **Paper#77: Utility of Pre-Flip Intraoperative Neurophysiologic Monitoring Baselines for Posterior Decompression and Fusion for Cervical Spondylotic Myelopathy**
Nora Kim, MD; Zoran Budimlija, PhD; Karl Sangwon, BS; Austin Feng, MD; Themistocles S. Protopsaltis, MD; Darryl Lau, MD

**denotes Non-CME session/event*

08:00 - 08:04 **Paper#78: Impact of Enhanced Recovery After Surgery (ERAS) Program on Post-Operative Course in Adult Cervical Deformity Patients**
Peter Tretiakov, BS; Ankita Das, BS; Jamshaid Mir, MD; Matthew Galetta, MD; Nathan Lorentz, MD; Oluwatobi O. Onafowokan, MBBS, MS; Pooja Dave, BS; Stephane Owusu-Sarpong, MD; Rohan Desai, MD; Djani Robertson, MD; Jared C. Tishelman, MD; Bassel G. Diebo, MD; Peter G. Passias, MD; Pawel Jankowski, MD

08:04 - 08:08 **Paper#79: Incorporation of Frailty Based Realignment Target Goals for Cervical Deformity Surgery in Adults Can Mitigate Mechanical Complications and Improve Perioperative Course**
Jamshaid Mir, MD; Pooja Dave, BS; Peter Tretiakov, BS; Oluwatobi O. Onafowokan, MBBS, MS; Ankita Das, BS; Nathan Lorentz, MD; Matthew Galetta, MD; Stephane Owusu-Sarpong, MD; Tyler K. Williamson, MS, BS; Peter G. Passias, MD

08:08 - 08:18 **Discussion**

08:18 - 08:22 **Paper#80: Microbiome Study of Cervical Disc Using Next Generation Sequencing**
Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Piyush Joshi, MS (Orthopaedics)

08:22 - 08:26 **Paper#81: The Clinical Impact on Range of Motion for Occipito- and Sub-Axial Cervical Fusion: A Comprehensive Guide Based on over 1000 Motion Segments**
S. Harrison Farber, MD; Anna 0. Sawa, MS; Joseph DiDomenico, MD; Luke Mugge, MD; Alexis Ratliff, MS; Temesgen Assefa, MD; Juan S. Uribe, MD; Jay D. Turner, MD; Brian P. Kelly, PhD

08:26 - 08:30 **Paper#82: Decreased Hounsfield Unit Measurements Are Associated with Cervical Corpectomy Subsidence More than Other Measures of Bone Mineral Density**
Steven J. Girdler, MD; Hannah Levy, MD; James Bernatz, MD; Caden Messer, BS; Andrew Pumford, BS; Matt Lindsey, MD; Brian Goh, MD; Anthony L. Mikula, MD; Mohammed Karim, MD; Peter S. Rose, MD; Bradford L. Currier, MD; Arjun Sebastian, MD; Brett A. Freedman, MD; Ahmad Nassr, MD

08:30 - 08:34 **Paper#83: Factors Associated with Postoperative Kyphosis and Loss of Range of Motion After Cervical Disc Replacement**
Abel De Varona Cocero, BS; Stephane Owusu-Sarpong, MD; Fares Ani, MD; Camryn Myers, BA; Constance Maglaras, PhD; Themistocles S. Protopsaltis, MD

08:34 - 08:45 **Discussion**

08:45 - 09:00

Refreshment Break & Exhibit Viewing*
MARRIOTT GRAND BALLROOM FOYER

09:00 - 11:00

Session 6: Biomechanics and Complex Spine Abstracts and Keynote Speaker
MARRIOTT GRAND BALLROOM SALONS 5-9

Moderators: Kristen E. Jones, MD, FAANS & Meric Enercan, MD

09:00 - 09:04 **Paper#85: Can Non-Operative Treatment with Brace and Scoliosis Specific Exercises Be Effective for Severe Scoliotic Curves Exceeding 40o at Peak of Growth?**
Nikos Karavidas, Physiotherapist

09:04 - 09:08 **Paper#84: Spinal Surgery in Achondroplasia: Causes of Re-Operation and Reduction of Risks**
Arun R. Hariharan, MD, MS; Hans K. Nugraha, MD; Aaron J. Huser, DO; David S. Feldman, MD

09:08 - 09:12 **Paper#90: A Novel External Hinge Correction System for Vertebral Column Resection of Severe Angular Kyphosis**
Hong Zhang, MD; David Ross, MFA; Daniel J. Sucato, MD, MS

09:12 - 09:16 **Paper#91: Y Shaped Osteotomy in The Apical Vertebra for Treating Congenital Complex Rigid Scoliosis: at Least 2 Year Follow Up**
Xuhong Xue, MD, PhD; Sheng Zhao, MD

09:16 - 09:25 **Discussion**

**denotes Non-CME session/event*

09:25 - 09:29 **Paper#86: New Artificial Intelligence (AI) Driven Surface Topography Phone Application Help Screen Spinal Deformity Patients: Early Results from One Institution**
Marjolaine Roy-Beaudry, MSc; Marie Beausejour, PhD; Justin Dufresne; Rachelle Imbeault; Stefan Parent, MD, PhD

09:29 - 09:33 **Paper#87: Comparison of Disc Height Restoration and Subsidence Rates Between Static Versus Expandable Titanium Interbodies for Lateral Lumbar Interbody Fusion**
Kimberly Ashayeri, MD; Sean N. Neifert, MD; Darryl Lau, MD

09:33 - 09:37 **Paper#88: Biomechanics of Cage Subsidence**
Anna-Katharina Calek, MD; Frederic Cornaz, MD; Mauro Suter; Marie-Rosa Fasser, MSc; Mazda Farshad, MD, MPH; Jonas Widmer, MSc

09:37 - 09:41 **Paper#89: The in vivo Immune Response of Peek Spinal Interbody Device Materials with and without Supplemental P-15 Peptides as a Osteobiologic Bone Graft Material**
Isaac Swink, MS; Patrick Schimoler, PhD; Daniel Altman, MD; Praveer Vyas, BS, MPH; Boyle Cheng, PhD

09:41 - 09:50 **Discussion**

09:50 - 09:54 **Paper#92: Gradual Anterior Column Lengthening at The Level of PVCR Provides Both Regional and Global Ideal Sagittal Alignment and Prevents Iatrogenic Neurological Deficit**
Hamisi M. Mraja, MD; Baris Peker, MD; Halil Gok, MD; Cem Sever, MD; Tunay Sanli, MA; Selhan Karadereler, MD; Meric Enercan, MD; Azmi Hamzaoglu, MD

09:54 - 09:58 **Paper#93: De-Novo Neurological Deficits Relative to Intraoperative Neuromonitoring (LOMN) Alerts and Surgical Events in Complex, Cord-Level Spinal Deformity Corrections: A Prospective International Study from the AO Spine Knowledge Forum Deformity**
Alekos A. Theologis, MD; Kenny Y. Kwan, MD; Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Zeeshan M. Sardar, MD; Justin S. Smith, MD, PhD; Ferran Pellisé, MD, PhD; So Kato, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Kristen E. Jones, MD, FAANS; Anastasios Charalampidis, MD; Brett Rocos, FRCS; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCS(C); AOSpine Knowledge Forum Deformity

09:58 - 10:02 **Paper#94: Intraoperative Surgical Events and Neuromonitoring (Ionm) Alerts in Relation to Post-Operative Neurological Deficits in Complex, Non-Cord-Level Spinal Deformity Corrections: Results from a Multi-Center Prospective Spinal Deformity Intraoperative Monitoring (Sdim) Study**
Zeeshan M. Sardar, MD; Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Alekos A. Theologis, MD; Kenny Y. Kwan, MD; Justin S. Smith, MD, PhD; Ferran Pellisé, MD, PhD; So Kato, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Kristen E. Jones, MD, FAANS; Anastasios Charalampidis, MD; Brett Rocos, FRCS; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCS(C); AOSpine Knowledge Forum Deformity

10:02 - 10:10 **Discussion**

10:10 - 10:15 **Introduction of Keynote**
Marinus de Kleuver, MD, PhD

10:15 - 11:00 **Keynote Address: Senescense and Aging**
Alessandra Sacco, PhD

11:00 - 11:30

Lunch Pick-Up & Exhibit Viewing*
MARRIOTT GRAND BALLROOM FOYER

11:30 - 12:30

Industry Workshops*
MARRIOTT GRAND BALLROOMS SALONS 1, 3, 10 & 12

IMAST delegates are encouraged to attend the Hands-On Workshops (HOWs). Each workshop is programmed by a single- supporting company and will feature presentations on topics and technologies selected by the company. Catering will be served at each Workshop. *Please note: CME credits are not available for Hands-On Workshops.*

For the full schedule, please refer to page 139.

**denotes Non-CME session/event*

12:30 - 12:45

Break & Exhibit Viewing*
MARRIOTT GRAND BALLROOM FOYER

12:45 - 14:15

Session 7A: Anterior Surgery: The Current State of the Art
MARRIOTT GRAND BALLROOM SALONS 5-9

Moderators: Jwalant S. Mehta, MD, FRCS (Orth), MCh (Orth), MS (Orth), D Orth, & Stefan Parent, MD, PhD

12:45 - 12:47 **Introduction**
Jwalant S. Mehta, MD, FRCS (Orth), MCh (Orth), MS (Orth), D Orth

12:47 - 12:59 **The Open Thoracotomy: The Procedure and the Post-Operative Course**
Alexander Gibson, BSc, MBBS, FRCS

12:59 - 13:11 **The Thoracoscopic Procedure: Is It Really Better than Open**
Amer F. Samdani, MD

13:11 - 13:23 **Instrumentation of the Anterior Column: Procedure, Implants, Problems, Mitigation Strategies, and Level Selection**
Michael Ruf, MD

13:23 - 13:29 **Discussion**
Stefan Parent, MD, PhD

13:29 - 13:41 **Medium and Long-Term Effects of Anterior Surgery: Respiratory and Functional**
Peter O. Newton, MD

13:41 - 13:53 **A Review of Complications and the Learning Curve of the Anterior Approach**
Jason Bernard, MD, MBBS, FRCS (Orth)

13:53 - 14:05 **Revisional Anterior Surgery: Is It a Big Deal?**
Thomas Terramani, MD

14:05 - 14:15 **Discussion and Wrap-Up**
Jwalant S. Mehta, MD, FRCS (Orth), MCh (Orth), MS (Orth), D Orth

Session 7B: Surgical Treatment of Osteoporotic Vertebral Fracture-Induced Spinal Deformity
SAN DIEGO BALLROOM B&C

Moderators: Eric O. Klineberg, MD, & Kota Watanabe, MD, PhD

12:45 - 12:55 **Perioperative Pharmacological Treatment for Osteoporotic Spinal Deformity Including Japan**
Mitsuru Yagi, MD, PhD

12:55 - 13:05 **Surgical Options for Treatment for Osteoporotic Spinal Deformity Including the United States**
Rajiv K. Sethi, MD

13:05 - 13:10 **Discussion**

13:10 - 13:15 **Situation of Treatment for Osteoporotic Spinal Deformity in South America**
Denis Sakai, MD

13:15 - 13:20 **Situation of Treatment for Osteoporotic Spinal Deformity in Europe**
Per D. Trobisch, MD

13:20 - 13:25 **Situation of Treatment for Osteoporotic Spinal Deformity in Asia (Especially in China)**
Qianyu Zhuang, MD

13:25 - 13:30 **Discussion**

13:30 - 14:15 **Case Discussion**
Denis Sakai, MD, Per D. Trobisch, MD, & Qianyu Zhuang, MD

14:15 - 14:30

Refreshment Break & Exhibit Viewing*
MARRIOTT GRAND BALLROOM FOYER

**denotes Non-CME session/event*

14:30 - 16:05

Session 8: Transition of Care for Patients with Spinal Deformities

MARRIOTT GRAND BALLROOM SALONS 5-9

Moderator: Stefan Parent, MD, PhD, & Lindsay M. Andras, MD

14:30 - 14:35 **Presentation of the Whitecloud Award Winning Papers and the IMAST Innovation Award**
Eric O. Klineberg, MD, & Per D. Trobisch, MD

14:35 - 14:40 **Introduction**
Stefan Parent, MD, PhD

14:40 - 14:47 **Transition of Care in EOS: When and How Should You Perform Final Surgery for Previously Treated EOS Patients**
Jwalant S. Mehta, MD, FRCS (Orth), MCh (Orth), MS (Orth), D Orth

14:47 - 14:52 **Discussion**

14:52 - 14:59 **The Mature AIS Patient with Moderate Scoliosis: Is There a Role for Scoliosis Specific Exercises?**
Michael G. Vitale, MD, MPH

14:59 - 15:04 **Discussion**

15:04 - 15:11 **Who Should Be Followed as a Young Adult? Are There Patients that Could Benefit from Long-Term Follow-Up During Adulthood?**
Jesse Shen, MD, PhD

15:11 - 15:16 **Discussion**

15:16 - 15:23 **Timing of Surgery for Moderate AIS: Should You Operate Early or Wait Later in Life?**
Baron S. Lonner, MD

15:23 - 15:28 **Discussion**

15:28 - 15:35 **The Buck Stops Here! The Difficult Decision Associated with Patients with Previous Spinal Deformity Surgery. Should Every Case Be Treated Surgically?**
Lawrence G. Lenke, MD

15:35 - 15:40 **Discussion**

15:40 - 16:00 **Case Presentation**
Stefan Parent, MD, PhD, Lindsay M. Andras, MD, Jesse Shen, MD, PhD, Baron S. Lonner, MD, & Lawrence G. Lenke, MD

16:00 - 16:05 **Conclusion**
Stefan Parent, MD, PhD

16:15 - 18:00

Innovation Celebration*

SOUTH PATIO POOL

A reception offering food & beverages to celebrate the conclusion of sessions. Open to all registered delegates and guests of registered delegates. Tickets are $25 USD for registered delegates and $50 USD for guests of registered delegates and must be purchased in advance. If you would like to add the Innovation Celebration and/or purchase guest ticket(s), please visit the IMAST Registration Desk.

Saturday, April 13, 2024: INNOVATION DAY*

Innovation Day is an opportunity for SRS stakeholders to meet with their key opinion leaders and IMAST attendees. This day is to be used for study group meetings, industry educational events, industry education events, etc. More information can be found on the IMAST website.

**denotes Non-CME session/event*

Podium Presentation Abstracts

1. Rigid Thoracolumbar Orthosis Does Not Improve Outcomes of Acute Adolescent Spondylolysis as Compared with Placebo. Bony Union Predicts Improved Health-Related Quality of Life Outcomes at 2-Year Follow-Up

Ella Virkki, MD, PhD; Olli T. Pajulo, MD, PhD; Milja Holstila, MD, PhD; Terhi Kolari, MSc; *Ilkka J. Helenius, MD, PhD*

Hypothesis

A rigid thoracolumbar orthosis does not add likelihood of achieving bony union of spondylolysis when compared with an elastic lumbar support (placebo) treatment. Non-union of spondylolysis predicts back pain during two-year follow-up time.

Design

A prospective, comparative study in adolescents with acute spondylolysis treated with a rigid thoracolumbar orthosis or a placebo with two years follow-up time.

Introduction

Spondylolysis is the most common cause of low back pain in young athletes. There is paucity of studies of optimal treatment of acute adolescent spondylolysis and their health-related quality of life (HRQoL) outcomes.

Methods

A total of sixty patients were prospectively enrolled. First 14 patients were randomized and the remaining 46 chose treatment method themselves. Treatment time was four months and follow-up time was two years. Bony union of spondylolysis was evaluated with a CT at 4 months. HRQoL was measured using a Scoliosis Research Society-24 (SRS-24) outcome questionnaire filled before treatment and at 4 months, 12 months and 24 months follow-up visits.

Results

Out of 60 patients, 57 were included to analysis. Thirty (30/57) patients were treated with a Boston brace and twenty-seven (27/57) patients with a placebo. The bony union rate of spondylolysis did not differ between study groups (20/30 vs 17/27, respectively, p=0.789). Five patients (5/47) developed low grade spondylolisthesis during two-year follow-up time. None of these patients needed operative intervention for spondylolisthesis. The HRQoL was similar in both treatment groups in all domains of the SRS-24 through follow-up time (p>0.05 for all). Two years after treatment patients who had bony union of the spondylolysis had higher total SRS-24 score (p=0.029) and higher satisfaction domain score (p=0.0003) compared to patients with non-union of the spondylolysis, while other domains did not differ (p>0.05 for all).

Conclusion

Achieving bony union of adolescent spondylolysis is desirable as their HRQoL is higher two years after treatment. A brace is not needed for treatment, as bony union rate with a placebo treatment and 4 months sport restriction was not different. There is a risk of developing spondylolisthesis if bony union of spondylolysis is not achieved.

SRS domain	Bony union (n=31) Mean (95% CI)	Non-union (n=17) Mean (95% CI)	Mean difference (95% CI)	p value
Total				**0.003***
• Baseline	3.71 (3.60, 3.83)	3.93 (3.77, 4.10)	0.22 (0.02, 0.42)	**0.033**
• 4 months	3.77 (3.65, 3.88)	3.79 (3.64, 3.94)	0.03 (-0.16, 0.22)	0.791
• 12 months	4.17 (4.06, 4.28)	4.10 (3.95, 4.26)	-0.07 (0.26, 0.13)	0.50
• 24 months	4.26 (4.15, 4.38)	4.05 (3.89, 4.21)	-0.21 (-0.41, -0.02)	**0.031**
Pain				0.331*
• Baseline	3.43 (3.25. 3.62)	3.59 (3.33. 3.84)	0.15 (-0.16, 0.46)	0.3395
• 4 months	4.36 (4.19. 4.54)	4.40 (4.16. 4.63)	0.03 (-0.26, 0.33)	0.8160
• 12 months	4.64 (4.46. 4.68)	4.52 (4.28. 4.76)	-0.12 (-0.41, 0.18)	0.4430
• 24 months	4.69 (4.51. 4.86)	4.53 (4.28. 4.77)	-0.16 (-0.46, 0.15)	0.3046
Self-image				0.148*
• Baseline	4.28 (4.07. 4.48)	4.65 (4.37. 4.93)	0.38 (0.03, 0.72)	0.0324
• 4 months	4.21 (4.01. 4.40)	4.50 (4.23. 4.77)	0.29 (-0.04, 0.63)	0.0816
• 12 months	4.37 (4.17. 4.56)	4.57 (4.30. 4.84)	0.20 (-0.13, 0.54)	0.2310
• 24 months	4.44 (4.24. 4.64)	4.46 (4.18. 4.73)	0.02 (-0.32 0.36)	0.9224
Function				0.326*
• Baseline	3.64 (3.49. 3.80)	3.83 (3.61. 4.05)	0.19 (-0.08, 0.46)	0.1732
• 4 months	3.84 (3.67. 3.99)	3.95 (3.75. 4.15)	0.11 (-0.14, 0.36)	0.3794
• 12 months	4.32 (4.18. 4.47)	4.27 (4.07. 4.48)	-0.05 (-0.31, 0.20)	0.6832
• 24 months	4.29 (4.14. 4.45)	4.19 (3.97. 4.40)	-0.11 (-0.37, 0.15)	0.4147
Activity				0.594*
• Baseline	3.89 (3.69. 4.10)	3.96 (3.67. 4.24)	0.07 (-0.28, 0.42)	0.7128
• 4 months	4.41 (4.22. 4.60)	4.21 (3.95. 4.47)	-0.20 (-0.52, 0.13)	0.2277
• 12 months	4.88 (4.68. 5.07)	4.91 (4.64. 5.17)	0.03 (-0.30, 0.36	0.8511
• 24 months	4.99 (4.79. 5.19)	4.82 (4.55. 5.10)	-0.17 (-0.51, 0.17)	0.3295
Posttreatment self-image				0.415*
• 4 months	2.86 (2.74. 2.97)	2.95 (2.79. 3.10)	0.09 (-0.10, 0.28)	0.3440
• 12 months	3.05 (2.94. 3.16)	3.07 (2.91. 3.23)	0.02 (-0.18, 0.21)	0.8538
• 24 months	3.02 (2.91. 3.14)	2.95 (2.79. 3.11)	-0.08 (-0.27, 0.12)	0.4520
Posttreatment function				0.312*
• 4 months	1.28 (1.00. 1.57)	1.26 (0.88. 1.65)	-0.02 (-0.50, 0.46)	0.9363
• 12 months	2.71 (2.42. 2.99)	2.83 (2.43. 3.22)	0.12 (-0.37, 0.61)	0.6230
• 24 months	3.10 (2.80. 3.39)	2.70 (2.30. 3.11)	-0.40 (-0.90, 0.11)	0.1225
Satisfaction				**0.047***
• 4 months	3.80 (3.63. 3.97)	3.65 (3.42. 3.88)	-0.15(-0.44. 0.14)	0.297
• 12 months	4.05 (3.88. 4.23)	3.68 (3.44. 3.92)	-0.37(-0.67. -0.08)	**0.013**
• 24 months	4.27 (4.09. 4.44)	3.70 (3.45. 3.94)	-0.57(-0.87. -0.27)	**0.0003**

Values are given as estimated means and 95% CI
Hierarchical linear mixed model with repeated
*p-value for statistically significant change at any time point

SRS-24 outcomes bony union group compared to non-union group

2. Core Muscle Strengths, Lumbar Flexibility and Quality of Life in Lenke Type 5 AIS Patients Treated with Either Cobb to Cobb VBT Versus Fusion Compared with Healthy Individuals.

Celaleddin Bildik, MD; Selen Saygili; Selmin Arsoy; Hamisi M. Mraja, MD; Baris Peker, MD; Halil Gok, MD; Tunay Sanli, MA; Selhan Karadereler, MD; *Meric Enercan, MD*; Azmi Hamzaoglu, MD

Hypothesis

VBT preserves posterior lumbar muscle structure integrity and therefore yields better lumbar core muscle strengths (LCMS), lumbar flexibility, and improved patient outcomes compared with Cobb to Cobb posterior fusion in surgical treatment of Lenke Type 5 curves.

Design

Prospective study with control group

Introduction

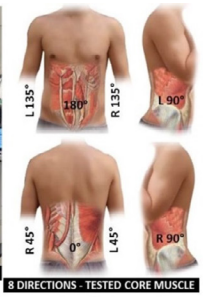
Cobb to Cobb posterior fusion is accepted as standard treatment for Lenke 5 curves. Recently VBT gained popularity as a non-fusion surgical alternative for

these curves. Unfortunately there are no available objective data showing the superiority of VBT over post fusion. Aim of this study was to assess lumbar core muscle strengths; flexibility and quality of life measures in Lenke 5 AIS pts treated with either VBT or post fusion between Cobb levels, and compare these results with healthy individuals.

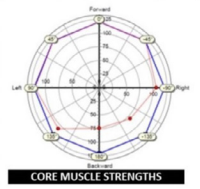
Methods
16 pts treated with VBT technique (VBT-Grp) and 26 pts treated with fusion (F-Grp) were included. Control group (C-Grp) included age and gender-matched 30 healthy individuals. LCMS were evaluated with endurance test using computer assisted 3D spatial rotation device (SRD). Schober test and lumbar ROM measurements were done by two experienced physical therapists. SRS22r scores were used for clinical assessment.

Results
Mean f/up was 4,2 yrs in VBT-Grp and 9,9 yrs in F-Grp. According to Schober test, lumbar flexibility of VBT-Grp was significantly higher than F-Grp (p<0,05;U=25), but lower than C-Grp(p>0,05). In terms of lumbar ROM assessment including forward bending, lateral bending and rotation towards both sides, VBT-Grp and C-Grp showed similar ROM values whereas F-Grp showed significant limitation (p<0.05). Posterior LCMS were similar in VBT-Grp and C-Grp (p>0,05), but significantly lower in F-Grp (p<0,05;U=20). SRS22r function were significantly higher in VBT-Grp and C-Grp than F-Grp (p<0,05;U=8,0). Total SRS22r scores did not show any difference between groups.

Conclusion
Cobb to Cobb VBT technique which preserves the posterior muscle structures showed similar lumbar core muscle strengths and lumbar ROM values with healthy individuals. Although the lumbar flexibility of the VBT group was significantly higher than the fusion group, it was lower than the control group. SRS22r function in the VBT group was higher than the fusion group, but there was no difference in total SRS22r scores between all groups.



Mean (min-max)		VBT Group	Fusion Group	Control Group
#		16 (10F, 6M)	26 (20F, 6M)	30 (24F, 6M)
Age at Follow-up (year)		19,2 (15-23)	24,2 (19-29)	23,7 (19-29)
Follow-up time (year)		4,2 (2-6)	9,9 (2-14)	-
Schober Test (cm)		4,73 (3,6 – 5,5)	3,45 (2,8 – 4,4)	6,13 (4,5 – 9)
Endurance Test Results Momentum (Nm) (%)	Momentum_0°	98,9	95,1	100,0
	Momentum_180°	90,6	88,7	98,1
	Momentum_LEFT 45°	98,7	95,7	100,0
	Momentum_RIGHT 45°	98,4	97,5	100,0
	Momentum_LEFT 90°	97,5	95,4	99,7
	Momentum_RIGHT 90°	97,8	95,4	99,4
	Momentum_LEFT 135°	88,6	82,8	97,5
	Momentum_RIGHT 135°	85,0	90,5	98,7
SRS22r_Function		4,72 (4,2 – 5,0)	4,38 (4,0 – 5,0)	4,89 (4,2 – 5,0)
SRS22r_Total		4,37 (3,7 – 4,7)	4,25 (3,45 – 4,9)	4,31 (3,45 – 4,95)



3. Liv Selection in 'Tweener' Patients Treated with MCGR Vs. PSF

Michael J. Heffernan, MD; Claudia Leonardi, PhD; Brandon Yoshida, MD; Lindsay M. Andras, MD; Tyler Tetreault, MD; Pediatric Spine Study Group; G.Ying Li, MD

Hypothesis
We hypothesized that surgical strategy would inform LIV selection with the LIV being more caudal in MCGR when compared to PSF.

Design
Retrospective, Multicenter

Introduction
Selection of the lowest instrumented vertebrae (LIV) is a foundational principle guiding the management of spinal deformity. Equipoise exists regarding the surgical strategy for 'tweener' patients where both magnetically controlled growing rods (MCGR) and posterior spinal fusion (PSF) are employed. There are no studies comparing the LIV for patients treated with MCGR vs PSF. The purpose of this study was to compare the LIV selection in 'tweener' patients treated with MCGR or PSF.

Methods
A multicenter pediatric spine database was queried for ambulatory patients ages 8-11 years treated by MCGR or posterior spinal fusion with at least 2-year follow up. The relationship between the LIV and preoperative spinal height, curve magnitude, and implant type were assessed. The relationship between the last substantially touched vertebrae (LSTV), the stable vertebrae (SV), and the LIV were also evaluated.

Results
One hundred and fifty-nine patients met inclusion criteria including 82 MCGR and 77 PSF patients. Preoperative curve magnitude was similar between groups (MCGR 68±19.0° vs PSF 66±17.2°, p=0.6), but age (MCGR 9.0±1.0 vs. PSF 10.2±0.8, p<0.0001) and T1-T12 spinal height (MCGR 194.5±29.8mm vs. PSF 206.4±31.7mm, p=0.041) were different. Neither age (p=0.07) or height (p=0.27) was associated with LIV selection. In contrast, curve magnitude was associated with LIV as larger curves were associated with a more caudal LIV (p=0.004). Distribution of the LIV was more varied in PSF compared to MCGR (Figure 1, p=0.05). L3 was the LIV in 43% of MCGR patients compared to 27% of PSF patients and 29% of PSF patients had an LIV of L1 or above compared to 17% of MCGR patients. The LIV was cephalad to the SV in 68% of PSF compared to 48% of MCGR patients (p=0.02).

Conclusion
The majority of LIV selection in 'tweener' patients was at L3 or below regardless of surgical strategy, likely driven by curve magnitude. However, 'tweener' patients treated with PSF had more cephalad LIV

selections compared to patients treated with MCGR. Potential LIV differences should be considered when selecting MCGR vs. PSF in 'tweener' patients.

Figure 1: Percentage of patients (bubble width) with Lowest instrumented vertebrae (LIV) on listed vertebra by surgery type [Fusion vs. Magnetically Controlled Growing Rods (MCGR)].

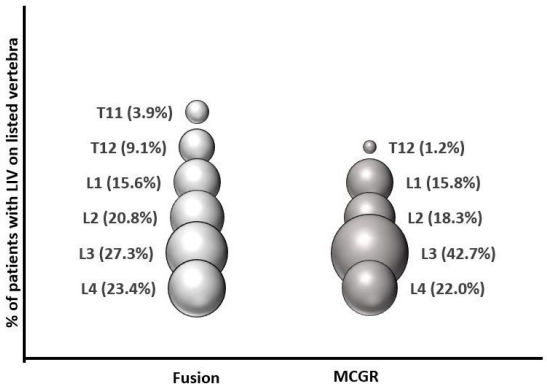


Figure 1: Percentage of patients with Lowest Instrumented Vertebrae (LIV) on listed vertebra by surgery type [Fusion vs. Magnetically Controlled Growing Rods (MCGR)]

4. The Hidden Consequences of Advanced Operative Spine Imaging in Children: Increased Lifetime Oncological Risk in Adolescent Idiopathic Scoliosis Patients Treated with Posterior Spinal Fusion Using Intraoperative Computed Tomography & Navigation

Bram Verhofste, MD; Brendan Striano, MD; Alexander Crawford, MD; Andrew Hresko, MD; Andrew Schoenfeld, MD; Andrew Simpson, MD, MBA; *Daniel J. Hedequist, MD*

Hypothesis

The goal was to compare the lifetime cancer risk of intraoperative computed tomography (iCT) with navigation in posterior spinal fusion (PSF) for adolescent idiopathic scoliosis (AIS) to traditional imaging techniques (non-iCT). We hypothesized that AIS patients undergoing PSF with iCT navigation would have increased risk of neoplastic transformation compared to non-iCT modalities.

Design

Retrospective cohort

Introduction

AIS develops in 1-3% adolescents, with trends signaling increased surgical rates. Advances in iCT, iCT-nav, and robotics suggest benefits in safety of instrumentation. However, these imaging modalities utilize ionization with increased radiation exposure. Radiation further accumulates via surveillance x-rays and is especially relevant in the vulnerable immature AIS population. Little data exists on the true oncological risks of iCT navigation PSF in AIS patients.

Methods

A retrospective AIS cohort (0-18y) treated with PSF at a quaternary pediatric center (2014-19) was reviewed. Demographic, surgical, deformity, and radiation variables were compared between groups (iCT vs traditional non-iCT PSF). Cumulative radiation was calculated as total effective dose (millisieverts, mSv) based on established algorithms. A pediatric low-dose iCT protocol was used.

Results

245 patients (mean 14.4y; 83% female) were included. 119 iCT cases (49%) were compared to 126 non-iCT (51%). Median radiation with fluoroscopy, radiography, and navigation (iCT) was 0.05, 4.14, and 8.19mSv, respectively. After accounting for clinical/radiographic differences, AIS patients treated with iCT-nav PSF received 8.18mSv more radiation than traditional non-iCT techniques (95%CI 7.22-9.15, p<0.001), theoretically resulting in 0.9 iatrogenic malignancies/1000 patients (95%CI 0.79-1.01).

Conclusion

Radiation is a well-established cancer risk factor. An estimated 1/1000 adolescents will develop cancer due to the radiation from iCT compared to traditional non-iCT modalities. There are benefits of iCT in PSF, but further research is necessary to analyze the long-term population risks of iatrogenic imaging-induced malignancies. Biomedical industries must focus on development of non-ionizing imaging modalities in this vulnerable pediatric population.

Table 1. Selected Cohort Characteristics and Results

Patient Demographics & Surgical Characteristics				
	iCT Navigated PSF	Traditional Non-iCT PSF	Entire Cohort	*P* Value*
Total patients (*N; %*)	N=119 (47.8%)	N=126 (51.4%)	N=245 (100%)	
Mean age ± SD (*y; years*)	14.6y ± 2.0	14.2y ± 1.9	14.4y ± 2.0	**0.03**
Number females (*N; %*)	N=105 (88%)	N=98 (78%)	N=203 (83%)	**0.03**
Mean BMI ± SD (*kg/m²*)	22.3 kg/m² ± 5.4	22.8 kg/m² ± 5.3	22.5 kg/m² ± 5.3	0.48
Coronal curve deformity (Cobb °; degrees)	56° ± 9.8	57° ± 7.6	56° ± 8.7	0.20
Median levels fused (*IQR*)	10 levels (8-11)	8 levels (7-10)	9 levels (8-11)	**<0.01**
Radiation Exposure Based on Method of Perioperative Imaging: Comparison of iCT with Navigation vs Traditional Non-iCT Imaging Modalities				
	Total patients *(N; %)*	**Median effective dose** *(mSv; IQR)*	**Median Lifetime Cancer Risk** *(N / 1,000 patients; IQR)*	
Non-iCT				
Fluoroscopy	N=104 (42.5%)	0.05 (0.03-0.07)	0.01 (0.00-0.01)	
Fluoroscopy + Flat Plate Radiographs	N=22 (9%)	4.14 (0.23-4.4)	0.46 (0.03-0.48)	
iCT				**<0.001**
Navigation	N=119 (48.6%)	8.19 (5.36-11.7)	0.90 (0.59-1.29)	
Intraoperative CT + Navigation Sub-analysis: Cumulative Effective Radiation and Lifetime Cancer Risk				
	Total patients *(N; %)*	**Median effective dose** *(mSv; IQR)*	**Median Lifetime Cancer Risk** *(N / 1,000 patients; IQR)*	
Total iCT acquisitions	N=119 (100%)	n/a	n/a	
0	N=126 (51.4%)	0.05 mSv (0.03-0.10)	0.001 / 100 (0.00-0.01)	
1	N=55 (22.5%)	5.33 mSv (3.98-6.69)	0.59 / 1000 (0.4-0.74)	
2	N=61 (24.9%)	10.6 mSv (8.43-13.14)	1.17 / 1000 (0.92-1.45)	
3	N=3 (1.2%)	21.57 mSv (13.38-29.72)	2.37 / 1000 (1.47-3.27)	**<0.001**

Image 1

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5. Anterior Scoliosis Correction for The Treatment of Patients with Early Onset Scoliosis

M. Darryl Antonacci, MD; Janet L. Cerrone, PA-C; Laury A. Cuddihy, MD; *Randal R. Betz, MD*

Hypothesis

Anterior Scoliosis Correction may be an option (besides traditional growing rod systems) for very young patients with severe curves.

Design

Retrospective

Introduction

Anterior Scoliosis Correction (ASC) is the advanced modification of vertebral body tethering (VBT) to a double screw-line technique with multilevel releases of the contracted anterior annular disc complex. We report the results of non-fusion ASC in a cohort of patients with early onset scoliosis (EOS) and a minimum 2-year follow-up.

Methods

Inclusion criteria: Patients with EOS, age < 10 years, Sanders ≤ 2, Risser 0, open triradiate cartilages, minimum 2-year follow-up. From a database of 840 patients with ASC, 13 patients (15 curves) met the criteria for analysis. Average follow-up was 46.5 months (range 24 to 77 months). Levels instrumented averaged 9 (range 8 to 13). The cohort included 9 curves with single screw-line cord constructs and 6 with double screw-line cord constructs. 12/13 patients had an average of 2.8 disc releases.

Results

Age at surgery averaged 8 years (range 5.7 to 9.9). The average pre-op curve was 83° (range 58 to 100°) with flexibility averaging 53%. The first erect instrumented post-op curve averaged 27° (range 14 to 46°) with an average 66% correction. The most recent post-op curve averaged 31° (range -10 to 68°) with an average 64% correction (Table 1). Pre-op 3-D calculated kyphosis averaged -7° (range -23 to 20°) which corrected to 29° (-1 to 55°) at most recent follow-up. A second procedure was done in 9/13 patients at an average of 42.6 months (range 23 to 77 months) following the index procedure. 7/13 (54%) had planned return to the operating room; 2/7 had an ASC lengthening procedure for overcorrection and 5/7 had ASC for broken cords with loss of correction. 2 patients (15%) had unplanned return to the operating room and needed fusion. The patients with revision surgery (n=9) had an average of 2.2 disc releases at the index procedure. Those without revision surgery (n=4) had an average 4.0 disc releases per patient.

Conclusion

The results of non-fusion Anterior Scoliosis Correction in a cohort of 13 patients with EOS and an average curve of 83° showed an average correction of 64% (average 46 months' follow-up). While some patients did end up having posterior spinal fusion, not all did, suggesting that there may be an alternative to traditional posterior growing rods for these very young patients with severe curves.

Table 1: Data Summary: 13 Patients (15 Curves) with Early Onset Scoliosis

	Patients/%	Average (Range)	
Mean age at surgery (years)		8.0 (5.7 to 9.9)	
Mean follow-up (months)		46.5 (24 to 77)	
Construct			
Single row screw/cord	9 (60)		
Double row screw/cords	6 (40)		
Disc Complex Releases			
# patients	12/13 (92)		
Avg # releases per patient		2.8 (1 to 7)	
Coronal Curve		MAXIMUM	INSTRUMENTED
Pre-op (°)		82.9 (58 to 100)	
Average flexibility (%)		53.1 (29 to 71)	
First erect post-op (°)		35.3 (16 to 66)	27.5 (14 to 46)
Average correction (%)		55.9 (23 to 78)	65.9 (47 to 83)
Most recent post-op (°)		34.5 (-21 to 73)	31.2 (-10 to 68)
Average correction (%)		59.4 (25 to 132)	64.3 (30 to 114)
2D Sagittal Curve			
Pre-op (°)		24.2 (7 to 57)	
Most recent (post-op) (°)		36.5 (2 to 58)	
3D Sagittal Curve			
Pre-op (°)		-7.4 (-23.2 to 19.7)	
Most recent (°)		28.8 (-1.0 to 54.6)	

Table 1

6. Radiation-Free Assessment of the 3D Morphology of The Adolescent Scoliotic Spine: A Feasibility Study in Synthetic (S)CT

Lorenzo Costa, MD; Tijl van der Velden, PhD; Tom P. Schlösser, MD, PhD; René M. Castelein, MD, PhD; Peter R. Seevinck, PhD

Hypothesis

Synthetic (s)CT enables fast and accurate 3D morphological assessment of the adolescent scoliotic spine

Design

Retrospective descriptive study

Introduction

Various imaging methods are employed in diagnosing and managing adolescent idiopathic scoliosis (AIS). X-rays offer 2D images with low ionizing radiation exposure, while CT scans provide 3D data at high radiation doses. sCTs from MRI scans show promise for visualizing osseous spinal structures in adults, but their applicability to adolescent and curved spines remains unclear. This study assesses the feasibility of sCTs in visualizing scoliotic spines in adolescents

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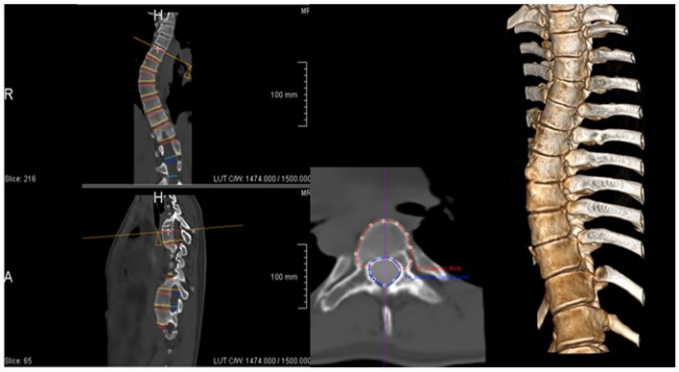
Methods
The study included 10 MRI scans from adolescent female patients, mean age 14 years (range 13-15), presenting significant thoracic or thoracolumbar curves (Cobb angle >40° by Cobb method). A 4-minute 3D spoiled gradient echo MRI sequence was applied, processed into quantitative (HU) sCTs (BoneMRI V1.7, MRIguidance BV, Utrecht, NL). Cobb angle, thoracic kyphosis (TK), axial rotation, anterior-posterior ratio (A-P%), and left-right ratio (L-R%) were analyzed using ScoliosisAnalysis 7.2 (UMCU, Utrecht, NL). Axial rotation per endplate was defined as the angle between each vertebral endplate's antero-posterior (AP) axis and the first distal neutrally rotated vertebra's AP axis. A-P% and L-R% were analyzed by identifying the most anterior, posterior, left, and right points of each endplate of involved vertebrae

Results
sCTs produced high-resolution 3D CT-like images, clearly visualizing the spine, allowing for easy measurement of crucial landmarks to assess the morphological status (Fig 1). Minor artifacts were observed in IVDs and near the respiratory tract, not impacting image analysis. Results aligned with existing literature, revealing significant reductions in Cobb angle (from 51° to 40°) and TK magnitude (from 28° to 21°) in the supine position versus standing X-rays (consistent with Brink et al. 2017). Vertebral rotation measured 16°±5.2° at the apex and 10°±3.3° overall. A-P% analysis indicated significant anterior elongation, particularly in IVDs (13.5%±7.2%), highlighting current literature trends and magnitudes (consistent with Brink et al. 2017)

Conclusion
sCTs provide CT-like images from MRI data enabling visualization and easy quantification of 3D deformities in AIS patients, without the need for ionizing radiation

Figure 1: *visualization of the 3D morphology of a scoliotic spine in a 16 y.o. female using multiplanar formatting of 3D CT-like images. Coronal (up-left), sagittal (down-left), axial (center) were used for landmarking of the synthetic CTs to detect anterior-posterior ratio, left and right ratio and vertebral axial rotation. The right image shows the 3D reconstruction of the spinal deformity via synthetic CT.*



7. Pseudotime Analysis and mRNA-lncRNA-mRNA Network Co-Analysis Reveals Abnormal Bone Marrow Niche Leads to Reduced Osteogenesis and Chondrogenesis of Bone Marrow Mesenchymal Stem Cells in Adolescent Idiopathic Scoliosis Patients

Qianyu Zhuang, MD; Yuechuan Zhang, MD; Terry Jianguo Zhang, MD

Hypothesis
The bone marrow niche in AIS patients exerts a significant influence on the osteogenic and chondrogenic differential abilities of bone marrow mesenchymal stem cells (BM-MSCs), which may contribute to the general osteopenia of AIS patients.

Design
Microarray approach and integrated network analysis, single-cell RNA sequencing, t-SNE dimensionality reduction analysis and pseudotime analysis.

Introduction
The pathogenesis of AIS and the accompanying generalized osteopenia remain unclear. Our previous study (2023 SRS) suggested increased proliferation ability and decreased osteogenic differentiation ability of BM-MSCs, and reported preliminary results of single-cell RNA sequencing in BM-MSCs of AIS patients. The differentiation trajectory of BM-MSCs can be affected by the bone marrow stem cell niche, which is made up of the supporting microenvironment and adjacent cells.

Methods
Microarray analyses on mRNA, lncRNA, and miRNA of AIS-MSCs and comprehensive bioinformatics analyses were conducted to construct integrated mRNA-lncRNA-miRNA networks. Bone marrow cell clusters were then separated using single-cell RNA sequencing technique and t-SNE dimensionality reduction analysis. Pseudotime analysis was then employed to model differentiation trajectories of BM-MSCs.

Results
The co-analysis of mRNA-lncRNA-miRNA networks highlighted marked down-regulation of LOC101927406, CTD-2184D3.6, and LOC101927588 in AIS patients, resulting in a subsequent decrease in the expression levels of SPRY4, ZDHHC9, MAP2K1 and SAMD12. Pseudotime analysis revealed surprisingly monotonous differentiation trajectory in BM-MSCs of AIS patients. AIS BM-MSCs hardly exhibited progression towards osteogenic and chondrogenic lineages, indicating aberrant differentiation kinetics. AIS BM-MSCs were mainly distributed at the start and end of a single pseudotime curve, which had no branches.

Conclusion
This study reported the results of co-analysis of mRNA-lncRNA-miRNA networks in BM-MSCs of AIS patients for the first time, and provides novel insights that dysregulated bone marrow niche results in abnor-

mal osteogenic and chondrogenic differentiation of BM-MSCs in AIS patients. Our results indicates that the aberrant bone marrow niche and abnormal macrophages-MSCs interactions play a significant role in not only the causal mechanism of osteopenia in AIS, but also the AIS pathogenesis.

8. Multi-Segment Growth Guidance Rod Can Change Curvature of Spine and Maintain the Growth of Spine in Immature Sheep

Kai Li, MD; Xuhong Xue, MD, PhD; Sheng Zhao, MD

Hypothesis
Multi-Segment Growth Guidance Rod (MSGGR) can maintain the spine growth, when it changes the curvature of the spine.

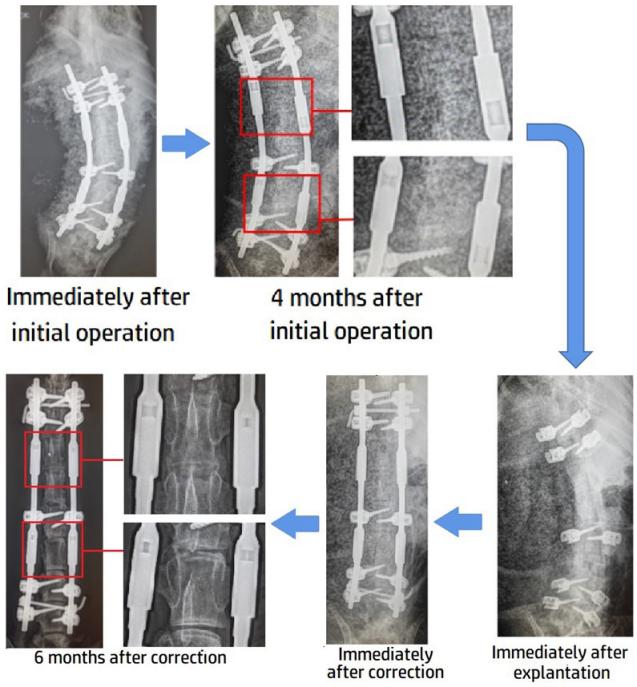
Design
Basic science

Introduction
Growing rod technique corrects the curve of scoliosis via distraction, which leads to insufficient correction and poor control of the curve apex. And The rigidity of the spine after a growing rod procedure may also interfere with the final correction. MSGGR is a growth guidance system that is designed to correct and control the curve, including the apex and allows the spine within the instrument to grow meanwhile does not require repeated surgical instrument lengthening. Growth of MSGGR instrumented spine has been validated in normal sheep with straight spine. However, during deformity correction, the rod will bear much more forces and greater friction between segments will be induced. It is a valid concern whether the system can still be extended when it changes the curvature of the spine. More animal validation is still necessary. The current animal study tested whether MSGGR instrumented spine segments can still grow when the curvature of the spine is changed.

Methods
The MSGGR system consists of several segments and is compatible with current commercial pedicle screw systems. It is stable when twisted and bent, but extendable when stretched. The rod extension occurs through sliding between the segments of the rod along the sockets during the growth of the spine. Five 3-month-old immature sheep were used in this study. Dual MSGGR system was implanted to fix the lumber and low thoracic spine in a curvature of about 40 degrees. After 4 months, three sheep were corrected using MSGGR and then observed for 6 months. Radiographs of the spine were obtained to evaluate the fixation and rod extension.

Results
The spine segments grew along the curve with the implants in position. The mean length of spine segments within the instruments grew relatively by 12.2% (range between 10% and 14.4%) in 4 months. The curvature was maintained after explantation. Three sheep had curvature correction surgeries. The instrumented spine segments grew relatively by 7% (range between 5.5% and 8.3%) in 6 months.

Conclusion
MSGGR can change the curve of the spine and maintain the spine growth without repeated instrument lengthening surgeries.



9. Development and Validation of an Artificial Intelligence Model to Accurately Predict Spinopelvic Parameters

Joseph Linzey, MD, MS; Edward Harake, BS; Jaes Jones, MD, MS; Mark Zaki, MD; Zachary Wilseck, MD; Jacob Joseph, MD; Todd Hollon, MD; Paul Park, MD

Hypothesis
We can create an artificial intelligence (AI) model which can accurately predict spinopelvic parameters with high accuracy compared to fellowship training spinal neurosurgeons and neuroradiologists.

Design
An AI model is trained and validated to predict spinopelvic parameters.

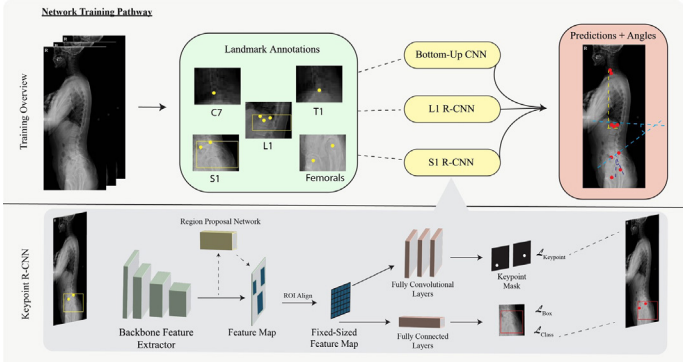
Introduction
Achieving appropriate spinopelvic alignment has been shown to be associated with improved clinical symptoms. However, measurement of spinopelvic radiographic parameters is time-intensive and interobserver reliability is a concern. Automated measurement tools have the promise of rapid and consistent measurements, but existing tools are still limited by some degree of manual user-entry requirements. This study

presents a novel artificial intelligence (AI) tool that automatically predicts spinopelvic parameters with high accuracy without need for any manual entry.

Methods
The AI model was trained/validated on 761 sagittal whole-spine x-ray's to predict Sagittal Vertical Axis (SVA), Pelvic Tilt (PT), Pelvic Incidence (PI), Sacral Slope (SS), Lumbar Lordosis (LL), T1-Pelvic Angle (T1PA), and L1-Pelvic Angle (L1PA). A separate test set of 40 x-ray's was labeled by 4 reviewers including fellowship-trained spine surgeons and a neuroradiologist. Median errors relative to the most senior reviewer were calculated to determine model accuracy on test images. Intraclass correlation coefficients (ICC) were used to assess inter-rater reliability.

Results
The AI model exhibited the following median (IQR) parameter errors: SVA [2.1mm (8.5mm), p=0.97], PT [1.5° (1.4°), p=0.52], PI [2.3° (2.4°), p=0.27], SS [1.7° (2.2°), p=0.64], LL [2.6° (4.0°), p=0.89], T1PA [1.3° (1.1°), p=0.41], and L1PA [1.3° (1.2°), p=0.51]. The AI model exhibited excellent reliability at all parameters (ICC: 0.92-1.0).

Conclusion
Our AI model accurately predicts spinopelvic parameters with excellent reliability comparable to fellowship-trained spine surgeons and neuroradiologists. Utilization of predictive AI tools in spine-imaging can substantially aid in patient selection and surgical planning.



Training Overview: Each whole-spine x-ray is labelled with a total of 9 keypoints: 3 on L1, 2 on S1, and 1 each on C7, T1, and both femoral heads. The L1 and S1 labels are fed into their own region-based convolutional neural networks (R-CNN's) which utilize a two-stage approach to keypoint detection: object detection followed by landmark localization in that particular object. The rest of the keypoints are fed through a Bottom-Up CNN which directly predicts keypoint coordinates and then secondarily maps these points to a particular object without the need for prior object detection. The keypoint outputs from each model are ultimately compiled together, and spinopelvic parameters are calculated using the aggregate output.

Training overview for the convolutional neural network. Each whole-spine x-ray is labelled

10. Multi-Center Prospective Cohort of Intractable Chronic Low Back Pain Patients Treated with Restorative Neurostimulation – Outcomes from 5-Year Data

Christopher I. Shaffrey, MD

Hypothesis
That restorative neurostimulation provides clinically meaningful in patients with chronic mechanical low back pain

Design
5 year prospective follow up

Introduction
Restorative neurostimulation is a relatively new approach to intractable mechanical chronic low back pain (CLBP) eliciting direct multifidus muscle contractions through long-term direct stimulation of the L2 dorsal rami medial branch nerves.1 This paper presents the 5-year follow-up data from a restorative neurostimulation sham-controlled randomized clinical trial (RCT) (Clinicaltrials.gov: NCT02577354) demonstrating meaningful long-term improvements in mechanical CLBP with multifidus dysfunction.

Methods
The RCT was conducted in full compliance with IRB, FDA, and Declaration of Helsinki approvals. Outcome measures of visual analog scale (VAS), Oswestry Disability Index (ODI), and quality of life (EQ-5D-5L) were documented at intervals out to five years. At baseline, consented patients (N=204, ages=22-75yrs) reported a mean back pain history of 14(±11)yrs. All failed traditional management, including combinations of physiotherapy (sessions=31±52), medications (37% taking opioids), injections (49%) and/or medial branch rhizotomies (13%). Baseline mean (±SD) VAS, ODI, and EQ-5D were 7.3(±0.7)cm, 39(±10) and 0.585(±0.174) respectively.

Results
Five year data were complete for 126 patients post-opt implantation. Data were statistically significant from baseline for all outcome measures (Fig. 1). Of 52 subjects on an opioid-containing medication at baseline, 69% either decreased (23%) or discontinued (46%) opioids at five years. Of the 74 participants not on opioids at baseline, 72 (97%) remained off opioids at five years.

Conclusion
The 5-year data results from restorative neurostimulation demonstrated substantial and durable improvements in pain, function, quality of life and reduced or eliminated opioid utilization. Majority of patients with mechanical CLBP with implanted neurostimulation receive substantial improvements in pain and disability long term, consistent with the published outcomes from the pivotal study.

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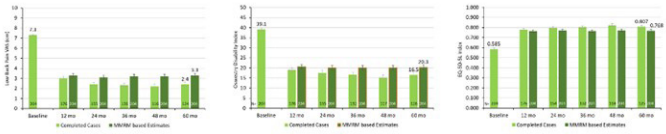


Continuous outcome variables from complete cases analysis for VAS, ODI, and EQ-5D.

11. Minimization of Lumbar Interbody Fusion by Percutaneous Full-Endoscopic Lumbar Interbody Fusion (PELIF), and Its Minimally Invasiveness Comparison with Minimally Invasive Surgery-Transforaminal Lumbar Interbody Fusion (MIS-TLIF)

Kenyu Ito, MD

Hypothesis
PELIF might be a less invasive surgery than MIS-TLIF.

Design
Case control study

Introduction
In fusion surgery, minimization of muscle damage and bone resection is important. To achieve these, we have developed a PELIF. We report the detailed operation procedure, and moreover a comparison of its minimally invasiveness with that of the MIS-TLIF.

Methods
PELIF is performed using the percutaneous full-endoscope under continuous water irrigation. The working-sheath measures 8.0 × 185 mm. The procedure is performed using instruments <8 mm in diameter except 11 mm percutaneous pedicle screw extender. We performed 126 lumbar fusion cases including 52 PELIF cases (24 males/28 females), aged 62.8 ± 12.5 years, and 74 MIS-TLIF cases (35 males/39 females), aged 63.7 ± 14.4 years managed by three surgeons at our hospital.

Results
In PELIF, bleeding volume, VAS (back pain), ODI, JOA score, and Macnab's criteria were significantly superior to MIS-TLIF except for VAS (leg symptom). The MRI cross-sectional area of degenerative spondylolisthesis was significantly improved after PELIF, but that of MIS-TLIF was significantly broader. PELIF was superior to MIS-TLIF in fat degeneration of multifidus muscle in the cross-sectional MRI under 50 years old. CT recognized insufficient fusion in one case of PELIF and seven cases of MIS-TLIF, with a tendancy to have more insufficient fusion in MIS-TLIF.

Conclusion
PELIF is an indirect decompression without canal invasion. PELIF is a less invasive surgery than MIS-TLIF.

12. Soft-Tissue Insufficiency as a Predictor for Proximal Junctional Kyphosis and Failure in Patients with Adult Spinal Deformity

Bahar Shahidi, PhD; Pearce Haldeman, BS; Eli O'Brien, BS; Brianna Kuhse, BS; Camille Nosewicz, BS; Courtney Moltzen, BS; Tina L. Iannacone, BSN; Robert K. Eastlack, MD; Gregory M. Mundis Jr., MD

Hypothesis
Soft tissue health will be associated with development of Proximal Junctional Kyphosis (PJK) and failure (PJF).

Design
A prospective observational study

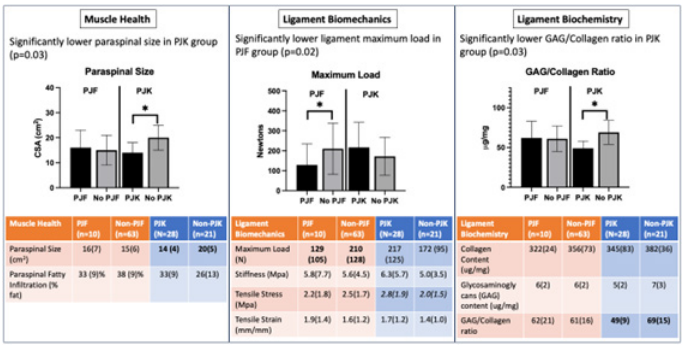
Introduction
Spinal soft tissues are key contributors to its stability. In adult spinal deformity (ASD), soft tissue health becomes impaired, increasing biomechanical stress at the junction of upper instrumented vertebrae (UIV) and the native spine after spinal fusion surgery. The contribution of soft tissue impairments to development of PJK (PJA) of >10deg from UIV-1 to UIV+2) and PJF (symptomatic PJK requiring revision) is unknown.

Methods
Data were collected prospectively from 73 consecutive individuals undergoing spinal fusion for ASD(>4 levels). Participants provided informed consent under an approved protocol. Demographics(age, gender, body mass index(BMI), smoking), radiograph-based alignment (proximal junctional angle;PJA, sagittal vertical axis, pelvic incidence, lumbar lordosis, pelvic tilt, PI-LL mismatch, thoracic kyphosis), bony health (DEXA, osteoporosis), MRI-based muscle health at the UIV (paraspinal fatty infiltration, cross sectional area;CSA), and biopsy-based ligament biomechanics/ biochemistry (peak force, stiffness, tensile stress/strain, collagen content, glycosaminoglycan content)were measured. Patients were monitored for 1 year for development of PJK or PJF, and measures were compared between groups.

Results
Mean(SD) age of participants was 67.0(13.5) years, and a majority were female (70.6%). 1-year follow up radiographs were available for 67% of participants. 28(38.4%) developed PJK within 1 year, and 10(13.6%) developed PJF. The only predictor of PJK was smaller paraspinal muscle CSA, with the PJK group demonstrating 32% smaller CSA vs those without (p=0.03). Predictors of PJF included greater pre-operative PJA (15.3(11.6) vs 7.2(6.0)deg, p=0.04), lower ligament peak force (94.8(34.7) vs 212.4(132.0)N, p<0.001), and lower BMI (23.4(2.8) vs. 26.1(5.3)kg/m2, p=0.02).

Conclusion
Paraspinal muscle atrophy is an important independent predictor of PJK, whereas pre-operative PJA, ligament strength, and BMI predicts PJF. Soft tissues

should be considered when making clinical decisions for risk of PJK/PJF.



Muscle Health	PJF (n=10)	Non-PJF (n=63)	PJK (N=28)	Non-PJK (n=21)
Paraspinal Size (cm^2)	16(7)	15(6)	14 (4)	20(5)
Paraspinal Fatty Infiltration (% fat)	33 (9)%	38 (9)%	33(9)	26(13)

Ligament Biomechanics	PJF (n=10)	Non-PJF (n=63)	PJK (N=28)	Non-PJK (n=21)
Maximum Load (N)	129 (105)	210 (128)	217 (125)	172 (95)
Stiffness (Mpa)	5.8(7.7)	5.6(4.5)	6.3(5.7)	5.0(3.5)
Tensile Stress (Mpa)	2.2(1.8)	2.5(1.7)	2.8(1.9)	2.0(1.5)
Tensile Strain (mm/mm)	1.9(1.4)	1.6(1.2)	1.7(1.2)	1.4(1.0)

Ligament Biochemistry	PJF (n=10)	Non-PJF (n=63)	PJK (N=28)	Non-PJK (n=21)
Collagen Content (ug/mg)	322(24)	356(73)	345(83)	382(36)
Glycosaminoglycans (GAG) content (ug/mg)	6(2)	6(2)	5(2)	7(3)
GAG/Collagen ratio	62(21)	61(16)	49(9)	69(15)

Figure 1. Soft tissue contributions to PJK and PJF

13. Minimally Invasive Fusionless Bipolar Fixation: A Six Year Follow Up Surgery Results in Severe Neuromuscular Scoliosis

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Hypothesis
We analyze the results of minimally invasive bipolar fixation technique and compared the outcome with conventional spinal fusion in severe neuromuscular scoliosis patients

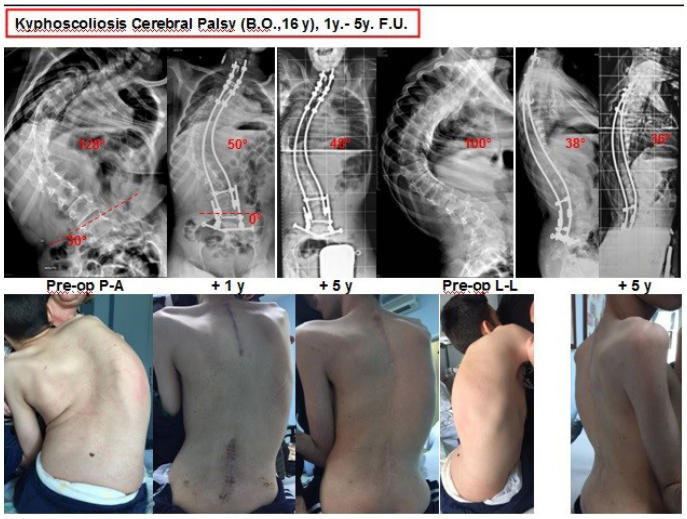
Design
Retrospective and Comparative case series

Introduction
In neuromuscular scoliosis patients the surgical treatment is a long posterior segmental arthrodesis as a standard surgical treatment. Patients have a long hospital stay, blood loss and high rate of complications. From 2016 we perform an innovative type of surgery with a minimally invasive approach and bipolar fixation proximally thoracic and distally ileosacral.

Methods
We analyze all neuromuscular patients underwent to surgery: a standard spinal fusion (SSF) and bipolar fixation technique (BF) with a bilateral double rod construct anchored proximally with a 2 couple of hooks and distally with bilateral ileosacral screws connected with connector and domino using a only two minimally invasive approach. 25 patients with a severe scoliosis (10 Rett Syndrome, 4 SMA, 11 CP), 15 male and 10 female with mean age 14y.(11-26y) underwent to surgery with intra-op traction and minimally invasive T1-T2 to ileosacral fusionless fixation. Patients were evaluated pre-op, post-op and at fu (1-2-3-5 years) cobb angle, pelvic obl(PO) and balance. The average of pre-op T-L curves is 96°(88-128), kyphosis 94°(85-120), PO 33°(20-45).

Results
Patients were followed for min 18 months and compared with a 24 patients treated with SSF in similar neuromuscular group (age, severity, ASA). There are better results in BF patients with a mean T-L curves 32°(12-50),correction 78%, kyphosis 25°(10-51),correction 75% and PO 4°(0-8)correction 88% with low rate of complication in BF group 10% (1cross-link dislocation and a 1nut unscrewing), compared with 29% in SSF.

Conclusion
The neuromuscular scoliosis surgery requires a particular attention to altered bony, muscular anatomy and patients general condition. It's necessary a pre-op or intraop traction to create a stable construct with internal bipolar distraction system which provides a gradual detorsion at the two ends away from the apex of the deformity and allow to a spontaneous autofusion. The Bipolar fixation technique ensures significant correction of the sagittal and coronal curves with the added benefit of minimally invasive surgery, including limited blood loss and greatly reduced operative time comparing to a conventional spinal fusion



14. Cervical Spinal Cord Signal Changes in the Absence of Apparent Compression Indicate Dynamic Compression - Insights from Load-Bearing Positional Sitting MRI in Patients with Degenerative Cervical Myelopathy

J. Naresh-Babu, MS

Hypothesis
Cord signal changes in the absence of overt cord compression, identification of dynamic compression, notably through ligamentum flavum buckling during sitting with neck in extension and increased disc bulge during sitting with neck in neutral, challenges traditional diagnostic and therapeutic approaches.

Design
Retrospective Study

Introduction
Degenerative cervical myelopathy (DCM) is a common condition characterized by MRI-detected cord signal

changes, often in the absence of apparent cord compression. To elucidate the reasons for signal changes in this specific context, we conducted a comprehensive study using positional sitting MRI.

Methods
10 DCM patients exhibiting cord signal changes without evident cord compression on traditional supine MRI examination. All patients underwent sitting MRI examinations with neck in neutral, flexion, and extension various Parameters are measured and compared between offloaded supine MRI and loaded sitting positions (with neck in neutral, flexion, and extension).

Results
Our study revealed evidence of dynamic compression at the levels corresponding to cord signal changes during sitting MRI. Five patients showed worsening in cord cross-section area in sitting neutral, seven in extension and three in flexion. Dynamic compression due to increased disc bulge was seen in six patients and ligamentum flavum thickness in six patients (More evident on sitting in extended position). Ligamentum flavum thickness increased by 25.4% in the neutral position ($p > 0.05$), decreased by 3.5% in flexion ($p = 0.025859$), and increased to 30.9% in extension ($p > 0.05$). sitting neutral exacerbated disc bulging by 48% ($p > 0.05$). flexion (14.5%, $p = 0.00239$) where as decreasing extension (23.5%, $p = 0.025386$). At the level of cord signal changes, Stretching of the cord against the disc was note on flexion and buckling of the ligamentum flavum was noticed in extension indicating the ongoing dynamic compression of the cord.

Conclusion
DCM patients with spinal cord signal changes but without apparent cord compression on supine MRI were shown to have significant spinal cord compression on axial loading.The identification of dynamic compression, notably through ligamentum flavum buckling during sitting with neck in extension and increased disc bulge during sitting with neck in neutral.

15. Is Upper Extremity or Lower Extremity Function More Important for Patient Satisfaction? An Analysis of 24-Month Outcomes from the QOD Cervical Myelopathy Cohort

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Hypothesis
To evaluate whether upper or lower extremity functional improvement is more closely tied to patient satisfaction following surgery for cervical spondylotic myelopathy (CSM).

Design
Retrospective analysis of prospectively-collected data

Introduction
In patients operated for cervical myelopathy (CSM), it is unclear whether upper limb or lower limb mJOA improvement is more strongly correlated with patient satisfaction.

Methods
This study utilizes the prospective Quality Outcomes Database (QOD) CSM cohort. PROs included mJOA and the North American Spine Society (NASS) satisfaction index. The upper limb mJOA score was defined as upper limb motor plus sensory mJOA, and the lower limb mJOA score was lower limb motor plus sensory mJOA (range 0-6 for each). Ordered logistic regression was used to determine whether upper or lower limb mJOA was more closely associated with 24-month NASS satisfaction, while adjusting for other covariates.

Results
Overall, 1,141 patients with CSM were included with 948 (83.1%) reaching 24-month follow-up. Baseline VAS neck pain (VAS-NP) was 5.1±3.3, VAS arm pain (VAS-AP) was 4.8±3.5, and mJOA score was 14.0±2.7. Postoperatively, 789 (83.4%) would undergo surgery again (NASS 1 or 2; i.e., satisfied). Patients exhibited mean improvement in upper limb (baseline: 4.0±1.4 vs 24m: 5.0±1.1, $p<0.001$) and lower limb mJOA scores (baseline: 3.9±1.4 vs 24m: 4.5±1.5, $p<0.001$), however the magnitude of 24-month upper limb mJOA improvement was larger (upper change: +1.1±1.6 vs lower change: +0.5±1.6, $p<0.001$). As 24-month NASS satisfaction decreased, 24-month upper limb mJOA improvement decreased as well ($p<0.001$). Similarly, the amount of lower limb improvement decreased as NASS satisfaction decreased ($p<0.001$). In ordered logistic regression, NASS satisfaction level was independently associated with upper limb mJOA improvement (OR=0.81; 95% CI 0.68-0.97; p=0.019), but not lower limb mJOA improvement (OR=0.84; 95% CI 0.70-1.0; p=0.054).

Conclusion
As patient satisfaction decreased, so too did the magnitude of upper and lower limb mJOA improvement. Upper limb mJOA improvement is ultimately more associated with satisfaction. These findings may aid preoperative counseling, which may be stratified based on a patient's upper and lower extremity treatment expectations.

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Table 1. Demographic comparison of 24-Month mJOA outcomes in patients with cervical spondylotic myelopathy.

Table 1. Demographic Groups	24-Month Upper Limb mJOA	24-Month Lower Limb mJOA	Change in Upper Limb mJOA	Change in Lower Limb mJOA
Age				
>= 65	5.0 ± 1.2	4.4 ± 1.5	1.1 ± 1.7	0.7 ± 1.7
< 65	5.0 ± 1.1	4.5 ± 1.5	1.1 ± 1.5	0.5 ± 1.6
p value	0.97	0.47	0.98	0.15
Gender				
Male	5.0 ± 1.2	4.4 ± 1.5	1.0 ± 1.6	0.5 ± 1.6
Female	5.0 ± 1.1	4.5 ± 1.5	1.1 ± 1.6	0.6 ± 1.7
p value	0.75	0.16	0.62	0.40
BMI				
>= 30	5.0 ± 1.1	4.5 ± 1.5	1.1 ± 1.6	0.5 ± 1.6
< 30	5.0 ± 1.2	4.6 ± 1.5	1.1 ± 1.7	0.6 ± 1.6
p value	0.75	0.16	0.57	0.52
Ethnicity				
Hispanic or Latino	4.8 ± 1.3	3.9 ± 1.8	1.1 ± 1.6	0.2 ± 1.7
Not Hispanic or Latino	5.0 ± 1.1	4.5 ± 1.5	1.1 ± 1.6	0.6 ± 1.6
p value	0.56	0.06	0.96	0.33
Education				
High School or Less	4.9 ± 1.1	4.4 ± 1.5	1.1 ± 1.5	0.6 ± 1.6
Some College or More	5.1 ± 1.1	4.6 ± 1.5	1.1 ± 1.6	0.6 ± 1.6
p value	0.13	0.14	0.98	0.89
Insurance				
Medicare/Medicaid	4.9 ± 1.2	4.3 ± 1.6	1.1 ± 1.7	0.6 ± 1.7
Private	5.1 ± 1.1	4.6 ± 1.4	1.0 ± 1.5	0.4 ± 1.5
p value	0.16	**0.003****	0.48	0.09
Symptom Duration				
< 3 Months	5.4 ± 0.9	4.7 ± 1.6	1.5 ± 1.6	0.6 ± 1.9
3-12 Months	5.0 ± 1.1	4.6 ± 1.4	1.1 ± 1.6	0.6 ± 1.6
> 12 Months	4.9 ± 1.2	4.3 ± 1.5	0.9 ± 1.5	0.3 ± 1.5
p value	**<0.001****	**<0.001****	**0.004†**	0.65
Primary Indication				
Radiculopathy	5.0 ± 1.1	4.6 ± 1.4	1.1 ± 1.6	0.3 ± 1.5
Myelopathy	5.0 ± 1.1	4.5 ± 1.5	1.1 ± 1.6	0.5 ± 1.6
Neck Pain	4.8 ± 1.3	3.9 ± 1.5	1.7 ± 2.0	-0.2 ± 1.6
p value	**<0.001****	**<0.001****	0.13	0.07

**Difference in upper or limb mJOA score was statistically significant ($p < 0.05$).
†Difference in change in upper or lower limb mJOA was statistically significant between subgroups ($p < 0.05$).

Table 2. Post-operative mJOA Outcomes Stratified by NASS Satisfaction Level

Table 2. 24-Month mJOA Outcomes	NASS 1 (n=610)	NASS 2 (n=182)	NASS 3 (n=89)	NASS 4 (n=62)	*p* value
mJOA					
Baseline mJOA Score	12.4 (2.7)	11.9 (2.8)	11.3 (2.9)	11.8 (2.9)	0.003**
24-Month mJOA Score	14.7 (2.4)	13.6 (2.4)	12.2 (2.9)	11.5 (2.7)	<0.001**
24-Month mJOA Change	2.3 (3.1)	1.7 (3.0)	0.8 (3.2)	-0.1 (3.1)	<0.001**
24-Month Recovery Rate	33.0 (56.8)	14.6 (57.0)	-0.6 (62.8)	-16.9 (71.5)	<0.001**
mJOA Upper Limb					
Baseline Upper Limb Function Score	4.0 (1.3)	3.9 (1.4)	3.6 (1.6)	3.9 (1.4)	0.096
24-Month Upper Limb Function Score	5.2 (1.0)	4.8 (1.2)	4.5 (1.3)	4.0 (1.2)	<0.001**
24-Month Upper Limb Function Change	1.2 (1.5)	0.9 (1.7)	0.9 (1.9)	0.1 (1.5)	<0.001**
No. Full Recovery	253 (41.7)	40 (22.0)	9 (15.5)	5 (5.7)	<0.001**
mJOA Lower Limb					
Baseline Lower Limb Function Score	4.0 (1.5)	3.9 (1.3)	3.7 (1.3)	3.8 (1.5)	0.201
24-Month Lower Limb Function Score	4.7 (1.4)	4.3 (1.4)	3.7 (1.4)	3.4 (1.5)	<0.001**
24-Month Lower Limb Function Change	0.7 (1.7)	0.4 (1.5)	0.1 (1.5)	-0.2 (1.5)	<0.001**
No. Full Recovery	216 (35.6)	36 (19.8)	5 (8.6)	7 (8.0)	<0.001**

mJOA recovery rate was calculated according to the Hirabayashi method.
**Difference was statistically significant ($p < 0.05$).

Tables

16. A Newly-Designed Wearable Device with Artificial Intelligence Detects Scoliosis and Monitor Disease Progression

Guilin Chen, MD; *Nan Wu, MD*; Hongjun Liu, PhD; Chao Yao, PhD; Xiaojuan Ban, PhD; Terry Jianguo Zhang, MD; Zohaib Sherwani, MD

Hypothesis
Scoliosis can be detected and monitored through movement monitoring by wearable devices and artificial intelligence.

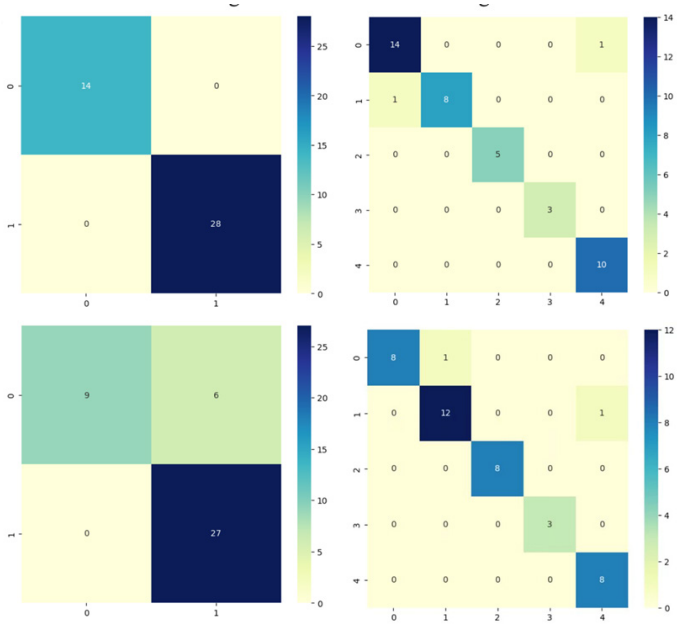
Design
Prospective, Multi-center Study

Introduction
Adolescent idiopathic scoliosis (AIS) is a three-dimensional spine deformity affecting about 1-4% of adolescents worldwide and affects more females. The diagnosis of AIS is based on the coronal whole-spine X-ray with the Cobb angle above 10°, and other known causes of scoliosis like vertebral malformation, syndromic disorders, and neuromuscular disorders are excluded. The screening for AIS was first reported in 1952. Forward bending test, Scoliometer, and Moiré topography are used in AIS screening. However, these methods have drawbacks, including "by-eye measurements," time-consuming, interrater bias, and low accuracy. We designed a new screening strategy that combines wearable devices and artificial intelligence.

Methods
The strain sensors are used to collect the signals produced by the movement of the spine, including flexion, extension, bending, and rotation, and a deep-learning model was used to deal with the strain time-series signals. First, we used twenty-nine patients with adolescent idiopathic scoliosis and controls aged twelve to eighteen to develop the strategy. Second, we use multi-center data to improve the efficiency and accuracy of the strategy.

Results
There are 62 AIS patients and 44 age-matched healthy controls. The median age was 14. 54.5% of the patients have a single curve, 43.9% have a double curve, and one has a tribble curve. These patients have various curvatures with Cobb angles from 11 to 115 degrees. First, the strategy was used to discriminate between normal people and scoliosis patients with a sensitivity of 100% and an accuracy of 88%. Second, the strategy was used to differentiate the Cobb angle of the patient. We divide the patient into five groups by Cobb angle between 0-10, 10-20, 20-30, 30-40, and above 40. The strategy has a sensitivity of 97.22% and an accuracy of 83.1%.

Conclusion
The strain sensor combined with artificial intelligence can be used to discriminate between normal people and scoliosis patients, which can be further used to screen for scoliosis in daily life, and the improved algorithm can be used to monitor the disease progression.



The Confusion Matrix of the Model

17. Are 3D-Printed Anatomic Haptic Adolescent Idiopathic Scoliosis Spine Models Better Resident Training Tools when Compared to Conventional Training Modalities

Selina C. Poon, MD; Haleh Badkoobehi, MD; Cynthia V. Nguyen, MD; Robert H. Cho, MD; *Ryan Finkel, MD*; Reginald S. Fayssoux, MD

Hypothesis
The present study aimed to determine if a 3D printed anatomic haptic AIS spine model can increase trainee accuracy of screw placement compared to conventional training tools.

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Design
This is a randomized controlled study at two distinct orthopaedic surgery residency programs.

Introduction
Spinal deformity surgery requires a thorough understanding of complex three-dimensional pathoanatomy. Opportunities to directly interact with 3 dimensional (3D) pathoanatomy and surgical practice techniques are limited. 3D printers are able to create models that accurately mimic deformed adolescent idiopathic scoliosis (AIS). To our knowledge, the use of 3D printed AIS models as a residency training tool has not been described.

Methods
Using a historical clinical computed tomography of a patient with 50-degree Lenke 1 AIS, a three-dimensional model from T1-L5 was created. Thirty-one orthopaedic trainees from two separate training programs were recruited and randomized into 3 groups. Cadaver (CG) had 10 residents, Sawbones (SG) had 9 and 3D model (3G) had 12 in the initial training cohort where they were taught how to insert pedicle screws in their respective models. A total of 25/31 residents completed the pedicle screw insertion test (CG=6, SG=7, 3G=12) 2-4 weeks post initial training. Breaches were recorded at each session and compared to assess each models' applicability in teaching and improving surgical technique. Trainees were also queried regarding their satisfaction (1-5) with the training model.

Results
The average number of breeches >2mm are shown in Figure 1. Compared to the other 2 methods of teaching, Sawbones had the greatest number of pedicle breeches. Trainees in the SG also had significantly improved accuracy at the post test session. There were no significant differences in the other 2 groups. When queried, 84% of residents chose to learn on a 3D model compared to sawbones and cadaver. Overall, the residents rated 4.7 for recommending the use of the 3D model in their training program.

Conclusion
A 3D printed anatomic haptic AIS spine model can serve as a resident training tool to help improve accuracy of pedicle screw placement in of AIS. We believe the present study illustrates the utility of having more accurate training tools for residents as they progress in training.

	Pre	Post	Diff	p
>=2mm				
Cadaver	0.83	0.17	-0.66	0.24
Sawbones	4.38	0.63	-3.75	0.001
3D	0.36	0.82	0.46	0.1

Figure 1. Number of resident breaches >=2mm recorded using cadaver, sawbones and 3D models at two different time points. P <0.05 represents statistical significance

18. Rigo Cheneau Brace for Adolescent Idiopathic Scoliosis: Higher in Brace Correction and Lower Rates of Curve Progression

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Hypothesis
Bracing treatment with Rigo Cheneau-style orthoses (RCSO) will be more effective at preventing curve progression and need for surgery when compared to Boston-style thoracolumbar sacral orthoses (BTLSO).

Design
Single-center retrospective cohort

Introduction
Bracing is the mainstay of conservative management for adolescent idiopathic scoliosis (AIS). However, there is little data comparing treatment outcomes among brace types. RCSO bracing has gained popularity over the past decade due to the perceived advantage of three-dimensional (3D) correction with initial studies showing that RCSO treatment is effective at preventing curve progression. The purpose of this study is to compare curve progression and need for surgery between patients treated with RCSO and BTLSO to further justify the widespread replacement of the BTLSO.

Methods
Patients who began treatment between 2009 and 2016 with an initial major coronal curve between 20° and 45° and no previous scoliosis treatment were included. Study endpoints were skeletal maturity or definitive fusion surgery. The outcome measures were degrees curve progression, percent curve progression, major coronal curve progression > 10°, and progression to surgery.

Results
89 patients (47 RCSO and 42 BTLSO) were included. RCSO patients had a higher mean initial major curve compared to the BTLSO cohort. RCSO patients had greater in-brace curve correction percent (48% vs 22%, p<0.001). Average curve progression over the follow-up period was 2° ± 9° (from 33 ± 7° at brace initiation to 35 ± 12° at last follow-up) in the RCSO group and 8° ± 11° (from 30 ± 6° at brace initiation to 38 ± 13° at last follow-up) in the BTLSO group (p = 0.004). Forty-three percent of patients treated with BTLSO experienced curve progression of more than 10° compared to only 13% of patients treated with RCSO (p = 0.003). There were no differences between RCSO and BTLSO in terms of surgery recommended or performed (30% vs. 31%, p=0.905).

Conclusion
Patients treated with RCSO have a higher in-brace

curve correction and lower rates of curve progression compared to patients treated with BTLSO. This study supports using RCSO as a first-line brace in AIS patients.

Features	All (n=89)		RCSO (n=47)		BTLSO (n=42)		*p*-value
	Mean (SD)	% (n)	Mean (SD)	% (n)	Mean (SD)	% (n)	
Follow up time (years)	4.0 (1.8)		3.8 (1.2)		4.5 (1.9)		0.034
In-brace curve correction (%)	36 (27)		48 (23)		22 (24)		< 0.001
≥ 30% in-brace curve correction		61 (54)		81 (38)		38 (16)	< 0.001
Curve progression (°)	4.6 (10.1)		1.7 (8.7)		7.9 (10.6)		0.004
Progression >10°		27 (24)		13 (6)		43 (18)	0.003
Progress to surgery		30 (27)		30 (14)		31 (13)	0.905

Table 1: Characteristics of BTLSO and RCSO bracing treatment

19. Optical-Kinematic Measurement of Spinal Alignment: a Radiation-Free Technique Using Light Field Navigation

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Hypothesis
Radiation-free Volumetric Intelligence (VI) measures intraoperative spinal alignment within 3° of standard practice.

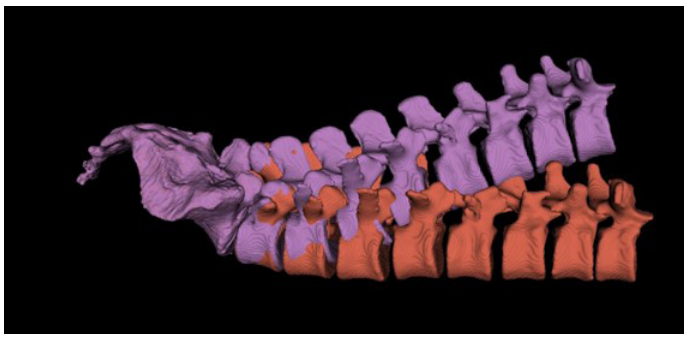
Design
Cadaveric study comparing VI with standard practice.

Introduction
Achieving patient-specific spinal alignment goals may improve outcomes, but intraoperative measurement of alignment is inherently variable, time consuming, and requires ionizing radiation leading to limited utilization. Volumetric Intelligence (VI) is a radiation-free optical tracking tool that measures alignment from 3D optical data. This study evaluates VI accuracy compared with manual measurements.

Methods
Data was collected with a navigation system powered by light-field and optical sensing technologies. The navigation system was used to create a digital 3D model of the spine, instrument T10-S1, and save the vertebral coordinates in a pre-corrected and post-corrected state. Lateral fluoro shots were also taken pre- and post-correction. The saved intraoperative vertebral coordinates were processed with VI to calculate regional and segmental sagittal angles automatically. The companion fluoro shots were individually reviewed by spine surgeons to define the vertebral endplates. For regional measures, fluoro shots were stitched together. Manual measures were calculated from the surgeon annotations and compared with the VI calculations.

Results
Seven spine surgeons each annotated 28 scans. The mean absolute difference between automated and manual measures was 1.96° (SD=1.30), and 95% of all data were within 2.53° of the mean manual measures, while on average the individual surgeon measures were within 3.38° of their mean (RMSE). The automated and the manual measures strongly correlated (r=0.98, p<0.0001). For the manual measures, inter-rater and intra-rater reliability was also good (ICC=0.94 and 0.90, respectively).

Conclusion
Volumetric Intelligence provides intraoperative alignment measurements with less error than spine surgeons' manual measurements without radiation, workflow interruption, or manual interpretation of imagery. VI will confirm alignment goals intraoperatively without radiation and in less time than standard practice. VI potentially reduces variability in assessment of spinal alignment and other parameters, such as disc height, foraminal area, and pelvic tilt.



Pre/Post Digital 3D Spine Models Used for Automatic Angle Calculations

20. Comparative Analysis of Utilization of Artificial Intelligence in Minimally-Invasive Adult Spinal Deformity Surgery

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Hypothesis
Artificial intelligence may impact the peri- and post-operative course in minimally-invasive adult spinal deformity corrective surgery.

Design
Retrospective cohort review

Introduction
Artificial intelligence (AI), machine learning, and minimally-invasive(MIS) technique may offer enhanced preoperative planning, intraoperative robotic or navigational guidance, and prediction of postoperative complications for adult spinal deformity patients.

Despite relatively widespread utilization, there remains a paucity of literature assessing the impact of AI in MIS surgery.

Methods
CD patients with complete pre- and up to 2-year post-op radiographic/HRQL data were stratified by primary utilization of AI-based patient-specific rod customization and robotic or navigational assistance in pre- and peri-operative course(AI+) or not(AI-). Differences in demographics, clinical outcomes, radiographic alignment, peri-operative factors and complications were assessed via means comparison analysis. ANCOVA assessed postoperative complications while controlling for BL age/gender.

Results
133 MIS patients were included(51.74±11.59 years, 41% female, 30.85±6.93 kg/m2) Of these patients, 44(33.1%) were classified as AI+. At baseline, patient groups were comparable in BL age, BMI, and CCI(all p>.05), though AI+ patients were more likely to be male(p=.040). Patient groups were comparable in terms of both regional and global radiographic alignment, as well as HRQLs at BL(all p>.05). Surgically, AI+ patients had significantly shorter operative times overall(p=.022) and decreased EBL(p=.001), as well as decreased likelihood of undergoing corpectomy(p=.001). Furthermore, AI+ patients reported significantly lower hospital LOS versus AI- patients (p=.012). At 2Y post-operatively, AI+ patients with custom rods had significantly improved segmental alignment in terms of decreased pelvic tilt(S1PT) and pelvic incidence(S1PI) (both p<.001). Adjusted complications analysis revealed that AI+ patients were significantly less likely to experience any post-operative complication(p=.003), neurological complications(p=.021), or complication requiring reoperation(p=.003).

Conclusion
This study demonstrate that using AI-based robotic or navigational guidance and customized instrumentation may reduce intraoperative invasiveness, hospital stay, and complication rates. Surgeons should consider utilization of AI-based technology in practice.

21. Development of an AI Algorithm for Automatic Cobb Angle Measurement in Spinal Deformities - Comparison of Accuracy Among Three Groups of Teaching Data with Deferent Diseases

Shuzo Kato, MD; Takeo Nagura, MD, PhD; Yoshihiro Maeda, MD; Morio Matsumoto, MD, PhD; Masaya Nakamura, MD, PhD; Kota Watanabe, MD, PhD

Hypothesis
In the realm of automatic Cobb angle measurement using artificial intelligence (AI), we hypothesize that an AI algorithm trained with both adolescent idiopathic scoliosis (AIS) and adult spinal deformity (ASD) cases will outperform algorithms trained exclusively on AIS cases or ASD cases.

Design
Analytical study

Introduction
The landscape of automatic Cobb angle measurements is flourishing. To enhance precision in Cobb angle measurements for both AIS and ASD, we have created three distinct AI models: one, the AIS-ASD-trained AI, trained with both AIS and ASD cases; two, the AIS-trained AI, trained solely to AIS cases; and three, the ASD-trained AI, trained solely ASD cases.

Methods
We used 1,612 whole spine radiographs, including 1,029 AIS and 583 ASD cases, as a training set. We employed a pre-trained Residual Network model as the foundation for transfer learning. We developed three AI models using the same learning method with three different sets of training data: cases of both AIS and ASD, only AIS cases, and only ASD cases. Our AI algorithm identified the thoracolumbar region as the region of interest (ROI) and detected the four corners of each vertebra from T1 to L5 as feature points for Cobb angle measurement. We measured both major and minor curves. To assess accuracy, we used 285 radiographs (159 AIS and 126 ASD) as a test set and calculated the Mean Absolute Error (MAE) and Intraclass Correlation Coefficient (ICC) between each AI model and the average of manual measurements by four spine experts.

Results
For all cases, the MAE was 2.8° for the AIS-ASD-trained AI, 4.2° for the AIS-trained AI, and 3.2° for the ASD-trained AI. The ICC were 0.974, 0.929, and 0.965, respectively. In AIS cases only, the MAE was 2.6°, 3.3°, and 2.9°, with ICC values of 0.969, 0.950, and 0.960, respectively. For ASD cases only, the MAE was 3.3°, 5.9°, and 3.6°, with ICC values of 0.975, 0.901, and 0.964, respectively.

Conclusion
The AI model trained on both AIS and ASD cases demonstrated superior accuracy when compared to the two models trained exclusively on AIS or ASD cases.

22. Automatic Prediction of Spinopelvic Parameters from Bi-Planar Radiographs

Stefan Lang, MS; Kim Ji Hyun, BS; Moritz Jokeit, MS; Frederic Cornaz, MD; Lukas Urbanschitz, MD; Carlos Torrez, MD; Jess Snedeker, PhD; Mazda Farshad, MPH; *Jonas Widmer, MSc*

Hypothesis
The prediction of spinopelvic parameters can be automated with deep learning algorithms.

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Design
Comparative study of clinically relevant parameters annotated by clinicians and a learning-based algorithm.

Introduction
Accurate landmark detection is vital for various medical applications, enabling precise analysis of anatomical structures and supporting diagnosis, treatment planning, surgical guidance, and monitoring in patients with adult spinal deformity or scoliosis. Conventional methods rely on manual landmark identification by medical experts. However, the inconsistency and time-intensive acquisition of measurements motivate its automatization. Without manual supervision, the proposed deep learning pipeline processes bi-planar radiographs to determine spinopelvic parameters and Cobb angles.

Methods
The data set comprised 555 bi-planar radiographs from uninstrumented patients, manually annotated by a medical professional. First, the pipeline determined the regions of interest (cervical/thoracolumbar spine, sacrum & pelvis). For each ROI a dedicated segmentation network was trained to identify vertebral bodies and pelvic landmarks. A refined U-Net architecture was trained on 455 bi-planar radiographs using a Dice loss. A post-processing algorithm derived the spinal alignment and angular parameters. The pipeline was evaluated on 100 unseen bi-planar radiographs using the mean absolute difference between annotated and predicted landmarks. Further, the pipeline's predictions were compared with the measurements of two experienced medical professionals using the intraclass correlation coefficient.

Results
The pipeline was able to successfully predict the Cobb angles in 61% of all test cases and achieved mean absolute differences of 3.3° (3.6°) and averaged ICC of 0.88. For thoracic kyphosis, lumbar lordosis, sagittal vertical axis, sacral slope, pelvic tilt, and pelvic incidence the pipeline produced reasonable outputs in 69%, 58%, 86%, 85%, 84%, 84% of the cases. The MAD was 5.6° (7.8°), 4.7° (4.3°), 2.8mm (3.0mm), 4.5° (7.2°), 1.8° (1.8°) and 5.3° (7.7°), while the ICC was measured at 0.69, 0.82, 0.99, 0.61, 0.96 and 0.70, respectively.

Conclusion
Despite limitations in patients with severe pathologies and high BMI, the pipeline produced an automatic prediction for coronal and sagittal spinopelvic parameters. It is a valuable tool for simplifying clinical routines and generating large-scale data sets for advancing spinal research.

23. Leveraging Image Augmentations to Accurately Predict Spinopelvic Parameters in Lumbosacral X-Rays Using a Whole-Spine Artificial Intelligence Model

Edward Harake, BS; Joseph Linzey, MD, MS; Jaes Jones, MD, MS; Mark Zaki, MD; Zachary Wilseck, MD; Jacob Joseph, MD; Siri S. Khalsa, MD; Todd Hollon, MD; Paul Park, MD

Hypothesis
Despite being trained on whole-spine x-rays, the AI model should still accurately predict spinopelvic parameters in lumbosacral x-rays through the use of appropriate image augmentations.

Design
Using an AI model trained on whole-spine x-rays, we implement image cropping augmentations to force the model to generalize to different image scales and resolutions. We then test the model on lumbosacral x-rays and assess its ability to accurately predict spinopelvic parameters on a heterogeneous dataset.

Introduction
The measurement of spinopelvic parameters is done radiographically via whole-spine or regionally-focused x-rays. Choosing the particular imaging view is informed by the anatomic range and severity of spinal pathology, radiation exposure, and other institutional preferences. Current tools to automate parameter measurement are often limited to one modality vs. the other which limits their applicability in clinical practice. We previously constructed an artificial intelligence (AI) model to automatically predict spinopelvic parameters in whole-spine x-rays. In this study, we extend the performance of that AI model to lumbosacral x-rays using only random image-cropping augmentations without the need for training on lumbosacral images.

Methods
The AI model was trained and validated on a set of 761 whole-spine sagittal x-rays with random cropping of images during the training process. The AI model was tested on a set of 40 lumbosacral spine x-rays to predict lumbar lordosis (LL) and sacral slope (SS). These predicted parameters were compared to annotations on the same images by a fellowship-trained spine surgeon with > 15 years of experience. Median error was recorded for each parameter and intraclass correlation coefficients (ICC) were calculated to assess interrater reliability.

Results
The median (IQR) error at each parameter was as follows: LL [2.9° (2.6°), p =0.80] and SS [1.9° (2.2°), p = 0.78]. The ICC values were LL (0.93) and SS (0.92) which both indicate excellent reliability between the model and ground truth predictions.

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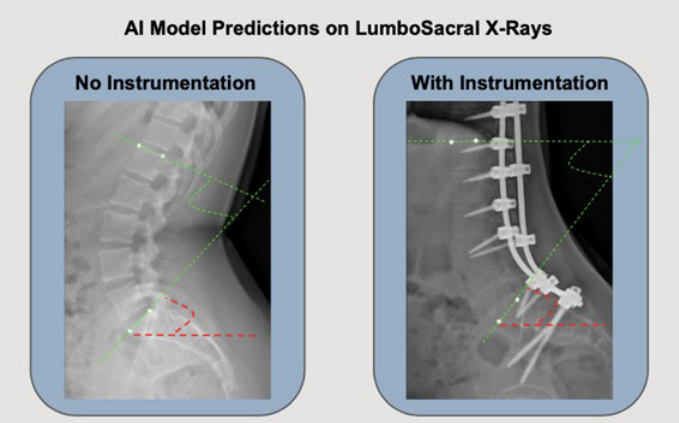
Conclusion
Using only random image augmentations, we were able to extend a whole-spine trained AI model to automatically predict spinopelvic parameters in lumbosacral images. With highly accurate and reliable performance on multiple radiographic modalities, our model exhibits a significantly increased range of clinical application.



24. Concurrent Radiographic Exam and Bone Mineral Density Assessments in an Upright Stereoradiography System: an Emerging Technology

Saba Pasha, PhD; Tyler Koski, MD; Craig McMains, MD; *Darryl Lau, MD*; Christopher I. Shaffrey, MD

Hypothesis
Bone mineral density (BMD) measurements of the frontal lumbar spine, calculated using a novel low-dose dual-energy(2E) stereoradiography system, are significantly correlated with conventional dual-energy X-ray absorptiometry (DEXA) BMD measurements.

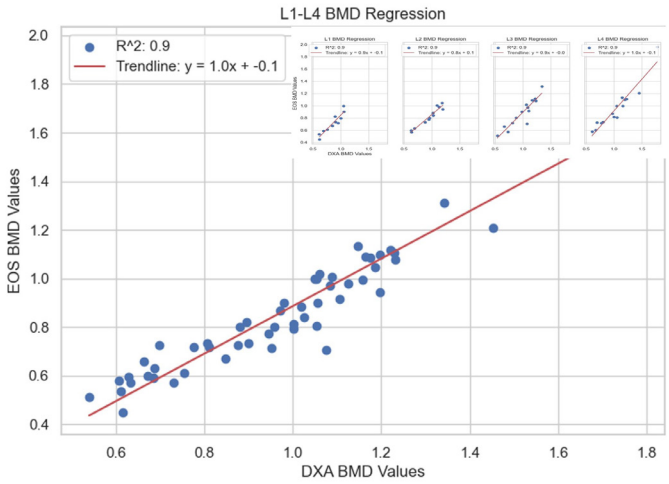
Design
Human cadaveric study

Introduction
While the role of biplanar, full-body, weight-bearing radiographic alignment measurements on patients' spinal health, surgical planning, and clinical care has been investigated, the application of BMD assessment in the treatment of spinal conditions is not well defined. A hindering factor in systematically including BMD in patients' clinical care is additional imaging requirements, increasing operational burden, and costs. DEXA, the current standard for BMD assessment, is needed in addition to clinical radiographic scans. Here for the first time, BMD measurements are compared between those computed from low-dose 2E stereoradiography and from conventional DEXA.

Methods
A total of 16 adult cadaveric torsos were scanned in a low-dose 2E stereoradiography system equipped with dual-energy photon counting technology and in a commercial DEXA system. An automated segmentation method identified vertebral bodies in the stereoradiographic system while a technician manually adjusted the pre-determined boundary of the vertebrae in DEXA as needed. The frontal lumbar (L1-L4) BMD values were computed for each and correlated statistically.

Results
A total of 10 male and 6 female cadavers were included (total 64 vertebrae). Vertebral bodies with large osteophytes (6 vertebrae) and cementoplasty (1 vertebra) were excluded, leaving 57 for analysis. There was a significant association between DEXA and stereoradiogaphy BMD values at all levels R2=0.9, p<0.05 (Fig.1).

Conclusion
The novel low-dose 2E stereoradiography system offers an efficient solution for clinical assessment of lumbar spine BMD. The system can provide radiographic and BMD assessment in one scan, integrating routine BMD measurements in patients' spinal care.



Correlation between L1-L4 BMD computed by DEXA and stereoradiography. Per level break-down is demonstrated in the subplot.

25. Safety Data for Robotics Coupled with Navigation for Pediatric Spine Surgery: Initial Intraoperative Results of a Prospective Multicenter Registry

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Hypothesis
Robotics coupled with navigation (RCN) for pedicle screw placement in pediatric spine surgery has a short-term complication profile equivalent to freehand screw placement.

Podium Presentation Abstracts

Design
Level I: prospective multicenter surgical outcomes registry

Introduction
The utilization of RCN in pediatric spine surgery remains a relatively novel approach. This registry evaluates intraoperative efficacy, potential challenges, and complications associated with RCN.

Methods
A review of prospectively consented patients who underwent surgery using RCN at six pediatric institutions from 2021-2023 was conducted. Patient demographics, surgical data, RCN data, technical difficulties, intraoperative and immediate postoperative complications were summarized.

Results
The registry consists of 186 patients averaging 15.1 years of age. Majority of patients are female (68%) with idiopathic scoliosis (60%). The mean preoperative major curve was 63° and total number of levels instrumented averaged 10.2. RCN levels averaged 6.4 (62%). RCN was mounted via spinous process clamp (80%) and posterior superior iliac spine pin (20%). RCN registration occurred an average of 1.2 times per patient. 38 patients had registration with preoperative CT (20%) and 146 had O-arm registration (79%). RCN was aborted due to failed registration in 2 cases (1%). Loss of registration was noted by safety check prior to drilling in 15 cases (8%). Technical difficulties with navigation occurred in 20 cases (11%) requiring recalibration. Inability to perform screw trajectories with RCN due to soft tissue pressure on the robotic arm occurred in 26 patients (14%). 3272 pedicle screws were placed. 1903 screws were executed with RCN (58%). 31 screws placed freehand were malpositioned (2.26%), with 4 medial breaches (0.29%) and 16 screws attempted with RAN were malpositioned (0.84%), with 3 medial breaches (0.16%). Based on granular screw data available for 124 patients, 297 in-out-in screw trajectories were attempted with RCN, of which 291 were executed successfully (98%). All malpositioned screws were redirected intraoperatively, thus no returns to the operating room for screw malposition were observed. There were no dural tears or neurologic deficits related to screw placement (Table 1).

Conclusion
Prospective multicenter data confirms retrospective studies outlining safety and efficacy of RCN-assisted pediatric spine surgery.

Table 1. Summary of cohort outcomes (N=186).

Characteristic	Freq.	(%)
Age *(years; mean (range))*	15.1	(8-21)
Female	126	68%
Idiopathic Scoliosis Diagnosis	112	60%
Preoperative Major Curve Angle *(degrees; mean (range))*	63	(33-116)
Total Instrumented Levels *(mean (range))*	10.2	(1-18)
RCN Instrumented Levels *(mean (range))*	6.4	(1-18)
Total Freehand Screws	1369	42%
Total RCN Screws	1903	58%
Successful Freehand Screws	1338	98%
Successful RCN Screws	1887	99%
Total Surgical Time *(minutes; mean (range))*	294.61	(101-1074)
Total RCN Time *(minutes; mean (range))*	29.06	(5-160)
Estimated Blood Loss (EBL) *(mL; mean (range))*	355.07	(0-2500)
Loss of Registration	15	8%
RCN Aborted – Failed Registration	2	1%
Return to Operating Room for Screw Malposition	0	0%
Dural Tears Related to Screw Placement	0	0%
Neurologic Complications Related to Screw Placement	0	0%
Immediate Postoperative Infections	2	1%

26. Analysis of 5,108 Consecutive Pedicle Screws Placed Utilizing Robotically-Assisted Surgical Navigation in 336 Patients: Surgical Safety and Early Perioperative Complications in Pediatric Posterior Spinal Fusion

Roger F. Widmann, MD; Jenna L. Wisch, BS; Colson P. Zucker, BA; Olivia Tracey, BA; Tyler Feddema; Florian Miller; Gabriel S. Linden, BA; Mark A. Erickson, MD; *Jessica H. Heyer, MD*

Hypothesis
Robotically-assisted pedicle screw placement has an acceptable safety profile with low complication rates

Design
Retrospective Review

Introduction
This is a retrospective evaluation of the safety profile and incidence of short-term surgical complications associated with robotically-assisted pedicle screw placement in a consecutive series of 360 pediatric patients undergoing posterior spinal fusion (PSF) at two tertiary hospitals.

Methods
We retrospectively reviewed 360 consecutive pediatric spinal deformity patients who underwent PSF with the assistance of robotic navigation for placement of pedicle screws at two institutions over three years (2020-2022). Surgery was performed by three surgeons, and a total of 5,525 screws placed utilizing robotic navigation were evaluated. The majority of the patients had idiopathic scoliosis (58.1%). We collected 1) intraoperative surgical complications, and 2) six-month postoperative complications.

Results
Intraoperative complications included one durotomy and four neurological injuries. The durotomy was due

to loss of registration during pedicle drilling, was noted at a depth of 12 mm, and was not associated with any neuromonitoring changes or neurological sequelae. The four neurological injuries were unrelated to pedicle screw placement: 3 peripheral nerve compression injuries related to positioning in the operating room (OR), and 1 lumbar plexus stretch injury below the fused/instrumented levels that fully resolved postoperatively without intervention. There were no spinal cord injuries and no vascular injuries. Evaluation of the 360 patients at six-months postoperatively revealed 0.56% (2/360) infections (both deep infections in patients with neuromuscular scoliosis), and 1.1% (4/360) unplanned return to OR (UPROR): 2 deep infection treatments, 1 for screw pull out that was unrecognized intraoperatively and occurred with rod reduction and was revised on POD4, and 1 for nonunion in a heavy smoker, which was revised at 3 years postoperatively). 0% neurological injuries related to screw placement, 0.28% (1/360) implant failures, 0.56% (2/360) delayed/non-union, and no deaths.

Conclusion
Robotically-assisted pedicle screw placement was performed reliably and safely at two centers by three surgeons in children as young as 7 years with an acceptable safety/complication profile and 1.1% (4/360) incidence of UPROR.

Characteristics	**N=360**	**%**
Sex		
Female	231	64.2
Male	129	35.8
Age (Mean, range), years	14.8 (7.6-22.9)	N/A
Diagnosis	**N**	**%**
Idiopathic Scoliosis	209	58.1
Scheuermann's Kyphosis	16	4.4
Congenital	11	3.1
Early Onset	4	1.1
Neuromuscular	73	20.3
Syndromic	28	7.8
Spondylolisthesis	11	3.1
Trauma	3	0.8
Other	5	1.4

Demographics

27. Assessing The Reproducibility of The Structured Abstracts Generated by ChatGBT and Bard Compared to Human-Written Abstracts in The Field of Spine Surgery: a Comparative Analysis of Scientific Abstracts Between Artificial Intelligence and Human

Dong-Gune Chang, MD, PhD; Hong Jin Kim, MD; Jae Hyuk Yang, MD, PhD; Lawrence G. Lenke, MD; Javier Pizones, MD, PhD; René M. Castelein, MD, PhD; Kota Watanabe, MD, PhD; Per D. Trobisch, MD; Gregory M. Mundis Jr., MD; Seoung Woo Suh, MD, PhD; Se-Il Suk, MD, PhD

Hypothesis
Due to recent advances in artificial intelligence (AI), language model applications such as ChatGPT and Bard can generate logical text output that is difficult to distinguish from human writing.

Design
A cross-sectional study.

Introduction
The use of AI to write scientific abstracts in the field of spine surgery is the center of much debate and controversy. Therefore, this study is to assess the reproducibility of the structured abstracts generated by ChatGPT and Bard compared to human-written abstracts in the field of spine surgery.

Methods
Sixty abstracts dealing with spine sections were randomly selected from seven reputable journals and used as ChatGPT and Bard input statements to generate abstracts based on supplied article titles. Eight reviewers in the spinal field evaluated 30 randomly extracted abstracts to determine whether they were produced by AI or human authors.

Results
The proportion of abstracts that met journal formatting guidelines was greater among ChatGPT abstracts (56.6%) compared with those generated by Bard (11.1%) ($p < 0.001$). However, a higher proportion of Bard abstracts (90.7%) had word counts that met journal guidelines compared with ChatGPT abstracts (50%) ($p < 0.001$). The cohort sample size in the human group was significantly correlated with that of the ChatGPT group ($r = 0.955$, $p < 0.001$) and Bard group ($r = 0.998$, $p < 0.001$). The plagiarism rate was significantly lower among ChatGPT-generated abstracts (20.7%) compared with Bard-generated abstracts (32.1%) ($p < 0.001$). A sensitivity of 56.3% and a specificity of 48.4% were shown in assessing human-written abstracts by human reviewers.

Conclusion
Both ChatGPT and Bard can be used to help write abstracts, but most AI-generated abstracts are currently considered unethical due to high plagiarism and AI-detection rates. ChatGPT-generated abstracts appear to be superior to Bard-generated abstracts in meeting

journal formatting guidelines. Because humans were unable to accurately distinguish abstracts written by humans from those produced by AI programs, it is crucial to special caution and examine the ethical boundaries of employing the AI programs including ChatGPT and Bard.

Study flowchart

28. 4.5 Mm Molybdenum-Rhenium Rods Use in Adult Spinal Deformity Have a 0% Incidence of Rod Fractures at 2-Year Follow-Up: A Multicenter Retrospective Review

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Hypothesis

A 4.5mm molybdenum-rhenium(MoRe) rod will have adequate performance and durability in complex spine surgeries.

Design

Retrospective, multicenter, case series study

Introduction

The rate of rod fractures at 2-year f/u with 5.5mm Ti-6Al-4V and CoCr rods is reported to be between 9-23%. This rate increases to 20-33% with the addition of three column osteotomies (PSO & SPO). Rod fractures have significant morbidities for patients, including pain, loss of deformity correction, and the physiological stress of revision surgery. Molybdenum-47.5 Rhenium (MoRe®) has demonstrated superior mechanical performance when compared to Ti-6Al-4V and CoCr. At the same rod diameter, MoRe rods have significantly higher yield strength and fatigue life compared to Ti-6Al-4V and CoCr. MoRe rods survive out to over 10M cycles while traditional rods often fracture at 4-6M cycles. In addition, a smaller diameter MoRe rod (4.5mm) is significantly less stiff when compared to a 5.5mm Titanium or CoCr rod yet provides superior yield strength and fatigue life.

Methods

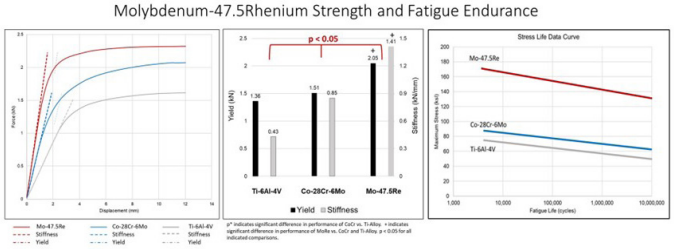
Retrospective review of 159 consecutive patients from 10 independent spinal surgical facilities undergoing multilevel complex surgical procedures with 4.5 mm MoRe rods. Inclusion criteria: ≥ 4 levels posterior instrumented fusion, Age ≥ 18 years and 2 year or longer with radiographic and clinical follow-up.

Results

One hundred and fifty-nine (159) consecutive patients from ten (10) different medical centers that had spinal surgery from August 2019 until April 2022 met the inclusion criteria. The patients' mean age was 63 ±11.8 years; 50% were women; 31% were smokers; 19% were diabetic and the mean body mass index (BMI) was 30 ±7.3. The mean number of levels fused was 5.9 ±2.7; 22.6% were 4 levels, 64.2% were 5-9 levels and 13.2% were 10 levels or greater. Approximately half were thoracolumbar or thoracolumbar to pelvis (27.7% thoracolumbar, 24.5% thoracolumbar to pelvis) and approximately half (47.2%) were lumbar-sacral. Thirty-eight (38) patients (24%) had a pedicle subtraction osteotomy (PSO) and 59 patients (39%) had a Smith Peterson Osteotomy (SPO). All cases were done only with molybdenum-rhenium 4.5mm diameter rods. There were no RFs reported in the 159 cases (0/159; 0.0%) at a mean follow-up of 22.36 months [range 12.23–44.93 months; 1 yr: 94 (59.1%), 2 yrs or >: 65 (40.9%)]

Conclusion

At similar rod diameters, a MoRe rod has significantly higher yield strength and fatigue endurance compared to Ti-6Al-4V and CoCr rods. Smaller diameter MoRe rod (4.5mm) is significantly less stiff when compared to a 5.5mm Ti-6Al-4V or CoCr rod. Because of the performance of the MoRe alloy, it is now possible to use smaller, lower profile spine constructs including smaller diameter rods (4.5mm) in complex spine surgery without sacrificing mechanical performance. With rod failures rates at approximately 10% (and up to 33% when including osteotomies) one would anticipate between 16-30 rod failures with the use of 5.5mm CoCr and Ti-6Al-4V rods. In this series using 4.5 mm MoRe rods with 2-yr follow-up , a 0% incidence of rod failures were seen at 2-year follow-up in the 159 consecutive patients who underwent complex spine surgery involving multiple levels and osteotomies. A low profile pedicle screw system based upon molybdenum-rhenium (MoRe) 4.5mm rods provides superior fracture resistance particularly in complex spine procedures.



MoRe Strength, Stiffness and Fatigue Life

Podium Presentation Abstracts

29. Short Posterior Spinal Fusion and Preventive Methods for Proximal Junctional Kyphosis in Adult Spinal Deformity

Jung-Hee Lee, MD, PhD; Ki Young Lee, MD, PhD; Kyung-Chung Kang, MD, PhD; Won Young Lee, MD; Seong Jin Cho, MD; Cheol-Hyun Jung, MD; Gil Han, MD; Hong-Sik Park, MD; *Woo-Jae Jang, MD*; Min-Jeong Park, RN

Hypothesis
Construct stiffness and back muscle atrophy may act as a risk factor for proximal junctional kyphosis (PJK) in short posterior spinal fusion (PSF) combined with anterior surgery of drop body syndrome (DBS) patients with low pelvic incidence (PI) and compensatory thoracolumbar (TL) lordosis.

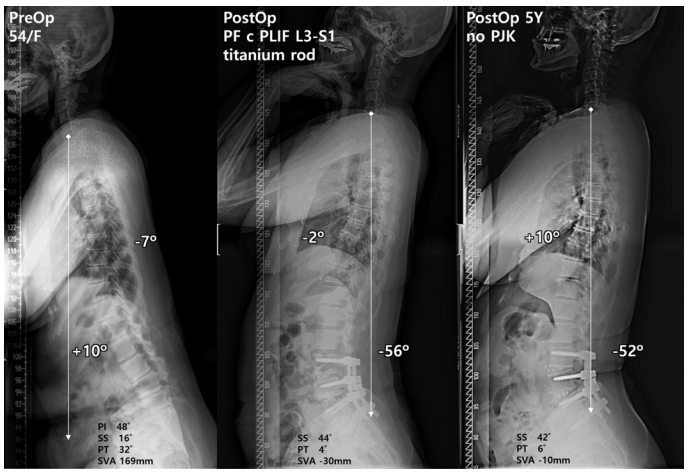
Design
A retrospective study.

Introduction
In DBS patients with low PI and compensatory TL lordosis, short PSF combined with anterior surgery can restore sagittal malalignment. However, studies regarding PJK after short PSF are lacking. The purpose of this study was to analyze short PSF for preventing PJK in DBS patients.

Methods
We retrospectively selected 72 consecutive patients (mean age 66.6 years) who underwent short PSF (uppermost instrumented vertebra [UIV]; L1 36pts, L2 23pts, and L3 13pts). The minimum follow-up period was 2 years. A comparative analysis was conducted by dividing the patients into two groups: non-PJK group and PJK group.

Results
PJK occurred in 35 (48.6%) of all patients. Postoperative spinopelvic parameters such as PI (50.4° vs. 50.6°), PI-LL (2.1 vs. 4.3) and LL (-51.1° vs. -48.7°) had no significant differences. The PJK group showed a significantly smaller fused spinopelvic angle (FSPA; 9.8° vs. 6.3°, p=0.045). PJK occurred more frequently with cobalt chrome rods than with titanium rods (57.8% vs. 33.3%, p=0.045), and with the application of sacropelvic fixation (63.2% vs. 32.4%, p=0.011). The higher UIV (L1 58.3%, L2 47.8%, and L3 23.1%) and a greater extent of fatty atrophy of back muscle led to a higher risk of PJK (p=0.044, 0.033, respectively). By logistic regression analysis, the greater negative value of FSPA and application of sacropelvic fixation were crucial risk factors of PJK (p<0.05).

Conclusion
For DBS patients with low PI and compensatory TL lordosis, short PSF could effectively restore sagittal balance. To that end, obtaining appropriate FSPA and utilizing less stiff construct must be taken into consideration to prevent PJK. Moreover, application of short PSF should be carefully considered, especially in patients with severe back muscle atrophy.



30. Preoperative Radiographic Parameters Versus 24-Month Clinical Success in Decompression and Sagittal Tether Stabilization or TLIF for Degenerative Spondylolisthesis

Todd Alamin, MD; William F. Lavelle, MD; Louis C. Fielding, MD; *Javier Castro, MD*; Serena S. Hu, MD

Hypothesis
Dynamic sagittal thether stabilization do not associate with radiographic predictors of failure in standalone decompression for degenerative spondylolisthesis

Design
Cohort prospective study, ongoing FDA IDE study (NCT03115983)

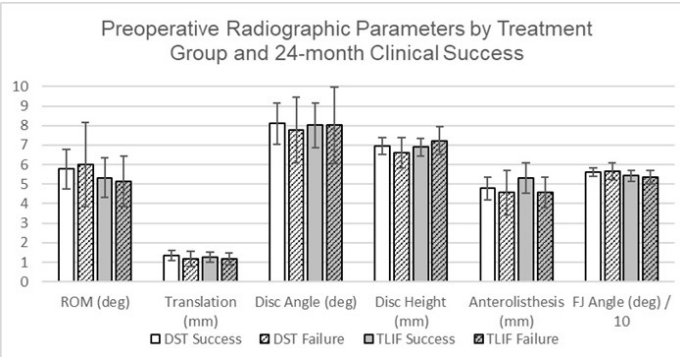
Introduction
Radiographic parameters are proposed as predictors for failure in standalone decompression for symptomatic degenerative spondylolisthesis (DS). Dynamic sagittal tethering (DST) is a motion-preserving stabilization device. An FDA IDE study (NCT03115983) comparing decompression with DST or transforaminal lumbar interbody fusion (TLIF) is conducted. This analysis assesses radiographic parameters as predictors of failure in both groups at 24 months follow up.

Methods
Patients with Grade I DS and symptomatic stenosis, ODI≥35, VAS leg/hip≥50, and age 25-80 (eligibility criteria at clinicaltrials.gov) are presented. No violations of per-protocol population eligibility criteria were considered. Preoperative radiographic parameters of segmental range of motion (ROM), translation, segmental lordosis (SL), Disc height (DH), anterolisthesis, and facet joint angle (FJA) were compared for the DST and TLIF subgroups determined to be composite clinical successes or failures at 24mo.

Results
246 patients were included. Overall, 24-month composite clinical success rate was 80.3% (106/132) in the DST group and 60.5% (69/114) in the TLIF. No significant differences in preoperative radiographic param-

eters in DST group for clinical success/failure regarding DH (7.0±2.0 v/s 6.6±1.8; p=.38), FJA (56.3±10 v/s 56.6±9.9; p=.71), anterolisthesis (4.8±2.6 v/s 4.6±2.6; p=.71), ROM (5.8±4.6 v/s 6.0±4.8; p=.83), translation (1.3±1.1 v/s 1.2±0.9; p=.46), SL (8.1±4.8 v/s 7.8±3.8; p=.69) were found. No differences were found in the TLIF group in ROM (5.3±3.6 v/s 5.1±3.6; p=.81), translation (1.3±0.9 v/s 1.2±0.9, p=.67), SL (8.0±5.2 v/s 8.0±5.8; p=.992), DH (6.9±1.7 v/s 7.2±2.1; p=.38) or anterolisthesis (5.3±2.8 v/s 4.6±2.2; p=.14).

Conclusion
No association between preoperative radiographic parameters and clinical success in DST or TLIF groups were found. Failures in the DST group were not associated with higher preoperative translation, DH, anterolisthesis or FJA, as has been seen in stand-alone decompression.



Preoperative Radiographic Parameters by Treatment group and 24-month Clinical Success

31. Radiographic Analysis of Early Changes in Upper Adjacent Segments After Fusion Surgery: OLIF vs PLIF

JooYoung Lee, MD; *Jae Hwan Cho, MD, PhD*; Sehan Park, MD; Chang Ju Hwang, MD, PhD; Dong-Ho Lee, MD, PhD

Hypothesis
Excessive disc height elevation leads to radiographic deterioration of the upper segment such as retrolisthesis, heperlordosis, or foraminal narrowing.

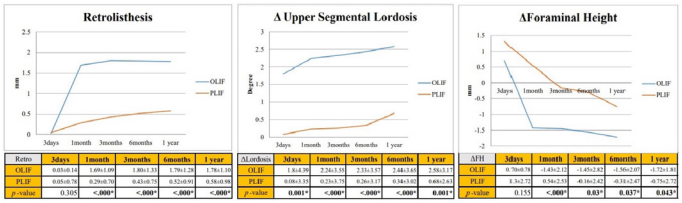
Design
Retrospective comparative study

Introduction
Recently, oblique lumbar interbody fusion(OLIF) is one of the most frequently performed lumbar fusion surgery techniques. The purpose of this study was to compare the early radiological changes of the upper adjacent segment between OLIF and posterior lumbar interbody fusion (PLIF).

Methods
Between 2013 and 2020, a group P(PLIF, n=131) and a group O(OLIF, n=65) were recruited as matched pairs. Each patient underwent plain upright whole spine lateral radiography preoperatively, 3 days, 1, 3, 6 months, and 1 year postoperatively. Radiographic outcomes (lumbar lordosis, upper adjacent segmental lordosis, retrolisthesis, and foraminal height) were measured at each time point. Patient-reported outcome measures were obtained preoperatively and 1-year follow-up.

Results
Group O was superior to group P with respect its capability to restore lumbar lordosis(O: 4.03°±4.38, P: 1.63°±5.11, p=0.001) and surgical segmental disc height(O: 5.50mm±3.39, P: 2.71mm±2.18, p<0.001) in 1 year after surgery. However, group O showed an increase in upper adjacent segmental lordosis at 3 days postoperatively(O: 1.8°±4.39, P: 0.08°±3.35, p=0.001) and showed a significant increase in the incidence(O: 76.9%, P: 24.6%, p<0.001) and degree of retrolisthesis(O: 1.69mm±1.09, P: 0.29mm±0.70, p<0.001) of the upper adjacent segment, and a decrease in the foraminal height of the upper adjacent segment(O: -1.43mm±2.12, P: 0.54mm±2.53, p<0.001) at 1month postoperatively.

Conclusion
OLIF shows superior ability to PLIF in recovery of lumbar lordosis and surgical segmental disc height. However, it causes radiographic deterioration in retrolisthesis, segmental lordosis, and foraminal height of the upper adjacent segment after surgery. During fusion surgery, it should be considered that excessive increase in disc height and lumbar lordosis of the surgical segment may cause early degenerative changes due to stress in the upper adjacent segment. Although it was not possible to confirm the clinical difference related to this in short-term follow-up observation, attention should be paid to the difference to be brought about in long-term follow-up observation.



Retro	3days	1month	3months	6months	1 year
OLIF	0.03±0.14	1.69±1.09	1.80±1.33	1.79±1.28	1.78±1.30
PLIF	0.05±0.78	0.29±0.70	0.43±0.75	0.52±0.91	0.58±0.98
p-value	0.305	<.000*	<.000*	<.000*	<.000*

ΔLordosis	3days	1month	3months	6months	1 year
OLIF	1.8±4.39	2.2±3.55	2.33±3.57	2.44±3.65	2.58±3.17
PLIF	0.08±3.35	0.23±3.78	0.26±3.37	0.34±3.02	0.68±2.63
p-value	0.001*	<.000*	<.000*	<.000*	0.001*

ΔFH	3days	1month	3months	6months	1 year
OLIF	0.70±0.78	-1.43±2.12	-1.45±2.82	-1.56±2.07	-1.72±1.81
PLIF	1.3±2.72	0.54±2.53	0.16±2.42	-0.31±2.47	-0.75±2.72
p-value	0.155	<.000*	0.03*	0.037*	0.043*

Comparison of postoperative radiological outcomes of upper adjacent segment between Groups O and P

32. One-Third of Surgical Adult Spinal Deformity (ASD) Patients Are Consuming Opioids Pre- and Postoperatively with Significant International Differences: This is a Cultural Issue

Brett Rocos, MD; Juan Sardi, MD; Jeffrey L. Gum, MD; Anastasios Charalampidis, MD; Stephen J. Lewis, MD, FRCS(C)

Hypothesis
There are substantial regional differences with regards to opioid use before and after ASD surgery.

Design
Post-hoc analysis of prospective multicenter international ASD surgical database.

Podium Presentation Abstracts

Introduction
Amidst a current opioid epidemic, it is important for providers to understand variables that contribute to sustained opioid use after ASD surgery. Our goal was to evaluate international variation in pre- and postoperative opioid consumption, with the hypothesis that there are substantial regional differences with regards to opioid use before and after ASD surgery

Methods
Patients ≥ 60 years of age from 12 international centers undergoing spinal fusion of at least 5 levels for spinal deformity were included. Pain scores were collected using a Numeric Rating Scale (NRS) for both back and leg pain. Opioid use was defined as the consumption of prescribed opioid drugs and from question 11 from the SRS 22r questionnaire. Scores were collected at baseline and 2-yrs. Centers were divided into North America (NA), Europe (E), and Asia (A).

Results
219 eligible patients were identified, of which 179 patients had data available at 2 year follow up. 176 (80.4%) were females with a mean age of 67.5 yrs. A similar number of patients were using preoperative opioids (OP, 75/219 [34%]) as those using them post operatively (55/179 [30%]) at 2-years. 5.8% and 7.7% of A patient were taking opioids pre- and postoperatively respectively, whereas 58.3% and 53.2% of E patients were consuming them. Equivalent data for NA patients were 50.5% and 40.2%. There was no difference in NRS-B or NRS-L for E patients at baseline or 2-yrs regardless of opioid use. Patients using opioids at baseline had worse mean NRS-L scores (7.6 vs 4.2, p-0.023). There was no difference in the baseline NRS-B or 2-yr NRS-B or -L scores. NA patients using opioids had worse baseline NRS-B (6.6 vs 5.5,p-0.003) and NRS-B (3.3 vs 1.4,p-0.001) and NRS-L (2.6 vs 1.0,p-0.007) at 2 years.

Conclusion
Almost 1/3 of surgical ASD pts are consuming opioids both pre- and postoperatively world-wide. There is a drastic international difference, with Asia having a much lower usage rate suggesting a cultural influence. Efforts to understand these cultural perceptions and opioid consumption can potentially help minimize sustained opioid use after ASD surgery.

33. Single-Level ALIF/ILIF and TLIF Are Associated with Identical Rates of All-Cause Subsequent Lumbar Surgery

Nakul Narendran, BS; Paal K. Nilssen, BS; David L. Skaggs, MD, MMM; Alexander Tuchman, MD

Hypothesis
When using a washout period to account for planned staged procedures, reoperation rates will be similar after ALIF/LLIF vs. TLIF, contradicting recent database literature.

Design
Retrospective cohort

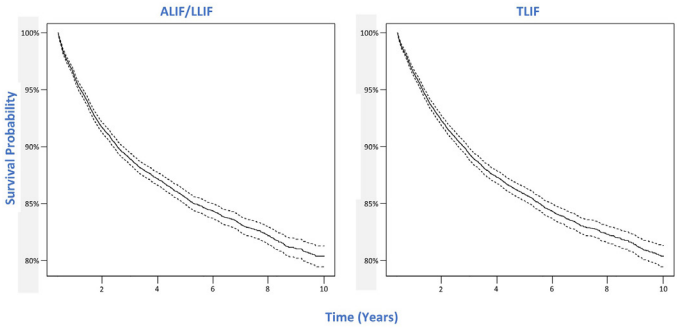
Introduction
Anterior and lateral lumbar interbody fusion (ALIF/LLIF) and transforaminal lumbar interbody fusion (TLIF) are widely used for degenerative disc disease. They have high rates of reoperation primarily related to adjacent segment pathology and pseudarthrosis. This study compares reoperation rates and complications following single-level ALIF/LLIF and TLIF with same-day posterior instrumentation.

Methods
The PearlDiver database was queried for patients (2010-2021) who had single-level ALIF/LLIF or TLIF with posterior instrumentation. All patients were followed for ≥2 years and excluded if they had spinal traumas, fractures, infections, or neoplasms prior to surgery. The two cohorts, ALIF/LLIF and TLIF, were matched 1:1 based on age, sex, ECI, smoking, and diabetes. The primary outcome was all-cause subsequent lumbar surgery. Secondary outcomes included 90-day surgical complications. Categorical variables were compared with Chi-squared tests, and continuous variables with t-tests.

Results
A total of 62,291 patients met inclusion and exclusion criteria (n=14,673 ALIF/LLIF; n=47,618 TLIF). After 1:1 matching, each cohort contained 14,070 patients. Mean follow-up was 5.92 (±2.62) years. All-cause subsequent surgery was identical at 5-year follow-up (13.8%, p=1). When categorized by specific procedure, 1-year follow-up revealed TLIF had more exploration of fusions (0.7% vs. 1%, p=0.02). 5-year follow-up revealed TLIF had more arthrodesis procedures (6.5% vs. 7.3%, p =0.03) and reinsertion of fixation devices (1.3% vs. 1.7%, p =0.02), while ALIF/LLIF had more removals of instrumentation (3.1% vs. 2.5%, p =0.002). Within 90 days, TLIF had more infections (1.3% vs. 1.7%, p=0.007) and dural injuries (0.2% vs. 0.4%, p=0.001). There was no difference in wound dehiscence, hardware complications, or medical complications.

Conclusion
As utilized in real-world clinical practice, anterior versus posterior approach for interbody fusion has no effect on long term reoperation rates. TLIF patients faced a higher risk of infection and dural injury.

Podium Presentation Abstracts



Survival analysis for ALIF/LLIF vs. TLIF using all-cause subsequent lumbar surgery as the endpoint showed an equivalent 10-year survival rate of 80.4% (95% CI: 79.5-81.3).

34. The Impact of Revisions on 5-Year Proms: An Analysis from the QOD Spondylolisthesis Data

Steven D. Glassman, MD; *Leah Y. Carreon, MD*; Mladen Djurasovic, MD; Andrew K. Chan, MD; Erica F. Bisson, MD, MPH; Mohamad Bydon, MD; Kevin T. Foley, MD; Christopher I. Shaffrey, MD; Eric A. Potts, MD; Mark E. Shaffrey, MD; Domagoj Coric, MD; John J. Knightly, MD; Paul Park, MD; Michael Y. Wang, MD; Kai-Ming G. Fu, MD, PhD; Jonathan R. Slotkin, MD; Anthony L. Asher, MD; Michael S. Virk, MD, PhD; Panagiotis Kerezoudis, MD, MS; Jian Guan, MD; Dean Chou, MD; Regis W. Haid Jr., MD; Praveen V. Mummaneni, MD, MBA

Hypothesis
The purpose of this study is to report on the incidence and types of revision surgeries in patients undergoing decompression only or decompression and fusion for grade 1 spondylolisthesis

Design
Retrospective analysis of prospectively collected data.

Introduction
A small but important number of patients treated surgically for grade 1 spondylolisthesis require revision surgery. These procedures encompass a variety of indications including infection, nonunion, or adjacent level pathology. The goal of this study is to determine how the need for revision impacts patient reported outcomes (PROMs) at five-year follow-up.

Methods
Patients in the 14 highest enrolling QOD with grade 1 spondylolisthesis and 80% five-year follow-up were studied. PROMs were compared between cohorts requiring revision surgery versus a single index procedure.

Results
Five-year follow-up data was available in 80% of cases enrolled. The revision rate in patients treated by decompression only (13/140, 10%) and by decompression and fusion (31/468, 6%) were similar (p=0.271). There were no revision surgeries in the Decompression only group at 30 days. The most common reason for reoperation at 30 days was irrigation and debridement (5/10) in the D+F group. The most common reason for reoperation at 1 year was repeat decompression (7/8) in the Decompression only group and ASD (3/6) in the D+F group. The most common reason for reoperation at 2 years was ASD (2/3) in the Decompression only group and ASD (3/6) in the D+F group. The most common reason for reoperation at 3 years was ASD (2/2) in the Decompression only group and non-union (4/6) in the D+F group. For the entire cohort, patients requiring revision were significantly worse at five years in terms of ODI (33.8 vs 21.5, p=0.001), BP (5.0 vs 3.2, p=0.002) and LP (4.5 vs 2.5, p=0.001). However, revision patients had lower baseline PROMs such that the amount of improvement between the cases that were revised compared to those who were not were similar (ODI:Δ17.5 vs Δ24.0, p=0.063, BP:Δ3.2 vs Δ4.0, p=0.256, LP: Δ2.6 vs Δ3.9, p=0.055). For patients who had decompression only as an index procedure, five-year PROMs were equivalent in the two groups (ODI:24.5 vs 22.7, p=0.795, BP:3.9 vs 3.3, p=0.699, LP:2.3 vs 2.4, p=0.820). For cases who had a decompression and fusion there was similar improvement in BP (Δ3.1 vs Δ4.4, p=0.120) but significantly less ultimate improvement in LP (Δ1.50 vs Δ4.0, p=0.002) and ODI (Δ16.2 vs Δ26.6, p=0.004).

Conclusion
Patients undergoing surgical treatment for spondylolisthesis with decompression or decompression and fusion showed improvement in PROMs five years after the index procedure. The need for revision surgery resulted in modestly diminished benefit. These differences were greater in the fusion cohort compared to the decompression only cohort.

35. Lumbar Vertebral Body Tethering: Single Center Outcomes and Reoperations in a Consecutive Series of 106 Patients

Alan Stein, MD; *Amer F. Samdani, MD*; Alexander J. Schupper, MD; Zan Naseer, MD; Ronit Shah, BS; Sabrina Zeller, MD; Joshua M. Pahys, MD; Solomon Samuel, D. Eng.; Alejandro Quinonez, BS; Steven W. Hwang, MD

Hypothesis
Lumbar anterior vertebral body tethering (AVBT) will allow a majority of patients to avoid spinal fusion while improving the major coronal curve.

Design
Single center retrospective

Introduction
Anterior vertebral body tethering (AVBT) is a viable option for children with idiopathic scoliosis. The benefit of motion preservation must be balanced with a higher reoperation rate. When considering the importance of motion in the lumbar spine in contrast to

the thoracic region, motion preservation afforded by AVBT becomes more significant. However, a paucity of reports have addressed lumbar AVBT.

Methods
A single center retrospective study was conducted to identify all patients who underwent lumbar AVBT (lowest instrumented vertebra L3 or L4) with minimum 2 years of follow-up. Clinical and radiographic parameters were collected including complications and re-operations. Statistical analysis was performed utilizing Students' t-test of qualitative variables.

Results
From a dataset of 551 patients, we identified 106 patients (89% female) who underwent a lumbar AVBT (33 lumbar only, 73 bilateral thoracic/lumbar) with mean follow-up of 4.1 ± 1.6 years at which point 85% (90/106) had reached skeletal maturity. Preoperatively, these patients were skeletally immature (age: 12.8 ± 1.3 years, Sanders: 3.3 ± 0.8, R=0.6 ± 0.9) with a lumbar coronal curve angle of 49.6° ± 11.2 which corrected to 19.9° ± 11.2 ($p < 0.0001$) at most recent follow-up. At latest follow-up, 76.4% (81/106) of patients had a coronal curve angle measuring < 30°. 20 patients (18.9%) underwent 23 reoperations with overcorrection being the most common cause (10/23, 43%). Broken tethers led to re-operation in 3 instances (3/23, 13%). Six patients in the cohort needed a posterior spinal fusion (6/106, 5.4%).

Conclusion
AVBT has emerged as a viable treatment option for skeletally immature patients with idiopathic scoliosis. The high reoperation rate must be balanced with motion preservation, the significance of which is paramount in the lumbar spine. This report is the largest to date for lumbar AVBT, with 84% of patients having a curve measuring < 35° at latest follow-up, but with an 18.9% reoperation rate. Surgeons can use these data to ensure that patients and their families make an informed decision regarding treatment options.

36. Effects of Natural Standing on Biomechanical and Diffusion Properties of Unfused Lumbar Intervertebral Discs in AIS Patients 5 Years After Fusion. A Serial MRI Post Contrast Diffusion Study in Supine and Standing

J. Naresh-Babu, MS

Hypothesis
Disc immediately below the long fusion (Fusion–1) exhibited significant alterations in diffusion patterns and multiple endplate breaks, with a notable reduction in disc diffusion on standing.

Design
Retrospective Study

Introduction
Adolescent Idiopathic Scoliosis (AIS) patients managed with Posterior Spinal Fusion (PSF) often experience intervertebral disc degeneration in the distal unfused lumbar segments.We aim to analyze the biomechanical and diffusion properties of the unfused lumbar discs, utilizing positional MRI in both supine and standing postures, and investigate solute transport changes occurring 5 years after fusion.

Methods
Our study group comprises 10 AIS patients who underwent PSF more than five years ago. We conducted radiographic evaluations, including plain and contrast-enhanced MR imaging of the lumbar spine in both supine and standing positions. After intravenous gadodiamide injection, we captured serial MR T1 weighted images at 2, 4, 6, 12, and 24 hours in both positions and measured the signal intensity of various parts of discs.

Results
No significant biomechanical changes were noted, the unfused lumbar disc immediately below the fusion (Fusion–1) exhibited significant alterations in solute transport properties compared to the distal unfused segments (fusion-2 onwards). Fusion–1 displayed a double-peak pattern of enhancement with multiple endplate breaks in both supine and standing positions. Interestingly, the peak enhancement percentage decreased by approximately 50% on standing, suggesting a leaky endplate-disc-contact zone. Unlike Fusion–1, these discs exhibited a 50% increase in peak enhancement percentage on standing, suggesting healthy disc diffusion.

Conclusion
Our study highlights the effects of long fusion on the unfused intervertebral discs 5 years post-fusion. While degeneration changes were not apparent on MRI in either supine or standing positions, the disc immediately below the long fusion (Fusion–1) exhibited significant alterations in diffusion patterns and multiple endplate breaks, with a notable reduction in disc diffusion on standing. This study is the first of its kind to document diffusion pattern alterations in both supine and standing positions in unfused lumbar segments

37. Improvement in Axial Rotation with Bracing Reduces Risk of Curve Progression in Patients with Adolescent Idiopathic Scoliosis

Michael Fields, MD; Christina C. Rymond, BA; Matan Malka, BA; Ritt Givens, BS; Matthew Simhon, MD; Hiroko Matsumoto, PhD; Gerard F. Marciano, MD; Afrain Z. Boby, MS, BS; Benjamin D. Roye, MD, MPH; *Michael G. Vitale, MD, MPH*

Hypothesis
Adolescent Idiopathic Scoliosis (AIS) patients with large in-brace axial vertebral rotation (AVR) and/or poor improvement in AVR with bracing would have increased risk of treatment failure.

Design
Single-center retrospective cohort

Introduction
While in-brace coronal plane correction is commonly used as a proxy for brace efficacy, emerging evidence supports the importance of three-dimensional (3D) in brace correction for AIS patients. This study investigated the relationship between axial plane parameters and treatment failure in patients undergoing brace treatment for AIS.

Methods
AIS patients (Sanders 1-5) undergoing Rigo Chêneau bracing at a single institution were included. AVR was determined by utilizing pre-brace and in-brace (3D) spinal reconstructions based on biplanar low dose EOS® radiographs. The primary outcome was treatment failure defined as coronal curve progression >5°. Minimum follow-up was two years.

Results
75 patients (61/75, 81% female) were included in the final cohort. Mean age at bracing initiation was 12.8±1.3 years and patients had a pre-brace major curve of 31.0°± 6.5°. 25 (33%; six male, 19 female) patients experienced curve progression >5°, and 18/25 required surgical intervention. The treatment failure group had larger in-brace absolute AVR than the success group (5.8°±4.1° vs. 9.9°±7.6°, p=0.003), but also larger initial coronal curve measures. The magnitude of in-brace AVR did not appear to be associated with treatment failure after adjusting for pre-brace major curve (Hazard Ratio (HR): 0.99, 95% Confidence Interval (CI): 0.94-1.05, p=0.833). After adjusting for pre-brace major coronal curve, patients with improvement of AVR with bracing had an 85% risk reduction in treatment failure versus those without improvement (HR: 0.15, 95% CI: 0.02-1.13, p=0.066). At final follow-up, 42/50 (84%) patients who did not progress had a Sanders≥7.

Conclusion
While absolute in-brace rotation was not an independent predictor of curve progression (due to its correlation with curve magnitude), improved AVR with bracing was a significant predictor of curve progression. This study is the first step toward investigating the interplay between three-dimensional parameters, skeletal maturity, compliance, and brace efficacy, setting the stage for a future prospective multicenter study with adequate design and power.

		Treatment Failure		
		No (N=50)	Yes (N=25)	P-Value
Age an Initiation of Bracing (age; mean ± SD)		12.9 ± 1.3	12.5 ± 1.4	0.171
Gender (N (%))	Female	42 (84%)	19 (76%)	0.402
	Male	8 (16%)	6 (24%)	
Sanders Stage (N (%))	2	4 (8%)	6 (24%)	0.097
	3	30 (60%)	11 (44%)	
	4	9 (18%)	7 (28%)	
	5	7 (14%)	1 (4%)	
CORONAL PLANE				
Pre-Brace Major Curve (°; mean ± SD)		28.4 ± 5.2	36.3 ± 5.9	<0.001
In-Brace Major Curve (°; mean ± SD)		16.2 ± 5.8	25.3 ± 7.4	<0.001
Pre to In-Brace Major Curve Correction (°; mean ± SD)		12.2 ± 6.5	11.0 ± 6.2	0.434
In-brace C7-CSVL (cm; mean ± SD)		13.0 ± 10.0	20 ± 15	0.017
In-brace Pelvic Obliquity (°; mean ± SD)		5.0 ± 3.7	5.3 ± 2.8	0.732
AXIAL PLANE				
|In-brace Major Curve Axial Rotation| (°; mean ± SD)		5.8 ± 4.1	9.9 ± 7.6	0.003

Baseline characteristics of treatment failure vs success group

38. Initial Outcomes of Posterior Dynamic Distraction Device Compared to Vertebral Body Tethering for Adolescent Idiopathic Scoliosis

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Hypothesis
We hypothesized that the posterior dynamic distraction device would result in shorter length of stay and reduced operative time compared to vertebral body tethering.

Design
Matched multicenter comparative study.

Introduction
Non-fusion procedures are growing in use for the AIS treatment. Two devices received limited HDE approval for clinical use by the US FDA in 2019. Although treatment indications are similar, to our knowledge, there is no multicenter comparative study of the perioperative outcomes for these two devices.

Methods
AIS patients who met FDA HDE criteria for PDDD were prospectively enrolled in this matched multicenter comparative study. Inclusion criteria were the diagnosis of Lenke 1/5 AIS, Cobb angle 35-60 degrees with correction to less than or equal to 30 degrees on lateral bend and minimal thoracic kyphosis. These patients were matched by age, gender, Risser score, curve type, and curve magnitude to a single-center cohort of prospectively enrolled VBT patients, and perioperative results were compared up to 1-year follow-up.

Results
23 PDDD patients were matched to 23 VBT patients. There was no difference in preoperative major Cobb angle (46 vs. 47 degrees, p=0.5), age (13.2 vs. 13.0, p=0.6), curve type (90% thoracic for both groups, p=1.0), Risser or gender. Mean blood loss was significantly higher in the VBT cohort (90 ml vs. 35 ml for

PDDD, p=0.0064). Mean operative time was longer in the VBT cohort, 173 min vs. 113 min for PDDD (p<0.0001), as was length of stay (3.0 days vs. 1.2, p<0.0001). Initial postoperative major Cobb angle and % correction at 6 months was improved in the PDDC cohort (15 vs. 24 degrees, p=0.0001; 67% vs. 48%, p=0.0003). One PDDD patient required an ICU stay. At 1-year follow-up the patients in the PDDD cohort had improved Cobb (15 vs. 21, p=0.001) but no significant difference was seen in kyphosis between the two (34 vs. 31, p=0.22). At latest follow-up, one VBT patient was readmitted with a pleural effusion, one underwent cord release due to overcorrection, and 2 PDDD patients had revision of the device.

Conclusion
Prospective perioperative outcomes demonstrate better index correction and reduced operative time, blood loss, and length of stay in PDDD compared to a matched cohort of VBT patients within one-year post-operation. Further data on long-term functional benefits and durability are needed.

Table 1: Matched outcomes of PDDD and VBT patient cohorts.

	PDDC (N=23) (Apifix MID-C)	VBT (N=23) (ZimVie The Tether)	P-value
Preop Coronal Curve	46 (5)	47 (5)	0.54
6 Month Coronal Curve	15 (8)	24 (6)	0.0001
12 Month Coronal Curve	15 (7)	21 (6)	0.001
Preop Kyphosis	22 (9)	18 (13)	0.24
6 Month Kyphosis	35 (9)	24 (10)	0.0005
12 Month Kyphosis	34 (11)	31 (13)	0.22

39. Tissue Response Following Implantation with The Posterior Dynamic Distraction Device in Adolescent Idiopathic Scoliosis

Olivia K. Richard, DVM; Aléthéa Liens, PhD; DesiRae Muirhead, MD; *Ron El-Hawary, MD*; Klaus Weber, PhD

Hypothesis
The posterior dynamic distraction device (PDDD) will be fully tolerated by the host and, if aseptic screw loosening occurs, it will be unrelated to wear particle formation.

Design
Basic science histological analysis of intra-operative human tissue samples.

Introduction
The posterior dynamic distraction device (PDDD) is a novel ratchet-based, unidirectional expandable rod to treat adolescent idiopathic scoliosis (AIS), primarily by correcting scoliotic deformity without full spinal fusion. As this is a dynamic device, there is the potential for wear debris and for aseptic screw loosening.

Methods
Twenty-eight tissue samples from 7 patients enrolled in a prospective FDA study to assess the PDDD's safety and benefits, were obtained during reoperations due to complications. Host response was assessed from histological slides (four levels/implant) in accordance with GLP and ISO10993-6:2016. The elementary chemical composition of wear particles present in tissue sections was quantified by energy dispersive x-ray spectroscopy (EDX).

Results
Host reaction was minor, characterized by low levels of diverse inflammatory cells, mild fibrosis, occasional small necrotic foci, neovascularization, hemorrhage, and, rarely, small bone fragments. Twenty-four of 28 tissue sections displayed varying degrees of wear particles (black discoloration), and most sections (17) were scored as 1 (<25% of the sample). The discoloration observed corresponded to black-appearing, fine granular pigment. EDX analysis confirmed particles were composed of titanium, aluminum, and vanadium. Twenty-six of 28 samples were scored zero for necrosis and 2/28 were scored 1. Eleven samples were scored zero for fibrosis, 12 as 1, and five as 2. No aseptic screw loosening occurred.

Conclusion
The PDDD induced minimal host reaction with little or no degeneration, inflammation, or fibrosis. No changes present could be expected to promote device failure. The PDDD implant for treating AIS is well-tolerated and locally safe.

Study Patient ID	Implantation duration	Reoperation reason	Tissue sample origin
021-A001	20 months	Screw prominence leading to late infection	Fibrous connective tissue (ligament)
090-A004	7 months	Breakage due to trauma	Fibrous connective tissue (ligament)
091-A002	11 months	Breakage due to trauma	Mostly fibrous connective tissue (ligament), little skeletal muscle
091-A007	2 months	Breakage due to trauma	Mostly fibrous connective tissue (ligament), little skeletal muscle, bone fragments, and loose connective tissue
102-A001	14 months	Breakage	Mostly fibrous connective tissue (ligament), little skeletal muscle, and nerve tissue
021-A004	22 months	Pain	Fibrous connective tissue (ligament)
090-A016	9 months	Breakage	Paraspinous muscle and scar of the index surgery, immediately adjacent to the proximal joint of the rod.

Overview of collected samples

40. Behavior of The Un-Instrumented Lumbar Curve Following Selective Thoracic Tether

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Hypothesis
Selective thoracic tether leads to spontaneous decrease in the un-instrumented lumbar curve.

Design
Multicenter Retrospective Cohort

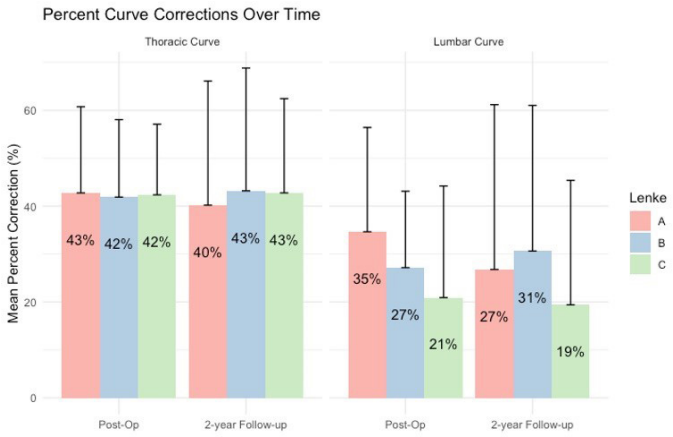
Introduction
Anterior vertebral body tethering (AVBT) has recently been utilized as an alternative to posterior spinal fusion for a subset of pediatric scoliosis patients. Indications for AVBT are evolving and, while early results

have been promising, there is a paucity of literature examining the behavior of the lumbar curve after selective thoracic tether.

Methods
The study population consisted of 142 patients with idiopathic scoliosis enrolled in the Pediatric Spine Study Group registry undergoing a selective thoracic tether with a minimum of two-year follow-up. Exclusion criteria included: patients with non-idiopathic scoliosis, patients with prior spine surgery, and patients instrumented below L1.

Results
Overall curve correction was notable, with mean pre-op, immediate post-op, and two-year follow-up angles of 51.3°, 29.5°, and 30.2° respectively for the thoracic curve and 32.7°, 22.8°, and 24.0° respectively for the un-instrumented lumbar curve. Overall, 108 subjects (76.1%) had a decrease in lumbar curve >5° immediately post-op. Over a two-year follow-up period, 28 subjects (19.7%) had a continued decrease in lumbar curve >5°, 77 subjects (54.2%) had minimal change, and 37 subjects (26.1%) had an increase in lumbar curve >5°. In a subgroup analysis of 29 subjects with decrease in thoracic curve >5° from post-op to two-year follow-up, 11 subjects (37.9%) had a concomitant decrease in lumbar curve with only 4 (13.8%) showing an increase in lumbar curve >5°. The changes in lumbar curve at post-op and two-year follow-up were moderately associated with changes in thoracic curve for the same time periods (rho= 0.643, p<.001, rho= 0.592, p<.001). When considering Lenke lumbar modifiers, the un-instrumented lumbar curve corrected 35%, 27%, and 21% following surgery and 27%, 31%, and 19% at two-year follow-up for A, B, and C curves respectively (p<.001 for all data points compared to pre-op).

Conclusion
Lumbar curves tended to mirror the behavior of the instrumented thoracic curve in terms of correction or decompensation both during surgery and during the two years following the procedure. This data provides clearer insight into the response of the lumbar curve following selective tethering and the effect of growth modulation on curve behavior.



Curve behavior at post-op and two-year follow-up

41. The Fate of the Broken Tether: How Do Curves Treated with Vertebral Body Tethering (VBT) Behave After Tether Breakage?

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Hypothesis
Skeletally mature patients will have stable curves following tether breakage after VBT.

Design
Retrospective, Multicenter

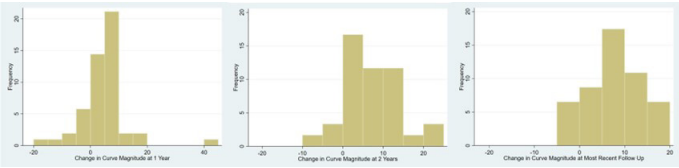
Introduction
VBT is a promising alternative to fusion for scoliosis treatment. However, tether breakage is common with rates up to 50% reported. In these cases, it remains unknown whether the curve will progress or remain stable.

Methods
Adolescent and juvenile idiopathic scoliosis patients in a multicenter registry s/p VBT treatment were identified with either 2 yr follow up or breakage prior to that. Broken tethers were identified by increase in screw divergence of >5° on serial radiographs. Revision procedures and curve magnitude at subsequent visits were recorded.

Results
88 patients with tether breakage were identified with mean age at time of index VBT of 12.4±1.4 years and mean curve magnitude of 51.8°±8.1°. Tether breakage occurred at a mean of 29.5±12.0 months and mean curve of 33.9°±13.2°. 6.8%(6/88) had tether revision and 2/88(2.3%) had fusion within the first year after breakage. At 1 year post breakage, remaining patients had a mean curve of 36.2°±15.5°. 22/51(43%) had progression >5°. 3 additional patients had a fusion be-

tween the 1st and 2nd year post breakage. At 2 years post breakage, the remaining patients had a mean curve of 40.5°±8.2°. 15/30(50%) had progression >5°. 2 patients had a fusion >2 years post breakage. The remaining patients with follow-up >2 years post breakage had a mean curve of 38.5°±9.2° and 11/21(52%) had progression >5°. In total, 45%(27/60) of patients had progression >5° and 20%(12/60) had progression >10° post tether breakage. 29% (11/38) of patients with a curve >35° at time of breakage had additional surgery versus 2%(1/50) of patients that had ≤35° (p<0.01). Skeletally immature patients(Risser≤3) had a higher rate of revision surgery compared to skeletally mature(Risser≥4) patients (9/30, 30% vs 3/58, 5%; p=0.002). Rates of curve progression >5° were similar between skeletally immature and mature patients (7/19, 37% vs 20/41, 49%,p=0.42).

Conclusion
Nearly half of patients had curve progression following tether breakage, including some that were skeletally mature. Approximately a third of skeletally immature patients or those with curves >35° at time of breakage had additional surgery. Additional surgery was rare (1/50) in patients with curves <35° at time of breakage.



Change in curve magnitude

42. Outcomes in Patients with Tether Rupture After Anterior Vertebral Tethering for Adolescent Idiopathic Scoliosis: The Good, The Bad, and The Ugly

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Hypothesis
The tether rupture (TR) rate after Anterior Vertebral Tethering (AVT) for AIS will be significant but only a small percentage of patients will require revision surgery.

Design
Retrospective 2010-23.

Introduction
Though multiple studies have reported TR rates after AVT as high as 50%, none have adequately analyzed the clinical significance of TR and factors that potentially increase the likelihood of revision surgery. We reviewed 264 consecutive AIS patients after AVT and found 5% with early TR at <2yrs and 18% with late TR at ≥2yrs. The impact of TR on patients was inconsequential in 62%, consequential in 11%, problematic in 19%, and beneficial in 8%.

Methods
Charts, x-rays, and CTs were reviewed for TR in 264 consecutive AIS patients treated with AVT for T and TL/L curves 33-71°. Early TR occurred <2yrs and late TR ≥2yrs. TR was further categorized as inconsequential (final curve <40° and no pain), consequential (curve ≥40° or pain), problematic (revision required), or beneficial (improvement of overcorrection).

Results
Of 264 consecutive AIS patients s/p AVT, TR was found in 26 patients with 39 curves (20T/19TL) treated at age 14.6yrs and R=2.5. Curves with TR corrected from 49.8° pre-op to 19.9° post-op, but lost 8.3° of correction with TR settling at 28.2° final at 2.3yrs (0-10yrs). Early TR was seen in 9/171 (5%) and late TR in 17/93 (18%) patients with 2-10 yr F/U. TR was inconsequential in 62% (16/26), consequential in 11% (3/26), problematic in 19% (5/26), and beneficial in 8% (2/26). TR occurrence was more common in TL/L curves (73%) and at L2,3 (92%). All TL/L revisions involved tether replacement only whereas thoracic revision required fusion. Revision surgery was unrelated to curve correction or loss of correction, but was related to convex back pain (p<0.05).

Conclusion
This study demonstrated an early TR rate of 5% and late TR rate of 18% in a large series of patients treated with AVT for AIS over 13 years. While the majority of patients had inconsequential TR (62%), with 8.3° loss of correction, a final curve <40°, and no pain, a number of patients had consequential (11%) or problematic TR (19%). These adversely affected patients had a final curve ≥40°, or pain, or required revision surgery. Fortunately, a small number of patients (8%) actually benefitted from TR by improvement in an area of impending overcorrection.

43. Which Lenke Type Curve is Most Appropriate for Vertebral Body Tethering in Adolescent Idiopathic Scoliosis?

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Hypothesis
Patients with Lenke type 5 scoliosis curves are the most appropriate candidates for two row vertebral body tethering (2RVBT) due to their flexibility, less rotational deformity, better residual curve correction, and lower probability of disk degeneration compared to fusion to L3-L4.

Design
Single-center retrospective cohort study

Introduction
2RVBT shows promising results as a fusion-less alternative for the management of AIS, however, the ideal

candidate for this procedure remains unknown. To date, no study has assessed the effects of Lenke curve type on the outcomes of 2RVBT. This study compares patients who underwent 2RVBT with Lenke 1, 3, 5, or 6 curves.

Methods
Patients undergoing two row vertebral body tethering (2RVBT) for the correction of AIS were included. The cohort was separated into Lenke type 1, 3, 5, or 6. Outcome measures: Age, height, weight, BMI, Risser, Sanders. Radiographic: pre- and post-op thoracic (T) and thoracolumbar (TL) cobb angle, coronal balance, cervical SVA (cSVA), L5 slope, thoracic kyphosis (TK), pelvic incidence lumbar lordosis mismatch (PI-LL), and pelvic tilt (PT), and % of tether breakage incidence. Independent T-test and $\chi 2$ test were used, with significance set at $p<0.05$.

Results
156 2RVBT (Lenke 1, N=61; Lenke 3, N=35; Lenke 5, N=37; Lenke 6, N=23) patients met the cohort criteria. Age, height, weight, gender, BMI, Risser, and Sanders scores were not different between the groups. There was a smaller L5 tilt angle in the Lenke 1 group (9.94±4.80; p = 0.001). The preop T cobb angle was smaller in the Lenke 5 group (36.20±10.62; p<0.001). There was a smaller TL cobb angle in the Lenke 1 group (38.91±15.94; p=0.014). There was a larger coronal imbalance in the Lenke 5 group (23.41±12.13; p=0.028). There was a smaller change in the T cobb angle in the Lenke 5 group (-20.13±16.25; p=0.011). There was a smaller change in the TL cobb angle in the Lenke 1 group (-17.68±14.85; p=0.004). There was a lower rate of tether breakage in the Lenke 1 group (3 (4.9%) vs 3 (8.6%) vs 4 (10.8%) vs 5 (21.7%))

Conclusion
Lenke type 5 is the most appropriate for an indication for 2RVBT due to its flexibility, less rotation, and the residual curve achieves better correction. Lenke type 5 has more cord breakage, but the revision rates are lower than the Lenke types whose structural curve is thoracic. All coronal parameters are corrected and there was no loss of sagittal parameters.

	2RVBT (N = 156)	Lenke 1 (N = 61)	Lenke 3 (N = 35)	Lenke 5 (N = 37)	Lenke 6 (N = 23)	p-value
Demographics	Age (years)	13.93±2.23	14.00±1.69	14.42±1.78	14.66±4.66	0.874
	Gender (% female)	81.48%	100.00%	83.33%	88.89%	0.621
	Height (m)	1.599±0.122	1.63±0.08	1.62±0.077	1.61±0.08	0.913
	Weight (kg)	52.14±12.86	59.76±15.52	53.10±7.46	54.56±8.02	0.448
	BMI	20.20±3.34	22.48±4.94	20.35±2.50	21.09±2.09	0.37
	Sanders	5.56±2.08	4.62±2.77	5.36±2.46	5.00±2.82	0.808
	Risser	3.12±1.70	2.50±2.13	3.27±1.48	3.11±2.03	0.793
Pre-Op	L5 Tilt (deg)	9.94±4.80	15.10±4.70	15.69±4.29	14.96±5.03	0.001
	Pelvic Tilt (PT) (deg)	5.67±7.90	10.54±5.60	7.48±6.31	10.27±8.10	0.258
	Sagittal Vertical Axis (SVA) (mm)	23.78±9.24	25.68±6.64	27.03±11.61	21.31±7.44	0.554
	Thoracic Kyphosis (TK) (deg)	26.74±13.10	31.65±10.34	24.12±13.18	24.57±10.30	0.572
	PI-LL mismatch (deg)	-7.42±11.54	-7.15±12.45	-7.84±7.20	-3.28±10.68	0.787
	Apex Cobb Angle (deg)	50.16±9.19	50.54±10.08	45.00±8.66	49.02±10.77	0.116
	Thoracic Cobb Angle (deg)	55.76±9.24	60.12±9.94	36.20±10.62	51.00±9.55	<0.001
	Thoracic Cobb Angle Bends To (deg)	21.52±10.35	21.42±9.34	11.11±6.41	21.25±10.30	0.053
	Thoracolumbar Cobb Angle (deg)	38.91±15.94	56.00±4.65	49.50±15.57	54.00±12.63	0.014
	Thoracolumbar Cobb Angle Bend To (deg)	9.92±8.94	12.43±3.74	15.10±7.21	14.56±13.04	0.538
	Coronal Balance (mm)	13.09±7.23	21.13±10.88	23.41±12.13	16.19±13.45	0.028
Post-Op	L5 Tilt (deg)	4.82±3.15	5.81±3.98	7.01±5.04	8.04±3.83	0.027
	Pelvic Tilt (PT) (deg)	8.75±8.59	10.19±6.26	11.43±8.89	15.15±13.13	0.348
	Sagittal Vertical Axis (SVA) (mm)	21.91±15.20	24.21±7.15	22.54±11.99	18.89±7.94	0.85
	Thoracic Kyphosis (TK) (deg)	24.66±12.55	28.72±10.95	24.06±8.86	22.31±8.66	0.682
	PI-LL mismatch (deg)	-3.68±13.10	-5.62±9.68	-0.48±9.99	-2.60±11.54	0.794
	Apex Cobb Angle (deg)	21.16±10.19	19.18±8.51	13.55±7.28	18.52±8.34	0.009
	Thoracic Cobb Angle (deg)	21.41±9.90	24.43±9.64	16.07±10.08	23.11±6.51	0.275
	Thoracolumbar Cobb Angle (deg)	21.23±10.82	20.75±7.90	15.60±5.60	21.84±9.51	0.395
	Coronal Balance (mm)	12.78±9.99	21.88±12.28	12.20±9.81	13.77±15.19	0.225
Change	Δ L5 Tilt (deg)	-4.82±4.53	-6.95±5.57	-8.42±3.39	-6.91±4.09	0.12
	Δ Pelvic Tilt (PT) (deg)	3.05±6.65	-0.34±2.10	3.94±4.41	5.99±14.90	0.412
	Δ Sagittal Vertical Axis (SVA) (mm)	-1.56±11.43	-1.47±6.12	-4.49±5.83	-3.38±10.70	0.824
	Δ Thoracic Kyphosis (TK) (deg)	-2.11±9.15	-2.93±7.89	-0.0652±10.63	-1.48±6.09	0.894
	Δ PI-LL mismatch (deg)	4.28±10.98	1.53±7.53	7.36±5.72	0.48±2.74	0.304
	Δ Apex Cobb Angle	-28.82±12.10	-29.21±10.60	-31.45±9.37	-26.69±14.79	0.61
	Δ Thoracic Cobb Angle (deg)	-34.35±9.59	-35.70±7.64	-20.13±16.25	-27.89±13.42	0.011
	Δ Thoracolumbar Cobb Angle (deg)	-17.68±14.85	-35.25±9.01	-33.90±14.45	-32.15±12.88	0.004
	Δ Coronal Balance (mm)	-0.35±11.14	0.76±13.20	-11.20±13.55	-2.42±17.06	0.1
Outcomes	% of Broken tethers	3 (4.9%)	3 (8.6%)	4 (10.8%)	5 (21.7%)	0.015
	Location of Breakage (% T, % TL)	1 (33.33%), 2 (66.67%)	1 (33.33%), 2 (66.67%)	1 (25.0%), 3 (75.0%)	1 (20.0%), 4 (80.0%)	0.264
	Revision Recommendation (% None, % VBT, % Fusion)	1 (33.33%), 1 (33.33%), 1 (33.33%)	1 (33.33%), 0, 2 (66.57%)	0, 2 (50.0%), 2 (50.0%)	1 (20.0%), 2 (40.0%), 2 (40.0%)	0.251

44. Anterior Vertebral Body Tethering Shows Clinically Comparable Shoulder Balance Outcomes to Posterior Spinal Fusion in Lenke 1 and 2 Adolescent Idiopathic Scoliosis

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Hypothesis
PSF will result in better improvement in shoulder balance and T1-Tilt than VBT.

Design
Retrospective comparison of data from a multi-center AIS registry.

Introduction
VBT is a non-fusion alternative to PSF, the gold standard surgical approach in AIS. Self-image is the primary quality of life indicator in AIS and is impacted by shoulder symmetry. There have been no reports comparing shoulder balance in patients treated with VBT versus those treated with PSF. Here we compare radiographic shoulder balance and T1-Tilt between techniques.

Methods
Inclusion criteria were diagnosis of AIS, Lenke type 1 or 2 curves between 35-65° and VBT or PSF surgery. The pre-operative (PRE) and 2-year follow-up (POST) radiographic shoulder height (RSH) of 46 VBT patients were compared to 45 PSF patients. Mean values were compared and then collapsed into discrete groups (RSH GROUP: good, acceptable, or moderate or severe imbalance) and compared. Patients were propensity score matched. Regression models based on pretest-post-test designs were used to compare procedure type on post-operative outcomes.

Results
Clinical and radiographic variables including shoulder height were similar between groups at baseline (Table). VBT had smaller shoulder height difference than PSF, POST (0.63±0.54cm vs 0.91±0.61cm, p=0.021). A smaller RSH change was noted for VBT (0.63±0.62cm vs 0.98±0.61cm, p=0.003). There were no significant differences seen PRE or POST in T1-Tilt but greater change occurred in PSF. No differences were seen in shoulder balance category between groups PRE or POST with the majority having good or acceptable balance PRE and POST and with improvements noted overall. Subanalysis of Lenke 2 patients showed no differences in RSH between groups PRE or POST despite greater T1 tilt correction in PSF. No differences in shoulder balance category were observed.

Conclusion
VBT demonstrated statistically significant but clinically insignificant improvements in shoulder balance over PSF at POST despite more caudal UIV, less coronal plane correction, and shorter constructs. Shoulder balance was even maintained in VBT for Lenke 2 curves despite a lack of proximal curve control offered by the procedure; VBT may be effective in achieving shoulder balance for PT curves up to 40 degrees in whom PRE RSH is no more than moderately imbalanced.

Table. Demographic and Clinical Variables

Demographics	VBT (n = 46)	PSF (n = 45)	P-Value
Age	12.8 ± 2.1	13.5 ± 2.2	0.126
Sex (F)	41	41	1.000
Risser 0|1|2|3|4|5	13 | 7 | 6 | 8 | 8 | 3	23 | 5 | 6 | 9 | 2 | 1	0.170
Lenke 1 | 2	36 | 10	30 | 15	0.247
UIV T2 | T3 | T4 | T5 | T6 | T7	0 | 0 | 0 | 22 | 22 | 2	15 | 15 | 9 | 6 | 0 | 0	**< 0.001**
Curves	**Pre-Op (2-year FU)**	**Pre-Op (2-year FU)**	
Proximal Thoracic Curve	29.3 ± 6.8 (19.76 ± 7.71)	29.2 ± 7.0 (16.47 ± 5.41)	0.943 (**0.020**)
Proximal Thoracic Curve %	32.7 ± 20.7	42.9 ± 16.0	**0.010**
Main Thoracic Curve	47.4 ± 5.7 (28.04 ± 10.07)	50.2 ± 6.9 (18.56 ± 6.52)	0.061 (**< 0.001**)
Main Thoracic Curve %	40.5 ± 21.7	62.80 ± 12.6	**< 0.001**
Thoracolumbar Curve	30.4 ± 8.5 (20.61 ± 10.60)	31.0 ± 9.0 (12.64 ± 8.95)	0.768 (**< 0.001**)
Thoracolumbar Curve %	32.8 ± 32.3	61.3 ± 26.0	**< 0.001**
Primary Outcomes (all)	VBT (n = 46) Pre-Op (2-year FU)	PSF (n = 45) Pre-Op (2-year FU)	P-Value
Shoulder Height (cm)	0.79 ± 0.72 (0.63 ± 0.54)	1.1 ± 0.90 (0.91 ± 0.61)	0.095 (0.021)
Avg |Δ Shoulder Height|	0.63 ± 0.62	0.98 ± 0.61	0.003
RSH Groups (all)			
Good (< 1cm)	29 (36)	22 (26)	0.139 (0.102)
Acceptable (1cm - < 2cm)	14 (9)	14 (16)	
Moderate (2cm - < 4cm)	3 (1)	9 (3)	
Severe (≥ 4cm)	0 (0)	0 (0)	
Secondary Outcomes (all)			
|T1 Tilt (°)|	5.8 ± 3.8 (6.8 ± 3.9)	4.4 ± 3.6 (5.8 ± 4.1)	0.082 (0.224)
Avg Δ |T1 Tilt (°)|	2.6 ± 1.9	4.1 ± 3.2	**0.015**
|Clavicular Angle (°)|	2.1 ± 1.3 (2.0 ± 1.5)	2.3 ± 1.9 (2.3 ± 1.7)	0.433 (0.379)
Avg Δ |Clavicular Angle (°)|	1.4 ± 1.2	2.2 ± 1.4	**0.003**
Primary Outcomes (Lenke 1)	VBT (n = 36) Pre-Op (2-year FU)	PSF (n = 30) Pre-Op (2-year FU)	P-Value
Shoulder Height (cm)	0.67 ± 0.63 (0.61± 0.55)	0.99 ± 0.94 (0.89 ± 0.59)	**0.123 (0.047)**
Avg |Δ Shoulder Height|	0.57 ± 0.57	0.97 ± 0.65	**0.010**
RSH Groups (Lenke 1)			
Good (< 1cm)	24 (30)	17 (20)	0.201 (0.286)
Acceptable (1cm - < 2cm)	10 (5)	7 (8)	
Moderate (2cm - < 4cm)	2 (1)	6 (2)	
Severe (≥ 4cm)	0 (0)	0 (0)	

Primary Outcomes (Lenke 2)	VBT (n = 10) Pre-Op (2-year FU)	PSF (n = 15) Pre-Op (2-year FU)	P-Value
Shoulder Height (cm)	1.20 ± 0.89 (0.71 ± 0.52)	1.25 ± 0.83 (0.95 ± 0.67)	0.881 (0.318)
Avg |Δ Shoulder Height|	0.83 ± 0.79	1.0 ± 0.54	0.546
RSH Groups (Lenke 2)			
Good (< 1cm)	5 (6)	5 (6)	0.653 (0.499)
Acceptable (1cm - < 2cm)	4 (4)	7 (8)	
Moderate (2cm - < 4cm)	1 (0)	3 (1)	
Severe (≥ 4cm)	0 (0)	0 (0)	

45. What Predicts a Successful Result for Vertebral Body Tethering?

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Hypothesis
We hypothesize that lower preoperative cobb and greater intraoperative correction correlate with successful VBT.

Design
Retrospective review.

Introduction
Vertebral Body Tethering (VBT) is a non-fusion alternative for management of pediatric scoliosis that allows for growth and flexibility of the spine. Interest in this procedure as an alternative to spinal fusion continues to grow. However, current rates of revision for VBT range 14%-25%. Current indications for VBT are skeletally immature AIS patients with a flexible major curve of 30-65 degrees and bracing failure. This study aims to evaluate perioperative factors influencing the success of VBT.

Methods
Our study employed retrospective review of 87 patients aged 9 to 16 that underwent VBT surgery at our institution for 2-year surgical outcomes. Success of VBT was defined as a major cobb less than 35 degrees and no re-operation at the two-year follow-up. 70 patients were considered successful (80%), 17 patients were unsuccessful (20%). The peri-operative factors associated with these patient populations were stratified and compared to evaluate potential characteristics for predicting VBT outcomes.

Results
Perioperative factors such as BMI, age, Risser/Sanders score, pre-operative major cobb, percent correction on bending films, and percent correction at 3 months post-operative visit were considered in evaluation of contributors to tethering outcomes. Of the 17 patients not considered successful 4 had suspected cord breakage and 8 (9%) underwent reoperation, with 3 of the reoperations due to overcorrection. The VBT patients who were successful showed significantly higher percent correction at first erect (45% compared to 37%, p<0.01), lower preoperative major cobb angles (50.5 compared to 56.2, p<0.01), and preoperative greater height (159 cm compared to 154 cm, p=0.02). They also demonstrated significantly better correction by lower cobb angles at 3 months compared to the unsuccessful group (27.7 compared to 34.9, p<0.01). Values for pre-operative kyphosis, correction with bending, weight, Risser score, and Sanders score did show differences between the groups but were not significant.

Conclusion
Patients with lower major cobb angles, greater height, and with greater pre-operative correction tended toward better outcomes at 2-year follow-up. These results indicate a need for maximizing intraoperative correction and selecting curves <55 degrees in order to achieve success with VBT.

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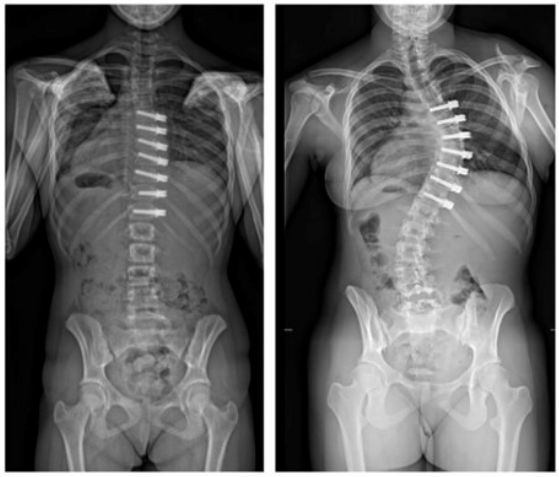


Figure 1: Successful (Left) and unsuccessful (Right) VBT patient radiographs at 2-year follow-up

46. The Link Between a Growth Mindset and Health-Related Quality of Life in AIS Patients on Brace Treatment

Joelle L. Wang, MPsych(Clinical); Nicole Lee, PhD; Matilda Kwek, MD; *Kevin B. Lim, MD, FRCS(Orth), MBA*; Patrick C. Hsieh, MD, MBA, MSc; Dhiraj V. Sonawane, MS (Orth)

Hypothesis
Braced AIS patients who have a growth mindset will report more favourable SRS22r scores compared with those with a fixed mindset.

Design
Retrospective cohort.

Introduction
Individuals with a growth mindset believe their abilities can be developed through hard work, good strategies and input from others, while those with a fixed mindset believe their talents are innate, unalterable gifts. Previous studies have shown that students who demonstrated a growth mindset enjoy higher academic achievement, experience lower mental health difficulties, and are more resilient to stressful life events than students with a fixed mindset. The aim of this study is to establish if having a growth mindset can be a protective factor against psychological stress associated with brace treatment.

Methods
Between Nov 2021 and April 2023 inclusive, braced AIS patients who completed the Growth Mindset Scale (3 items) during their outpatient visit were included in this analysis. Scores of 0 - 3.9 indicate a fixed mindset, while scores of 4.0 - 6.0 indicate a growth mindset. Health-related quality of life was assessed using the SRS-22r questionnaire (22 items).

Results
Scores from 237 patients undergoing brace treatment were analysed (13.55 ± 2.04 years of age, 86% females). Those with a growth mindset had higher Management Satisfaction domain scores than those with a fixed mindset (3.66±0.75 vs. 3.41±0.75, p=0.027). Patients with a growth mindset also scored better in domains such as low self-Image (3.50±0.57 vs. 3.40±0.54) and Mental Health (3.90±0.61 vs. 3.79±0.80) but these did not reach statistical significance (p=0.263, p=0.290, respectively).

Conclusion
Adolescents with a growth mindset reported better HRQoL scores, compared with those with a fixed mindset. Those with a growth mindset may have higher levels of self-efficacy or employed more adaptive coping styles during brace treatment, contributing to better HRQoL scores. Time and effort to develop or reinforce a growth mindset in AIS patients on brace treatment may be worthwhile in helping these adolescents cope with the psychological stress of bracing.

47. Changes in Diaphragm Intrusion and Thoracic Dimensions After Posterior Spinal Fusion in Patients with Neuromuscular Scoliosis

Gregory Benes, BS; *Peter G. Gabos, MD*; Gregory Redding, MD; Joann Hunsberger, MD; Patrick J. Cahill, MD; Harms Study Group; Paul D. Sponseller, MD, MBA

Hypothesis
We hypothesized that curve correction would be associated with an increase in lung volume and change in diaphragm position, which would be positively correlated with preoperative curve magnitude.

Design
retrospective review

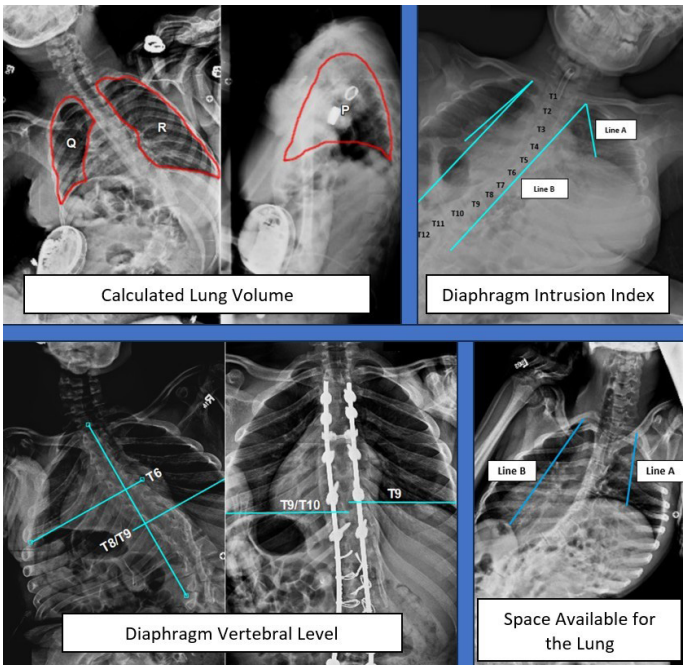
Introduction
Cerebral palsy (CP) can cause scoliosis with large thoracolumbar or lumbar curves. Such curves may impair pulmonary function by causing the abdomen and diaphragm to encroach on the thorax. In this study, we investigated changes in diaphragm position and other thoracic measurements at 2 years after posterior spinal fusion (PSF).

Methods
Reviewed data from 64 pediatric patients who underwent PSF for CP-related (neuromuscular) scoliosis at our US tertiary hospital from 2010 through 2018. We used radiographs taken preoperatively and 2 years after PSF to measure lung volume, diaphragm intrusion index (DII), diaphragm vertebral level (DVL), space available for the lung (SAL), and T1-S1 height.

Results
Lung volume had increased by a mean (and standard deviation) 969 cm3 at 2-year follow-up. DII improved from a mean of 61% ± 11% to 71% ± 10% on the left side and 59% ± 13% to 68% ± 11% on the right ($p < 0.001$). DVL increased caudally by a mean 1.2 vertebral

levels on the left and 1.3 vertebral levels on the right, with a mean postoperative position between T8 and T9. Lung space became more symmetrical as the SAL increased from 0.77 to 0.91 ($p < 0.001$). T1-S1 height increased by a mean 7.4 ± 4.1 cm.

Conclusion
These findings suggest a new way to understand changes in thoracic volume and redistribution of thoracic and lumbar balance in the correction of the collapsing spinal deformity in CP. A more caudal postoperative diaphragm position with less diaphragm intrusion into the thorax may reflect an improved length-tension configuration, which could in turn produce greater diaphragmatic strength and endurance.



Thoracic measures. a) Lung volume is calculated by inputting summed lung fields (P + Q + R) into a prediction equation. b) Diaphragm intrusion index = line A/line B. c) Diaphragm vertebral level is measured by counting down from the superior endplate of T1 to where the tangent line from the dome of the diaphragm horizontal line in relation to the thorax intersects the sagittal midline of the vertebra. d) Space available for the lung = line A (shorter distance) / line B (longer distance)

48. Intra-Operative Skin Traction in Posterior Spinal Fusion for Non-Ambulatory Pediatric Scoliosis

Grace H. Coughlin, BS; Suken A. Shah, MD; Jennifer M. Bauer, MD, MS

Hypothesis
Intraoperative skin traction (ISkinT) is as effective for T2-pelvis posterior spinal fusion (PSF) correction as intraoperative skeletal traction (ISkelT), with no associated complications.

Design
Retrospective chart review

Introduction
Intraoperative traction has been demonstrated to improve deformity during PSF. This is commonly done with invasive distal femoral traction pins or traction boots. ISkinT offers a novel technique that may avoid risks associated with ISkelT or hyperlordosis with extended hip position, without loss of effectiveness. We aimed to describe ISkinT and assess its safety and efficacy for PSF in non-ambulatory scoliosis.

Methods
Retrospective review of patients aged 5-21yo who underwent T2-pelvis PSF with ISkinT in 2017-2023. Demographics and radiographic measurements were statistically compared to a published cohort that used ISKelT for the same scoliosis treatment.

Results
51 patients treated with ISkinT were included and compared to 41 patients treated with ISkelT with no difference in demographics. ISkinT was applied setting a cranial attachment (6, 12% with halo ring and 45, 88% with Mayfield) and attaching an average of 12% body weight to the pelvis with the hips and knees flexed, using medical tape-rope-weight system with Trendelenburg assistance. The preoperative major Cobb was 91° ± 20° in the skin traction cohort and 91°± 17° in the skeletal traction cohort ($p= 0.019$; $d=0.02$), which corrected to 24°± 14° (75% correction) in ISkinT and 43°± 15° (53%) in ISkelT ($p<0.0001$; $d=1.29$). Preoperative pelvic obliquity averaged 22°± 10° in ISkinT and 34°± 14° in ISkelT, that corrected to 24°± 14° (75%) in ISkinT and 43°± 15° (53%) in ISkelT ($p<0.0001$; $d=1.29$). No intraoperative or postoperative skin traction-related complications occurred.

Conclusion
In non-ambulatory neuromuscular pediatric scoliosis patients, intraoperative skin-based traction during PSF to the pelvis is a safe and effective technique for deformity correction. There were no associated perioperative complications and no loss of corrective strength for ISkinT compared to ISKelT. This can be considered for T2-pelvis PSF for pediatric scoliosis.

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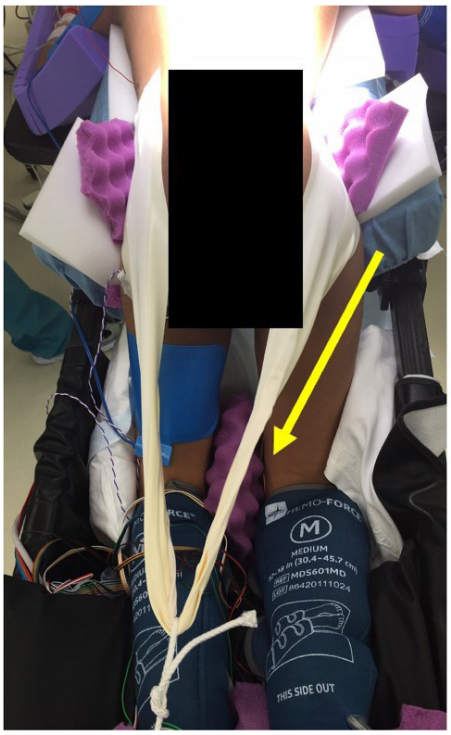

ISkinT technique

49. Documenting the Variation of Proximal Foundation Constructs and Their Correlation with Unplanned Return to the Operating Room in Children with Magnetically Controlled Growing Rods

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Hypothesis
Proximal construct configuration, including the upper instrumented vertebra (UIV), the number of foundational levels, and the number and type of anchors, is an important factor affecting the outcomes of MCGR. We hypothesize that the most commonly utilized configurations are the most protective against UPROR.

Design
Retrospective Cohort Study.

Introduction
The evolution of MCGR technique has led to modifications in the configuration of the proximal construct to decrease the incidence of implant related complications (IRC) and revision surgeries. However, there is no data characterizing the performance of the most used configurations reducing risk of complications.

Methods
487 patients were identified from an international multicenter EOS database. Inclusion criteria: EOS patients, primary dual MCGR, age ≤9years, complete radiographs, and minimum of 2 year follow up. 76 patients had incomplete x-rays, 5 had apical fusions, and 18 had inconclusive complications status; leaving 388 patients for review. A digital spine template was created to document UIV; number of levels; number, type, and location of anchors; as well as implant configuration. We reviewed the first postoperative and latest follow-up radiographs by a group of 2 senior surgeons and 2 spine fellows. UPROR due to IRC was defined as change in proximal anchors between the post-operative and follow up radiographs.

Results
The most common proximal construct configuration: UIV at T2 (50.0%) with 17.5% UPROR, followed by T3 (34.0%) with 12.1% UPROR; number of levels was 3 (57.1%) with 16.8% UPROR, and 2 (26.0%) with 17.0% UPROR; number of proximal anchors was 6 (49.9%) with 14.1% UPROR, and 4 (27.0%) with 18.3% UPROR. The most common types of anchors were all screws (42.0%) with 9.9% UPROR, and all hooks (26.4%) with 31.4% UPROR ($P<0.001$). The most protective construct (9 cases) was UIV at T3 across 3 levels with 6 anchors, screws and hooks (0% UPROR) followed by UIV at T3, across 3 levels (28 cases) with 6 anchors, hooks (7.1% UPROR). The most common construct (46 cases) was UIV at T3, with 6 anchors, screws (17.4% UPROR).

Conclusion
Proximal anchor configuration impacts the incidence of implant related UPROR in MCGR. The most protective (T3 UIV, 3 levels, 6 anchors, screws and hooks) was used in only 2.3% of cases.

Anchor configurations	Prevalence	UPROR Incidence
All screws	42.0%	9.9%
All Hooks	26.4%	31.4%
Screws and Hooks	14.8%	12.3%
Screws and Crosslinks	7.5%	10.3%
Hooks and Crosslinks	6.7%	30.8%
Hybrid	2.6%	10.0%

Anchor configurations and UPROR incidence.

50. The Role of Enabling Technology in Growth-Friendly Spine Surgery

Daniel Gabriel, BS; Sydney Lee, BA; Shanika De Silva, PhD, MS; Daniel J. Hedequist, MD; Craig M. Birch, MD; Brian D. Snyder, MD, PhD; M. T. Hresko, MD; *Grant D. Hogue, MD*

Hypothesis
Enabling technology (ET) can improve proximal anchor density in growth-friendly spine surgery, improving construct accuracy and reducing complications.

Design
Retrospective single-center cohort study

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Introduction
Over the last decade, enabling technology has shown promise in enhancing construct placement accuracy and reducing complications in spine surgery. However, its role in growth-friendly spine surgery remains underexplored.

Methods
Patients were included if they had a diagnosis of early-onset scoliosis (EOS) and underwent instrumented growth-friendly surgery with traditional growing rods (TGR) or magnetically controlled growing rods (MCGR) at a single pediatric institution from 2013 to 2023. Those with a history of prior spine surgery were excluded. Key metrics including proximal anchor density (defined as the number of anchors per vertebral level), proximal fixation failure rates, operative time, and unplanned returns to the operating room, were compared between ET patients and non-ET patients using t-tests, Wilcoxon rank sum tests, or Fisher's Exact tests.

Results
Of the 123 eligible patients (48% female), 34 received enabling technology assistance, primarily via CT-based O-arm guidance (one case utilized both O-arm and robotic guidance), while 89 underwent traditional fluoroscopic surgery. Mean age at the index surgery was 7.4 years ± 2.8, average follow-up was 51 months, and average BMI was 16.4 ± 2.7. Preoperative Cobb angles averaged 77.4 ± 23.9 (major) and 43.2 ± 17.6 (minor). ET-assisted patients had a significantly higher screw-based proximal anchor density (1.3 vs 0.0, p<0.001) but longer operative times (374 mins vs 272 mins, p < 0.001). There were no significant differences in proximal fixation failure rates (p = 0.5) or unplanned returns to the operating room (p = 0.6). ET use was found to be increasing over the past decade.

Conclusion
Enabling technology in growth-friendly pediatric spine deformity surgery increased screw-based anchor density and higher operative times but did not significantly alter proximal fixation failure rates or unplanned revisions in this cohort.

Outcome	Overall (N=123)[1]	Enabling Technology (N=34)[1]	Freehand (N=89)[1]	p-values[2]
Intraoperative measures				
Count of anchor				
Screws	3 (0, 8)	4 (4, 8)	0 (0, 6)	<0.001
Hooks	3 (0, 8)	2 (0, 2)	4 (0, 8)	<0.001
Hooks + Others	3 (0, 8)	2 (0, 4)	4 (0, 8)	<0.001
All anchors	6 (2, 9)	6 (4, 9)	6 (2, 8)	<0.001
Anchor density				
Screw density (screws/proximal levels)	0.8 (0.0, 2.0)	1.3 (0.8, 2.0)	0.0 (0.0, 2.0)	<0.001
Hook density (hooks/proximal levels)	1.0 (0.0, 2.0)	0.6 (0.0, 0.7)	1.3 (0.0, 2.0)	<0.001
Hook + Other density (non-screw anchors/proximal levels)	1.0 (0.0, 2.0)	0.7 (0.0, 1.0)	1.3 (0.0, 2.0)	<0.001
Anchor density (anchors/proximal levels)	2.0 (0.9, 2.0)	2.0 (0.9, 2.0)	2.0 (1.0, 2.0)	0.012
Operative time (mins)	300.2 (101.7)	374.4 (107.1)	271.9 (84.3)	<0.001
Postoperative outcomes				
Proximal fixation (n=122)	15 (12)	5 (15)	10 (11)	0.5
Unplanned return to OR	15 (12)	5 (15)	10 (11)	0.6

1. Median (Range); Frequency (Percentage)
2. p-values from Wilcoxon rank sum test; Fisher's Exact test

51. Comparison of Unilateral Versus Bilateral Pedicle Screw Fixation (U/BPSF - TLIF) Transforaminal Lumbar Interbody Fusion in Lumbar Degenerative Disorders - An Analysis of 1098 Cases

Vigneshwara M. Badikillaya, MD; Sharan T. Achar, MS; Sajan K. Hegde, MD

Hypothesis
UPSF-TLIF procedure is a minimal invasive technique with lesser operative time, blood loss and lesser adjacent segment disease at 4 year follow up compared to BPSF-TLIF.

Design
Retrospective comparative cohort study

Introduction
TLIF has become gold standard technique for management degenerative lumbar disc disease, traditionally performed with BPSF. UPSF TLIF has been reported as an effective alternative procedure. This study compares the clinical and radiological outcomes in a select series of patients treated with U/L versus BPSF TLIF.

Methods
Retrospective cohort study of a total 1098 patients operated with UPSF TLIF at 1 level in 460 cases,2 level in 103 cases compared to 425,110 patients operated with 1 level,2 level BPSF TLIF respectively with a minimum of 4 years follow-up. Demographic data, operative time, blood loss, hospital stay, implant costs, complications were evaluated. Functional outcome was assessed using the Oswestry disability index(ODI), Short-Form health survey(SF-36) and visual analog score(VAS) preoperatively and at 6 months,1 year and 2 years after surgery. Adjacent level degeneration(ASD) were assessed in terms of loss of disc height, instability or facetal arthropathy. Fusion rates were assessed using Bridwell interbody fusion grading at 4yrs follow up. Data were analyzed and compared by means of X^2 test, t test and Fisher exact test.

Results
The mean follow-up was 46 months(44–86 months). A significant improvement in VAS, SF-36 and ODI in both groups at 2 years follow-up was noted, and there was no significant difference between the groups. The complication rates between the groups were similar, except for cage migration with bullet cage in UPSF group causing no symptoms(P>0.05). The fusion rate in UPSF TLIF was 97.3% and 98.34% in BPSF TLIF; difference was not statistically significant. The UPSF group had a significantly shorter operative time, less blood loss, shorter hospital stay and reduced implant cost compared with BPSF group(P<0.001). ASD was noticed to be significantly lesser in USPF group compared to BPSF.

Conclusion
UPSF in TLIF is comparable with BSPF in terms of

patient-reported clinical outcomes, fusion rates and complication rates with the additional benefits of less operative time, less blood loss, shorter hospitalization, lesser ASD and less cost in selective cases.

Statistical data & Case

52. Lumbar Disc Arthroplasty Leads to Increased Subsequent Facet Injections Compared to Anterior & Lateral Lumbar Interbody Fusions

Nakul Narendran, BS; Paal K. Nilssen, BS; Christopher Mikhail, MD; Alexander Tuchman, MD; David L. Skaggs, MD, MMM

Hypothesis
Lumbar disc arthroplasty, when compared to anterior lumbar interbody fusion, results in equal or increased long-term facet arthrosis.

Design
Retrospective cohort.

Introduction
Lumbar disc arthroplasty (LDA) has become a popular alternative to anterior lumbar interbody fusion (ALIF). While current literature supports equivalent or better patient-reported outcome scores for LDA, there is no objective data on the utilization of facet injections for persistent pain following surgery. This study aims to compare the rate of lumbar facet injections as a measure of persistent symptomatic facet joint arthrosis following LDA vs ALIF.

Methods
The PearlDiver database was queried for patients (2010-2021) who had single-level LDA or ALIF without posterior techniques for a diagnosis of degenerative disc disease. All patients were followed for ≥2 years and excluded if they had spinal trauma, fracture, infection, or neoplasm prior to surgery. The two cohorts, LDA and ALIF, were matched 1:1 based on year of operation, age, sex, CCI, and smoking status. The primary outcome was incidence of lumbar facet injections (CPT-64493) following index surgery. Secondary outcomes included 90-day surgical complications. Categorical variables were compared with Chi-squared tests, and continuous variables with t-tests.

Results
A total of 34,547 patients met inclusion and exclusion criteria (n=1,618 LDA; n=32,929 ALIF). After 1:1 matching, each group had 1,466 patients. Mean follow-up was 3.68 (±2.49) years. Average length of stay was not significantly different (p=0.5) between LDA (4 ± 3.61 days) and ALIF (2.33 ± 1.53 days). Lumbar facet injections occurred significantly more frequently in the LDA group at 1-year (8.7% vs. 6.3%, p=0.049), 2-year (12.8% vs. 9.3%, p=0.013), and 5-year (18.6% vs. 14.3%, p=0.008) follow-ups. Within 90 days, there was no difference in surgical site infections, wound dehiscence, hardware complications, dural injuries, or medical complications.

Conclusion
Patients who underwent single-level LDA received significantly more lumbar facet injections at 1-, 2-, and 5-year follow-up compared to single-level stand-alone ALIF. Over time, facet injections were increasingly more likely with LDA vs. ALIF, suggesting continued progression of symptomatic facet joint arthrosis.

53. Abstract moved to E-Point Presentations

54. Outcomes of Minimally Invasive Decompression Alone Versus Fusion in Patients with Predominant Back Pain

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Hypothesis
Minimally invasive decompression alone and fusion have similar outcomes in patients with predominant back pain.

Design
Retrospective cohort

Introduction
No previous study has compared the outcomes of minimally invasive decompression alone and fusion in patients with predominant back pain and evidence is lacking on whether back pain alone, in absence of radiological indications for fusion, should be a deciding factor between decompression and fusion.

Methods
Patients who underwent minimally invasive decompression alone or fusion and had preoperative back pain > leg pain were included. The decompression and fusion groups were compared for these outcome measures were: 1) patient-reported outcome measures

(PROMs), 2) minimal clinically important difference (MCID) achievement, 3) patient acceptable symptom state (PASS) achievement, and 4) global rating change (GRC). As a subgroup analysis, MCID, PASS, and GRC rates were also compared between the decompression and fusion groups for patients with preoperative back pain < leg pain.

Results
510 patients were included. There were statistically significant improvements in all PROMs in both groups at <6 and >6 months with no significant difference in the magnitude of improvement. The fusion group showed significantly higher MCID achievement rates for VAS back at <6 months (85% vs. 70%, p=0.02) and ODI at >6 months (67% vs. 51%, p=0.04). Proportion of patients achieving PASS and feeling better after surgery based on response to GRC showed no difference between the two groups. The subgroup analysis for decompression versus fusion in patients with preoperative back pain < leg pain showed no differences in MCID, PASS, or GRC rates.

Conclusion
In patients with predominant back pain, minimally invasive decompression alone had significantly less MCID achievement rates in VAS back at <6 months and ODI at >6 months. However, it did lead to an overall significant improvement in PROMs, similar PASS achievement rates, and similar responses on the GRC scale.

55. Hypertension and High Post-Operative Diastolic Pressure Shown to Be Significant Risk Factors in Onset of Postoperative Lumbar Epidural Hematoma

Samuel Ezeonu, BA; Juan Rodriguez Rivera, BS; Alyssa Capasso, BS; Nicholas Vollano, MBS; Constance Maglaras, PhD; Tina Raman, MD

Hypothesis
Risk factors may be identified preoperatively for patients at higher risk for developing postoperative lumbar epidural hematoma.

Design
Single center retrospective study.

Introduction
Postoperative lumbar epidural hematoma (PLEH) is a well-known complication that though rare, has potentially catastrophic effects on outcomes and neurologic status. Our study sought to evaluate risk factors influencing PLEH in a large multi-surgeon, single institution database.

Methods
A total of 8407 lumbar cases were taken from 2017 to 2021 at a single institution. To assess potential risk factors, we utilized SPSS-based randomization to develop a control group selected at an approximately 4:1 ratio with PLEH cases. Univariate analysis included chi square analyses and independent t-tests. Multivariate regression analysis was also conducted for risk factors approaching or achieving significance. We followed all patients that had PLEH and evaluated patient outcomes up to 90 days.

Results
Of 8407 cases, PLEH had a prevalence of 0.27%. Univariate analysis showed that hypertension and postoperative DP were significant risk factors (p=0.009, p<0.001). Chi square analysis between the different thresholds of DP showed a significant association with PLEH at postoperative DP ≥ 90 mmHg (p=0.025). In multivariate analysis, we found that postoperative DP ≥ 90 mmHg (p=0.025) was also an independent predictor associated with 9.567 greater odds of having PLEH. Patients with PLEH had 6.83±8.07 days until onset of PLEH. Of the PLEH group, we found that 47.8% had delayed onset set at 3 days or more and 21.7% exhibited incomplete neurologic recovery up to 90 days. No significant relationship was able to be observed between delayed onset and neurologic recovery.

Conclusion
Patients with hypertension and higher postoperative diastolic pressure were found to be at greater risk of developing PLEH.

Figure 1: Univariate and Multivariate Analysis of Risk Factors For Post-Operative Lumbar Epidural Hematoma Requiring Return to OR

		Post-Operative Epidural Hematoma Requiring Return to OR		
UNIVARIATE ANALYSIS		Yes (N=23)	No (N=80)	p-value
Demographics	Age	61.52±15.39	61.33±14.99	0.956
	Gender (%F)	47.80%	50.00%	1.000
	BMI	30.11±6.11	29.85±6.22	0.854
	Diabetes Mellitus	21.70%	22.80%	1.000
	Hypertension	78.30%	46.30%	**0.009**
	History of Cancer	17.40%	8.90%	0.262
	Baseline Platelet Count (thousands/ml)	261.38±61.18	267.04±96.94	0.800
	Baseline Hgb (g/dL)	14.20±1.21	13.51±1.45	0.070
Perioperative Characteristics	%MIS	30.40%	18.80%	0.254
	# Operated Levels	1.83±0.94	1.81±1.01	0.954
	With Direct Decompression	87.30%	71.30%	0.175
	Use of Deep Drain	56.50%	66.30%	0.462
	Robot Assisted	17.40%	11.30%	0.480
	Incidental Durotomy	13.00%	11.30%	0.728
	Estimated Blood Loss (ml)	262.61±351.73	353.04±450.42	0.378
	Operative Time (min)	203.57±136.47	255.06±134.77	0.110
	Postop Diastolic Pressure (mmHg)	77.65±11.76	68.06±11.16	**<0.001**
	Postop Diastolic Pressure ≥ 90 mmHg	21.70%	2.50%	**0.006**
	Postoperative Hgb (g/dL)	11.68±1.62	10.94±1.85	0.147
	Postoperative Chemoprophylaxis	30.40%	31.30%	1.000
MULTIVARIATE REGRESSION ANALYSES			p-value	OR
		Hypertension	0.084	
		Baseline Hgb (g/dL)	0.304	
		Postop Diastolic Pressure ≥ 90 mmHg	**0.028**	**9.567**

56. Effects of Anti-Osteoporotic Therapies on Lumbar Interbody Fusion in Postmenopausal Osteoporotic Females

Lei Kuang, MD

Hypothesis
The effects of denosumab,teriparatide and their combination therapy on the BTMs,BMD and fusion after TLIF vary.

Design
Single-center,retrospective study

Introduction
Osteoporosis is a common reason of postoperative mechanical complications after lumbar fusion.Anti-osteoporotic treatment for them are necessary. Teriparatide and Denosumab,has already been approved to increase bone mineral density(BMD).However,the knowledge of their effects on lumbar fusion were inadequate.

Methods
Ninety-nine postmenopausal female with osteoporosis who underwent single-level TLIF with cement augmented pedicle screw fixation were included. Patients were categorized into teriparatide(T) group,denosumab(D) group,negative control(NC) group,and combination therapy(C) group. The age,menopause time,height,weight,body mass index,surgery segment were collected and compared between groups. The fusion rate,femoral neck T-scores,VAS,ODI scores recorded at preoperation,6,12 months after surgery were compared within and between groups. The bone turnover markers(BTMs) of serum P1NP and CTX were recorded and compared at preoperation,3,6,12 months after surgery. Pearson's correlation coefficients(R) were calculated to determine the relationship between BTMs and changes in femoral neck T-score.

Results
T-scores increased over 12 months in three treatment groups but decreased in group NC,with the largest increases in group C. Compared to the fusion rate of group NC,the fusion rate of the other three groups increased,with group C being the highest. At 6 and 12 months after surgery,ODI and VAS scores were significantly lower than preoperative scores in all groups. In group D and T,BTM changes at 12 months after surgery predict 12-month femoral neck T-score gains. In group C,more suppression in P1NP at 12 months after surgery predict 12-month femoral neck T-score gains.

Conclusion
The combination therapy of teriparatide and denosumab expedites spinal fusion subsequent to TLIF in postmenopausal women with osteoporosis. For patients received either denosumab or teriparatide alone,alterations in BTMs at the 12-month post-surgery correlate with 12-month gains in femoral neck T-scores. For patients received combination therapy-,although the trends in BTM changes align with denosumab,greater suppression of P1NP at the 12-month post-surgery is indicative of 12-month gains in femoral neck T-scores.

57. Commonly Used Patient-Reported Outcome Measures (PROMS) Do Not Adequately Reflect Patient-Perceived Changes in Health Status Following Lumbar Decompression

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Hypothesis
Patient-perceived changes in health status will correlate with Patient-reported Outcome Measures (PROMs) after lumbar decompression

Design
Retrospective review from a prospectively maintained registry

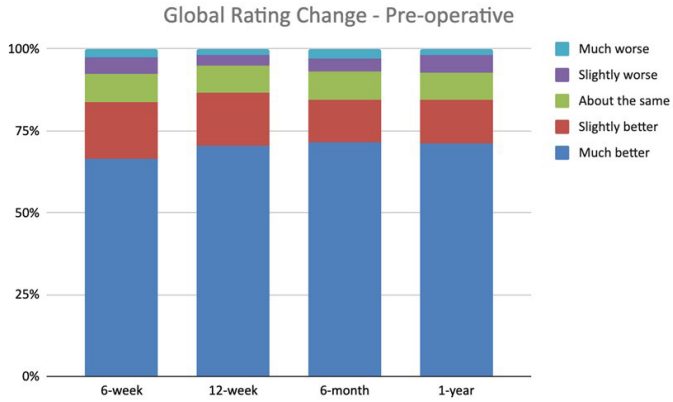
Introduction
PROMs are being increasingly utilized. However, there is little data on whether PROMs represent patient-perceived health status. The purpose of this study was to assess the correlation between commonly used PROMs and patient-perceived changes in health following lumbar decompression.

Methods
Consecutive patients undergoing lumbar decompression at a single institution were included (Apr '17-Feb '23). PROMs, including Oswestry Disability Index (ODI), Visual Analogue Scale (VAS) for back& leg pain, Short-Form 12 (SF-12 PCS/MCS) and PROMIS Physical Function, were collected pre- and postoperatively (6 wks, 12 wks, 6 mo, 1 yr). Patients also completed a 'Global Rating Change (GRC)' questionnaire, a 5-item Likert Scale ('much better', 'slightly better', 'about the same', 'slightly worse', 'much worse') for how their spine condition compared to preoperatively and to their prior visit. Spearman correlation coefficient (Rho) was used to assess the correlation of change in PROMs and GRC.

Results
965 patients were included (mean age 59yrs, 61% males). Percentage of patients feeling 'Much better' compared to pre-operatively was 66.6% at 6 weeks, 70.5% at 12 weeks, 71.7% at 6 months, and 71.1% at 1 year. Change in PROMs from pre-operatively showed a statistically significant but weak-to-moderate correlation with GRC at all timepoints for all PROMs (Spearman's Rho: 0.201 to 0.556). Change in PROMs compared to prior visits demonstrated statistically significant but very weak-to-weak correlation for all timepoints for ODI, VAS Back, SF-12 PCS and PROMIS-PF, and 2 of 3 time-points for VAS Leg, and 1 timepoint for SF-12 MCS (Spearman's Rho: 0.101 to 0.301).

Conclusion
Commonly utilized PROMS demonstrated a

weak-to-moderate correlation with patient-perceived changes in health, suggesting that these PROMs may not adequately reflect patient perceptions.



58. Review of Intraoperative Management and Outcomes of Incidental Durotomy in Minimally Invasive Spine Surgery

Chad Simon, BS; Jung Mok, MD; Tomoyuki Asada, MD; Kasra Araghi, BS; Eric Mai, BS; Olivia Tuma, BS; Max Korsun, BS; Avani S. Vaishnav, MBBS; Yeo Eun Kim, BS; Joshua Zhang, BS; Cole Kwas, BS; Myles Allen, MBchB; Nishtha Singh, BS; Eric Kim, BS; Sheeraz Qureshi, MD; Sravisht Iyer, MD

Hypothesis
Incidental durotomy (ID) in lumbar minimally invasive spine surgery (MISS) repaired without suture can achieve similar postoperative outcomes to primary suture repair.

Design
Retrospective review

Introduction
ID is a well-recognized complication of lumbar MISS. Due to limited visualization, ID is often repaired without suture in MISS under the postulate that smaller incisions and muscle sparing lead to decreased dead space and lessen the risk of perioperative complications. A relative lack of data remains on non-suture repair of IDs in MISS and its postoperative effects.

Methods
Lumbar MISS patients from 2017-23 at a single institution who experienced an ID were included. ID repair was performed with dural patch and/or sealant. Descriptive statistics, hospital and postoperative course, and PROMs at early (2-12 weeks) and late (6-24 months) follow-up were analyzed.

Results
Of 3,081 patients, 43 (1.4%) experienced IDs repaired without suture. Mean age was 66.4±14.0 years, mean BMI was 26.4±3.8, and mean CCI age was 2.9±1.6. Operations included 31 decompressions, 4 fusions, and 8 microdiscectomies. Thirty-eight were primary procedures. Thirty IDs were repaired with patch and sealant, 6 with patch, and 7 with sealant. Mean stay was 33.7±48.3 hours with 31 patients discharged same day or POD1. In-hospital complications included one headache, one new foot drop, and one case of CSF leak, which returned to the OR for suture repair. At 2 weeks, 4 patients had new radiculopathy—2 were unrelated to CSF leak. Three reoperations occurred: new radiculopathy (6 weeks), which returned to the OR for exploration of rootlet clumping and suture repair; cyst removal (12 weeks); recurrent stenosis (6 months). Compared to preoperatively, significant improvement was seen at late follow-up for VAS back (p=0.002), VAS leg (p=0.038), and SF-12 PCS (p=0.05) (Table).

Conclusion
MISS patients with non-suture ID repair experienced early discharge and significant improvement in certain PROMs. Complications related to the ID were transient with no permanent deficits, except for two reoperations that required primary repair.

Table. PROMs - Combined Timepoints

Variable	No Suture	p-value (preop vs. time point)
ODI		
Preoperative	36.7 ± 19.1	--
Early	37.6 ± 19.6	0.852
Late	26.3 ± 19.7	0.062
VAS back		
Preoperative	5.5 ± 3	--
Early	3.8 ± 2.4	**0.013**
Late	2.7 ± 3	**0.002**
VAS leg		
Preoperative	5.2 ± 3.4	--
Early	3.9 ± 2.9	0.089
Late	3.2 ± 3.5	**0.038**
SF-12 PCS		
Preoperative	34.2 ± 6.9	--
Early	34.8 ± 8.4	0.789
Late	39.4 ± 10.3	**0.05**
SF-12 MCS		
Preoperative	45.4 ± 9.9	--
Early	47.6 ± 7.8	0.352
Late	48.3 ± 9.9	0.347
PROMIS-PF		
Preoperative	36.6 ± 8.5	--
Early	36.4 ± 8.2	0.91
Late	41.3 ± 9.9	0.108

Podium Presentation Abstracts

59. Vancomycin Efficacy in Reducing Surgical Site Infection in Posterior Spinal Fusion Surgery

Aditya Joshi, BS; James Baber, MBChB, MPH; Amit Jain, MD; Khaled M. Kebaish, MD; *Hamid Hassanzadeh, MD*

Hypothesis
Intrawound vancomycin powder use in posterior spinal fusion surgery does not decrease the incidence of surgical site infection (SSI).

Design
Multicenter retrospective cohort.

Introduction
Intrawound vancomycin powder is one of many prophylactic measures against SSI in spinal surgery. Previous studies on vancomycin efficacy in SSI prevention were done at individual institutions or with a small sample. Furthermore, studies have demonstrated an increase in the incidence of non S. aureus and gram negative infections with increased antibiotic usage. The purpose of this study is to reevaluate vancomycin use as a preventative factor for SSI.

Methods
A prospectively collected international database of 3,595 patients from the STRIVE trial was stratified according to intrawound antibiotic usage. Multivariate logistic regression was used to determine the effect of vancomycin use on the incidence of SSI after adjusting for patient demographics and factors associated with developing SSI. Secondary outcomes included readmission due to complications from index surgery, critical care stay, additional surgery, and sepsis.

Results
3,311 patients underwent surgery. 1,533(46%) patients received intrawound vancomycin, 246(8%) received other intrawound antibiotics, and 1,532(46%) patients received none. The rate of infections was low; 250(8%) patients developed SSIs. Microbiological analysis confirmed 53(21.2%) S. aureus and 69(28%) non-S. aureus infections. The remaining cases were non-microbiologically confirmed. 131(52%) patients with SSIs received intraoperative vancomycin. Intrawound vancomycin was not associated with SSI incidence relative to patients who did not receive intrawound antibiotics (OR:1.17(0.88-1.55), p=0.29). Patients who received vancomycin had 1.82(1.28-2.6, $p < 0.001$) increased odds of readmission due to complications from index surgery and need for additional surgery (OR:1.75(1.18-2.6), p=0.005). Intrawound vancomycin use was not associated with patient critical care stay or sepsis (OR: 0.94(0.78-1.12), p=0.47; OR: 2.04(0.62-6.73), p=0.243). Factors associated with vancomycin use included readministration of antibiotics during procedure (OR:2.97(1.36-6.5), p=0.005) and hospital location in Europe or Asia relative to North America (OR:0.13(0.06-0.29), p<0.001) OR:0.02(0-0.08), p<0.001).

Conclusion
Vancomycin use is not associated with decreased incidence of SSI following posterior spinal fusion surgery.

60. Predictors of Delayed Clinical Benefit and Deterioration in Back Pain Following Surgical Treatment for Low Grade Spondylolisthesis an Analysis from QOD

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Hypothesis
Factors associated with long-term deterioration in back pain after surgical treatment for low-grade lumbar spondylolisthesis at 2 and 5 years can be identified.

Design
Retrospective analysis of prospectively collected data.

Introduction
Surgical treatment for low grade spondylolisthesis generally leads to significant improvement in health-related quality of life. Most patients experience rapid improvement in the first 3-6 months after surgery, however a minority of patients have delayed improvement. The purpose of this study is to examine factors associated with delayed improvement after surgical treatment of low grade spondylolisthesis.

Methods
Patients were identified from a prospectively enrolled multi-center registry of patients undergoing lumbar fusion surgery for spondylolisthesis. 436 patients were identified who had lumbar fusion for grade 1 spondylolisthesis, with a minimum 1 year follow up. Outcome measures were collected at 3, 6, 12, 24 and 60-month follow-up time points, including Numeric Rating Scale (NRS) back and leg pain, Oswestry Disability Index (ODI), EuroQol-5D (EQ-5D). Two separate analyses were done (1) Patients were categorized as demonstrating delayed clinical improvement if they had not reached MCID threshold at 3 months, but did ultimately reach MCID at 12-months. Binary logistic regression analysis was used to analyze factors associated with delayed clinical improvement (2) Patients were categorized based on back pain scores at 60 months compared to baseline as greater than or equal to 0 (improved or no worse), versus less than 0 (worsened).

Results
For the first analysis, 317 (72.7%) patients reached the

MCID threshold at 12 months following surgery. Of these patients, 249 (78.5%) exhibited a rapid clinical improvement trajectory and had achieved MCID threshold by the 3 month postop follow-up. 68 patients (15.6%) showed a delayed trajectory, and had not achieved MCID threshold at 3 months but did ultimately reach the threshold at 12-month follow-up. Factors which predicted delayed clinical improvement included pre-op ambulatory status (OR=6.09, p<0.001), baseline back pain (OR=0.80, p=0.018), and baseline (OR=0.82, p=0.032) and 3 month leg pain (OR=1.46, p<0.001). For the second analysis, at the 24-months (N = 388) 289 underwent lumbar fusion, 266 improved and 23 reported worse back pain at 24 months. At 60-months, (N = 456) 347 patients underwent fusion, 320 had improved pain scores, while 27 reported increased pain. Better baseline NRS back pain scores were associated with the deterioration group at both time points (6.91 vs 3.6 for the 24-month group and 6.92 vs 4.04 for the 60-month group). Less ODI improvement at 3 months post-op and persistent leg pain throughout were also associated with ultimate deterioration in back pain scores.

Conclusion
The majority of patients undergoing lumbar decompression and fusion for low grade spondylolisthesis reach MCID threshold rapidly, within the first three months following surgery. Independent predictors of delayed clinical improvement include impaired preoperative ambulation status, high preoperative low back pain and high preoperative and 3-month leg pain. Patients with better back pain scores at baseline were more likely to report frank deterioration back pain scores at 2 and 5 years. As most of these cases were fusion procedures, this emphasizes one potential risk of operating on patients with less severe symptoms. Persistent leg pain was also associated with deterioration in back pain scores

61. Predictors of Oswestry Disability Index (ODI) Deterioration at 5 Years After Surgery for Grade 1 Spondylolisthesis: A QOD Study

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Hypothesis
Worse pain and functional status at baseline are expected to be correlated with functional deterioration at 5 years after surgery.

Design
This was an analysis of the prospective Quality Outcomes Database Grade 1 Spondylolisthesis cohort which included adult patients who were diagnosed with primary grade 1 spondylolisthesis undergoing elective surgery at 14 highest enrolling sites.

Introduction
There is limited data on patient characteristics that contribute to long-term functional decline in patients with grade 1 spondylolisthesis who undergo surgery. The aim of this study is explore the factors that contribute to functional deterioration at 5 years postoperatively.

Methods
Function was measured with Oswestry Disability Index (ODI). Patients were dichotomized based on whether their ODI improved or worsened at 5-year follow-up compared to baseline. Those who maintained the same ODI were excluded. A multivariable logistic model using the stepwise selection method was used to find the most contributive predictors of ODI deterioration.

Results
Of the 608 patients with grade 1 spondylolisthesis who underwent surgery, 483 had 5-year follow-up ODI. Of these, 36 (7.5%) had worse ODI, 110 (22.8%) had no change in ODI, and 337 (69.8%) had improved ODI at 5-year follow-up. The 5-year follow-up rate was 81%. Patients with worse and improved ODI had similar age (65.4±12.6 vs 61.7±11.6), BMI (31.9±5.9 vs 30.2±6.4), and ASA grade (2.4±0.6 vs 2.3±0.6). Surgical characteristics were also similar between the two groups with similar length of surgery (175±79.3min vs 174±86.8min), and length of stay (2.6±1.5d vs 2.7±1.8d) (all p>0.05). The two groups had similar baseline back pain (6.9±2.4 vs 6.8±2.6) and leg pain (5.9±2.6 vs 6.6±2.8) (all p>0.05). Using multivariable logistic modeling, worse baseline back pain (OR=1.02,p<0.01) was predictive of worse ODI at 5 years.

Conclusion
Patients with worsened and improved function at 5-year follow-up after surgery for grade 1 spondylolisthesis did not differ in demographics, comorbidity, or surgical characteristics. Worse back pain at baseline was a significant predictor for ODI deterioration at 5 years.

62. Fused Spinopelvic Angles: Determining The Overcorrection Threshold to Prevent Proximal Junctional Kyphosis

Jung-Hee Lee, MD, PhD; Ki Young Lee, MD, PhD; Kyung-Chung Kang, MD, PhD; Won Young Lee, MD; Seong Jin Cho, MD; *Gil Han, MD*; Cheol-Hyun Jung, MD; Hong-Sik Park, MD; Woo-Jae Jang, MD; Min-Jeong Park, RN

Hypothesis
In the surgical treatment of adult spinal deformity (ASD), determining the threshold of overcorrection is

essential to achieve favorable outcomes and to reduce various potential complications.

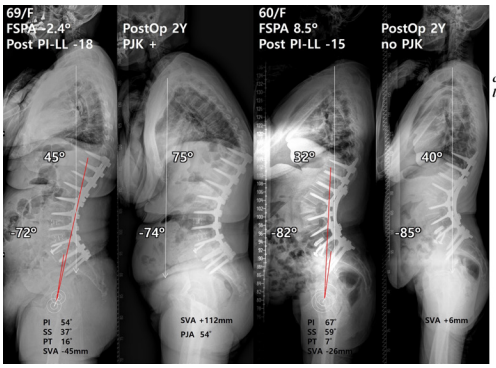
Design
A retrospective study.

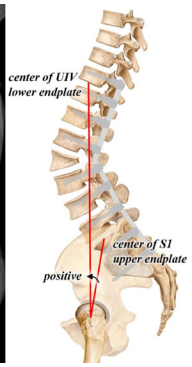
Introduction
Proximal junctional kyphosis (PJK) is a common complication that can occur after surgical treatment for ASD. However, there is still no consensus on how the degree of correction of lumbar lordosis (LL) affects PJK. Recently, a novel and fixed parameter known as the fused spinopelvic angle (FSPA) has been introduced as a method for preventing PJK. In this study, our goal is to determine the threshold of overcorrection using FSPA and validate its effectiveness.

Methods
We retrospectively selected 258 consecutive patients (mean age 71.4 years) with a minimum 2-year follow-up who underwent long segment fixation with sacropelvic fixation. A comparative analysis was performed by dividing the patients into two groups: the non-PJK group (n=135) and the PJK group (n=123). Pearson's correlation coefficient was used to analyze the relationship between parameters, while linear regression analysis and a multivariate logistic regression model were conducted to identify the risk factors for PJK and assess the upper limit of overcorrection.

Results
The PJK group exhibited significantly more negative postoperative FSPA (4.9° vs. -0.3°, p<0.05). Logistic regression analysis identified the FSPA as a crucial risk factor for PJK (p<0.05). In ROC curve analysis aimed at preventing PJK, the target value for FSPA was determined to be 2.38°. The FSPA has a strong positive correlation with the postoperative pelvic incidence (PI)-LL (r=0.516, p<0.001). A linear regression model revealed a threshold for the postoperative PI-LL, with FSPA exceeding 2.38°, to be -17.6 (r=0.61).

Conclusion
We found that in order to prevent PJK after surgical treatment of ASD, it is important to correct FSPA 2.38° or more. Furthermore, achieving an overcorrection where the PI-LL does not exceed -17.6 can result in clinical and radiological improvements after surgery.





63. Normalized Total Psoas Area Predicts Early Postoperative Mobility and Perioperative Complications After Complex Adult Spinal Deformity Surgery

Takashi Hirase, MD; Myles Allen, MBchB; Chukwuebuka Achebe, BS; Hiroyuki Nakarai, MD; Han Jo Kim, MD; Francis C. Lovecchio, MD

Hypothesis
We hypothesize that sarcopenia measured by L3 and L4 NTPA are both associated with lower postoperative mobility and higher rates of complications among patients undergoing complex adult spinal deformity(ASD) surgery.

Design
Retrospective Cohort Study

Introduction
Sarcopenia measured by normalized total psoas area (NTPA) has been shown to predict perioperative outcomes after various types of spine surgery. However, there is limited data regarding its association with post-operative mobility and perioperative complications in complex adult spinal deformity surgery. The purpose of this study was to determine the relationship between sarcopenia and postoperative mobility and complications among patients undergoing complex adult spinal deformity surgery.

Methods
Patients that underwent complex adult spinal deformity surgery were included in the study. Sarcopenia was analyzed by using NTPA at the L3 and L4 mid-vertebral body on preoperative magnetic resonance imaging (MRI). Intraclass Correlation Coefficient (ICC) was calculated for analyzing inter-rater reliability. Patients were grouped into sex-specific terciles based on L3 and L4 NTPA and the lowest terciles were defined as the sarcopenic groups. Primary outcome measures were postoperative ambulation distance and complications. Secondary outcome measures were length of stay (LOS), discharge disposition, and 30-day readmission and reoperation rates.

Results
113 patients (86 females 27 males, mean age 66.0±10.4 years) were included in the study. ICC for L3 NTPA was 0.945 (95% CI:0.785-0.981) and 0.827 (0.632-0.926) at L4. Sarcopenia was defined as L3 NTPA<440 mm2/m2 for females and <680 mm2/m2 for males and L4 NTPA<624 mm2/m2 for females and<852 mm2/m2 for males. Both L3 and L4 sarcopenia groups had significantly lower ambulation distances on postoperative days 1-3 compared to the non-sarcopenia groups. 84.2% of patients in the L3 sarcopenia group and 86.8% in the L4 sarcopenia group had one or more complications compared to 50.7% and 49.3% in the L3 and L4 non-sarcopenia groups, respectively (p<0.001, p=<0.001). The L4 sarcopenia group had a

longer LOS compared to the non-sarcopenia group (6.3±2.5 days vs 5.2±1.7 days, p=0.014).

Conclusion
Sarcopenia measured by L3 and L4 NTPA are both associated with lower postoperative mobility and higher rates of complications among patients undergoing complex (ASD) surgery.

L3 NTPA Characteristics and Outcomes			
Variable	**Sarcopenia (n=38)**	**No Sarcopenia (n=75)**	***P* Value**
Male (n, %)	9 (23.7)	18 (24.0)	0.968
Age (y) (mean, SD)	64.9 ± 14.2	66.6 ± 7.9	0.479
BMI (kg/m²) (mean, SD, range)	25.7 ± 5.8 (18.4-40.2)	27.7 ± 5.3 (19.2-44.6)	0.098
Postoperative Ambulation Distance (ft) (mean, SD, range)			
POD 1	18.1 ± 23.7 (0-80)	45.1 ± 53.7 (0-300)	<0.001*
POD 2	58.9 ± 62.5 (0-220)	112.7 ± 96.4 (0-450)	0.001*
POD 3	97.6 ± 64.4 (0-250)	146.4 ± 96.2 (0-550)	0.005*
POD 4	131.5 ± 85.0 (0-300)	132.3 ± 65.5 (0-400)	0.971
LOS (days) (mean, SD, range)	5.8 ± 2.4 (3-15)	5.4 ± 1.8 (2-11)	0.317
Discharge Disposition (n, %)			
Home	9 (23.7)	17 (22.7)	0.904
Home Health	28 (73.7)	49 (65.3)	0.368
Facility	1 (2.6)	9 (12.0)	0.097
30-day Reoperation (n, %)	1 (2.6)	1 (1.3)	0.624
30-day Readmission (n, %)	1 (2.6)	1 (1.3)	0.624
Postoperative Complications			
Any adverse events	32 (84.2)	38 (50.7)	<0.001*
Anemia requiring transfusion	24 (63.2)	31 (41.3)	0.029*
Cardiac (Afib RVR, MI)	3 (7.9)	2 (2.7)	0.201
Ileus	14 (36.8)	5 (6.7)	<0.001*
Wound complication (dehiscence, infection)	0 (0.0)	1 (1.3)	0.478
Delirium	1 (2.6)	2 (2.7)	0.992
Perioperative HW failure	1 (2.6)	0 (0.0)	0.159
AKI	2 (5.3)	2 (2.7)	0.478
Pneumonia	1 (2.6)	0 (0.0)	0.159
Hypotension requiring pressures	4 (10.5)	2 (2.7)	0.078
Urinary retention	11 (28.9)	7 (9.3)	0.007*
VTE	0 (0.0)	1 (1.3)	0.478
Syncope	1 (2.6)	0 (0.0)	0.159
L4 NTPA Characteristics and Outcomes			
Variable	**Sarcopenia (n=38)**	**No Sarcopenia (n=75)**	***P* Value**
Male (n, %)	9 (23.7)	18 (24.0)	0.968
Age (y) (mean, SD)	64.6 ± 14.3	66.7 ± 7.8	0.399
BMI (kg/m²) (mean, SD, range)	24.7 ± 5.2 (18.4-40.2)	28.1 ± 5.3 (19.2-44.6)	0.002*
Postoperative Ambulation Distance (ft) (mean, SD, range)			
POD 1	16.6 ± 22.7 (0-80)	46.8 ± 54.0 (0-300)	<0.001*
POD 2	61.1 ± 70.1 (0-270)	113.2 ± 94.7 (0-450)	0.002*
POD 3	101.9 ± 83.2 (0-280)	145.7 ± 89.5 (18-550)	0.022*
POD 4	117.5 ± 81.7 (0-300)	142.6 ± 65.4 (30-400)	0.186
LOS (days) (mean, SD, range)	6.3 ± 2.5 (3-15)	5.2 ± 1.7 (2-11)	0.014*
Discharge Disposition (n, %)			
Home	5 (13.2)	21 (28.0)	0.077
Home Health	31 (81.6)	46 (61.3)	0.029*
Facility	2 (5.3)	8 (10.7)	0.337
30-day Reoperation (n, %)	1 (2.6)	1 (1.3)	0.624
30-day Readmission (n, %)	1 (2.6)	1 (1.3)	0.624
Postoperative Complications			
Any adverse events	33 (86.8)	37 (49.3)	<0.001*
Anemia requiring transfusion	27 (71.1)	28 (37.3)	<0.001*
Cardiac (Afib RVR, MI)	2 (5.3)	3 (4.0)	0.757
Ileus	13 (34.2)	6 (8.0)	<0.001*
Wound complication (dehiscence, infection)	0 (0.0)	1 (1.3)	0.478
Delirium	1 (2.6)	2 (2.7)	0.992
Perioperative HW failure	1 (2.6)	0 (0.0)	0.159
AKI	3 (7.9)	1 (1.3)	0.075
Pneumonia	1 (2.6)	0 (0.0)	0.159
Hypotension requiring pressures	3 (7.9)	3 (4.0)	0.384
Urinary retention	10 (26.3)	8 (10.7)	0.031*
VTE	0 (0.0)	1 (1.3)	0.478
Syncope	1 (2.6)	0 (0.0)	0.159

**Statistically significant values*
NTPA, normalized total psoas area; SD, standard deviation; BMI, body mass index; POD, postoperative day; LOS, length of stay; Afib, RVR, atrial fibrillation with rapid ventricular response; MI, myocardial infarction; HW, hardware; AKI, acute kidney injury; UTI, urinary tract infection; VTE, venous thromboembolism

64. Forward Global Sagittal Alignment of The Cranium Relative to The Hips Drives Surgical Complexity and is Associated with a More Adverse Perioperative Course

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Hypothesis
Patients(pts) with forward cranial sagittal vertical axis relative to the hips(CrSVA-H) need more complex correction and suffer greater perioperative complications.

Design
Retrospective cohort of prospectively collected adult spinal deformity (ASD) pt database

Introduction
CrSVA-H is superior to C7SVA in predicting patient reported outcomes among ASD pts. Whether preop CrSVA-H impacts pts' operative complexity and periop course remains unclear.

Methods
314 ASD pts were stratified into quartiles by preop CrSVA-H (Q4 with the most forward cranial translation). Q1-3 (0-75th %ile) was aggregated and compared to Q4 (>75th%ile). Outcome variables were measures of operative complexity (TIL, osteotomies, blood loss (EBL), intraop complications, operative time) and periop course (length of stay (LOS) & inpatient complications). Continuous and categorical outcomes were assessed via Welch's T- and Chi-Squared Tests respectively. Continuous and binary outcomes were assessed in linear and logistic regression models respectively, adjusted for age/TIL/ASA score.

Results
Preop CrSVA-H alignment (cm) was: Q1<-4.6 (N=81), -4.6<Q2<-1.9 (N=82), -1.9<Q3<1.2 (N=74), Q4>1.2 (N=77). Demographics, alignment, and operative/periop course were similar between Q1, 2, and 3 (Table 1). For Q4, mean age was 54(2.25), BMI 27.6(1.18), TIL 14.2(0.46) and for Q1-3, mean age was 45(2.25), BMI 24.7(0.74), TIL 13.3(0.29). Q4 was significantly different in alignment from Q1-3 for PT (Q4 29.0[1.39] v. Q1-3 20.2[0.87], p<0.0001), PI-LL (Q4 26.8[2.05] v. Q1-3 6.1[1.28], p<0.0001), and CrSVA-H (Q4 6.8[0.13] v. Q1-3 -3.4[0.08], p<0.0001). A significantly greater % of Q4 pts underwent PCO (p=0.0131), PSO (p<0.0001), and VCR (p=0.0289). Q4 pts had 2.4(P=0.03) higher odds of undergoing VCR(vs Q1-3). Q4 was also associated with significantly greater EBL(p<0.0001), operative time(p=0.0104), intraop neuromonitoring loss(p=0.0014), LOS(p<0.0001), and inpatient complications(p=0.0238). On regression, Q4 alignment (vs Q1-3) was predictive of EBL(β=650, p<0.0001), operative time(β=1.55, p<0.0001), intraop neuromonitoring loss(OR=3.91, p=0.0011), length of stay(β=1.06, p=0.0159), and occurrence of inpatient complication(OR=1.95, p=0.0297).

Conclusion
Patients with forward CrSVA-H exceeding 1.2cm underwent more extensive procedures and had a more challenging operative and perioperative course.

Podium Presentation Abstracts

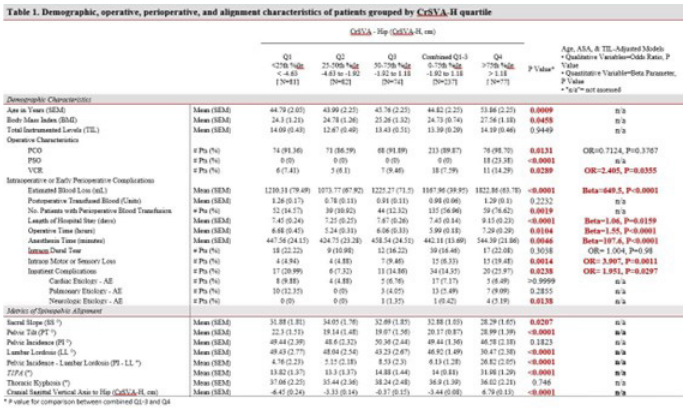

Table 1. Demographic, operative, perioperative, and alignment characteristics of patients grouped by CrSVA-H quartile

CrSVA - Hip (CrSVA-H, cm)

		Q1 <25th %ile < -4.63 [N=81]	Q2 25-50th %ile -4.63 to -1.92 [N=82]	Q3 50-75th %ile -1.92 to 1.18 [N=34]	Combined Q1-3 0-75th %ile -1.92 to 1.18 [N=237]	Q4 >75th %ile > 1.18 [N=77]	P Value*	Age, ASA, & TIL-Adjusted Models: • Qualitative Variables=Odds Ratio, P Value • Quantitative Variable=Beta Parameter, P Value • "n/a"= not assessed
Demographic Characteristics								
Age in Years (SEM)	Mean (SEM)	44.79 (2.05)	43.99 (2.25)	45.76 (2.25)	44.82 (2.25)	53.86 (2.25)	**0.0009**	n/a
Body Mass Index (BMI)	Mean (SEM)	24.3 (1.21)	24.78 (1.26)	25.26 (1.32)	24.73 (0.74)	27.56 (1.18)	**0.0458**	n/a
Total Instrumented Levels (TIL)	Mean (SEM)	14.09 (0.43)	12.67 (0.49)	13.43 (0.51)	13.39 (0.29)	14.39 (0.46)	0.9449	n/a
Operative Characteristics								
PCO	# Pts (%)	74 (91.36)	71 (86.59)	68 (91.89)	213 (89.87)	76 (98.70)	**0.0131**	OR=0.7124, P=0.3707
PSO	# Pts (%)	0 (0)	0 (0)	0 (0)	0 (0)	18 (23.38)	**<0.0001**	n/a
VCR	# Pts (%)	6 (7.41)	5 (6.1)	7 (9.46)	18 (7.59)	11 (14.29)	**0.0289**	**OR=2.405, P=0.0355**
Intraoperative or Early Perioperative Complications								
Estimated Blood Loss (mL)	Mean (SEM)	1210.38 (79.49)	1073.77 (67.92)	1225.27 (71.5)	1167.96 (39.95)	1822.86 (83.78)	**<0.0001**	**Beta=649.5, P<0.0001**
Postoperative Transfused Blood (Units)	Mean (SEM)	1.26 (0.17)	0.78 (0.11)	0.91 (0.11)	0.98 (0.06)	1.28 (0.1)	0.2232	n/a
No. Patients with Perioperative Blood Transfusion	# Pts (%)	52 (64.57)	39 (50.82)	44 (32.32)	135 (56.96)	59 (76.62)	**0.0019**	n/a
Length of Hospital Stay (days)	Mean (SEM)	7.45 (0.24)	7.25 (0.27)	7.67 (0.26)	7.45 (0.14)	9.15 (0.23)	**<0.0001**	**Beta=1.06, P=0.0159**
Operative Time (hours)	Mean (SEM)	6.68 (0.45)	5.24 (0.31)	6.06 (0.33)	5.99 (0.18)	7.29 (0.29)	**0.0104**	**Beta=1.55, P<0.0001**
Anesthesia Time (minutes)	Mean (SEM)	447.56 (24.15)	424.75 (23.28)	458.54 (24.31)	442.11 (13.69)	544.39 (21.86)	**0.0046**	**Beta=107.6, P<0.0001**
Intraop Dural Tear	# Pts (%)	18 (22.22)	9 (10.98)	12 (36.22)	39 (16.48)	17 (22.08)	0.3038	OR=1.004, P=0.98
Intraop Motor or Sensory Loss	# Pts (%)	4 (4.94)	4 (4.88)	7 (9.46)	15 (6.33)	13 (19.48)	**0.0014**	**OR=3.907, P=0.0011**
Inpatient Complications	# Pts (%)	17 (20.99)	6 (7.32)	11 (34.86)	34 (14.35)	20 (25.97)	**0.0238**	**OR=1.951, P=0.0297**
Cardiac Etiology - AE	# Pts (%)	8 (9.88)	4 (4.88)	5 (6.76)	17 (7.17)	5 (6.49)	>0.9999	n/a
Pulmonary Etiology - AE	# Pts (%)	10 (12.35)	0 (0)	3 (4.05)	13 (5.49)	7 (9.09)	0.2855	n/a
Neurologic Etiology - AE	# Pts (%)	0 (0)	0 (0)	1 (1.35)	1 (0.42)	4 (5.19)	**0.0138**	n/a
Metrics of Spinopelvic Alignment								
Sacral Slope (SS °)	Mean (SEM)	31.88 (1.81)	34.05 (1.79)	32.69 (1.85)	32.88 (1.03)	28.29 (1.65)	**0.0207**	n/a
Pelvic Tilt (PT °)	Mean (SEM)	22.3 (1.51)	19.14 (1.48)	19.07 (1.58)	20.37 (0.87)	28.99 (1.39)	**<0.0001**	n/a
Pelvic Incidence (PI °)	Mean (SEM)	49.44 (2.39)	48.6 (2.32)	50.36 (2.44)	49.44 (1.36)	46.58 (2.18)	0.1823	n/a
Lumbar Lordosis (LL °)	Mean (SEM)	49.43 (2.77)	48.04 (2.54)	43.23 (2.67)	48.92 (1.49)	30.47 (2.38)	**<0.0001**	n/a
Pelvic Incidence - Lumbar Lordosis (PI - LL °)	Mean (SEM)	4.78 (2.23)	5.15 (2.18)	8.53 (2.3)	6.13 (1.28)	20.82 (2.07)	**<0.0001**	n/a
TIPA (°)	Mean (SEM)	13.82 (1.37)	13.3 (1.37)	14.88 (1.44)	14 (0.81)	31.98 (1.29)	**<0.0001**	n/a
Thoracic Kyphosis (°)	Mean (SEM)	37.06 (2.25)	35.44 (2.36)	38.24 (2.48)	36.9 (1.39)	36.02 (2.28)	0.746	n/a
Cranial Sacral Vertical Axis to Hip (CrSVA-H, cm)	Mean (SEM)	-6.47 (0.24)	-3.33 (0.14)	-0.37 (0.15)	-3.44 (0.08)	4.79 (0.13)	**<0.0001**	n/a

* P value for comparison between combined Q1-3 and Q4

65. Can Patient Specific Precontoured Rod Instrumentation Reduce The Rate of Proximal Junctional Kyphosis for Adult Spinal Deformity? A Propensity Score Matched Analysis.

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Hypothesis

Adult spinal deformity(ASD) patients instrumented with precontoured rods(PCR) will experience a reduced rate of proximal junctional kyphosis(PJK) and failure when compared to those instrumented with conventional rods.

Design

Retrospective cohort study.

Introduction

This is the first study that seeks to investigate the impact of PCR instrumentation on the rate of PJK in ASD patients undergoing multilevel PSIF.

Methods

ASD patients undergoing minimum 5 level PSIF were consecutively reviewed from 2016-2021. A propensity score matching algorithm was used to match patients undergoing instrumentation with precontoured rods (PCR group) to those from a historical group of 210 consecutive patients treated with conventional rods (CR group). Covariates used for matching included age, gender, BMI, osteopenia/osteoporosis (T-score < -1), smoking history, total number of fusion levels, UIV at the thoracolumbar (TL) region, and fixation at the pelvis/sacrum. The primary outcome was the rate of radiographic PJK at minimum one year follow up. PJK was defined by two criteria: (1) a postop proximal junctional sagittal Cobb angle ≥ 10° and (2) at least 10° greater than the preop measurement.

Results

Following propensity score matching, 160 patients were included in the study (80/group). Patients demonstrated similar preop baseline characteristics including age (PCR: 59.7±17.4yrs vs. CR: 59.5±15.1yrs, p=0.470), gender (58.8% female vs. 60% female, p=0.872), BMI (27±6 vs. 27±5, p=0.435), osteopenia/osteoporosis (16.3% vs. 26.3% , p=0.122), smoking history (23.8% vs. 31.3%, p=0.288), mean total number of fusion levels (12±5 vs. 13±4, p=0.367), UIV at the TL region (45% vs. 38.8%, p=0.423) and, fixation to the sacrum (80% vs. 81.3%, p=0.841). Furthermore, preop radiographic alignment was similar between groups (Table). Preop, average PJA measured 9.24±6.8° and 8.8±7.3° for the PCR and CR groups, respectively (p=0.751). At most recent follow up, PCR and CR groups demonstrated an average PJA of 11.6±9.1° and 10.8±8.3°, respectively (p=0.545). 10 (12.5%) patients experienced PJK in the PCR group compared to 16 (20%) patients in the CR group (p=0.199).

Conclusion

In the largest study comparing the use of PCR to CR bending and correction, we found that fewer patients developed radiographic PJK in the PCR group, however this did not reach significance.

		Precontoured Rod Group				Conventional Rod Group				
		Mean	Standard Deviation	Count	%	Mean	Standard Deviation	Count	%	P Value
Age At Surgery		59.7	17.4			59.5	15.2			0.470
Gender	Female			47	58.8%			48	60.0%	
	Male			33	41.3%			32	40.0%	0.872
BMI		27	6			27	5			0.435
Osteopenia/Osteoporosis	No			67	83.8%			59	73.8%	
	Yes			13	16.3%			21	26.3%	0.122
Smoking Hx	No			61	76.3%			55	68.8%	
	Yes			19	23.8%			25	31.3%	0.288
Total Instrumented Levels		12	5			13	4			0.367
UIV Thoracolumbar Region	No			44	55.0%			49	61.3%	
	Yes			36	45.0%			31	38.8%	0.423
Fusion to Pelvis/Sacrum	No			16	20.0%			15	18.8%	
	Yes			64	80.0%			65	81.3%	0.841
Preop SVA		61.7	68.7			41.5	61.0			0.052
Preop TK		34.0	16.8			37.3	21.3			0.278
Preop LL		48.1	17.4			28.9	18.4			<0.001
Preop SS		31.5	12.6			28.1	13.5			0.111
Preop PT		24.3	12.3			27.3	12.6			0.129
Preop PI		55.5	12.6			55.5	16.8			>0.999
PJK	No			70	87.5%			64	80.0%	
	Yes			10	12.5%			16	20.0%	0.199

66. Post-Operative Hyperextension Bracing Has The Potential to Reduce PJK: A Propensity Matched Analysis of Braced Versus Non-Braced Cohorts

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Hypothesis

Postoperative extension bracing reduces rate of proximal junctional kyphosis (PJK) after adult spinal deformity (ASD) surgery

Design

Retrospective cohort

Introduction

Postoperative hyperextension bracing has not been shown to affect rates of PJK after ASD surgery. How-

ever, past studies have used heterogeneous bracing strategies. We conducted a pilot study on a specific type of extension brace to examine preliminary effects on proximal junctional complications.

Methods
Patients were identified from a single-surgeon dataset of posterior-only fusions for ASD (2017 to 2021, pelvis to UIV of T9-12) with a minimum of 1 year follow up. Proximal tethers were not used at any point. Starting in 2021, all lower thoracic to pelvis fusions were braced using a Jewett hyperextension brace fitted in the supine position. Patients wore the brace (B) at all times (unless in bed) for the first 6-8 weeks after surgery. A 1:1 propensity-match was performed based on age, number of levels, three column osteotomies, and magnitude of correction to identify a matched non-braced (NB) cohort.

Results
A total of 141 (113 non-brace, 28 brace) were evaluated. Overall rate of PJK was 31.9%. 28 patients from the NB group were propensity matched to 28 patients in the B group based on the parameters above (Table). For the overall cohort, the change in proximal junctional angle from preop to 1 year was higher in the NB group (7.6° vs. 8.1°, p=0.04), trending toward a higher effect size in the propensity matched analysis (4.5° vs. 8.1°, p=0.06). NB patients had a higher incidence of PJK at one year in both the overall cohort (36% vs 14%, p=0.04) and the matched analysis (43% vs 14%, p=0.03). The incidence of revision for PJF was 8.5%, no differences were seen in the rate of revision surgery for PJF between groups (p=1.00).

Conclusion
Extension bracing may reduce rates of PJK. These findings can form the basis for future multicenter trials examining the effect of extension bracing on rates junctional complications.

Variable	No Brace Matched N=28	Brace N=28	P-Value
Age (mean in years (sd))	67 (10.8)	66 (9.3)	0.571
Body Mass Index BMI (mean (SD))	29.18 (5.16)	27.50 (6.55)	0.291
Current Smoker (%)	1 (3.6)	0 (0.0)	1.000
Hypertension (%)	13 (46.4)	11 (39.3)	0.787
Osteoporosis (%)	4 (14.3)	2 (7.1)	0.666
Charlson Comorbidity Index with Age (mean (SD))	2.55 (0.69)	2.68 (1.56)	0.987
Posterior Column Osteotomy Levels (mean (SD))	2.07 (0.88)	2.56 (1.09)	0.193
Three Column Osteotomy Performed (%)	6 (21.4)	5 (17.9)	1.000
Number of Interbody Fusion Levels (mean(SD))	0.50 (0.69)	0.32 (0.55)	0.339
Preop Pelvic Incidence (mean (SD))	56.39 (12.35)	54.52 (13.46)	0.607
Preop PI-LL (mean (SD))	26.24 (20.40)	21.01 (23.78)	0.422
Preop TK (mean (SD))	27.86 (17.15)	31.38 (18.26)	0.490
Preop TPA_ (mean (SD))	26.24 (12.02)	24.59 (13.28)	0.654
Δ PI-LL pre to postop (mean (SD))	-17.68 (17.25)	15.65 (18.09)	0.748
Δ TK pre to postop (mean (SD))	9.32 (15.30)	9.89 (14.14)	0.917
Δ TPA pre to postop (mean (SD))	-14.17 (9.56)	-9.18 (8.87)	0.174
Δ L1PA pre to postop (mean (SD))	-5.05 (4.88)	-6.00 (7.24)	0.568
Δ One Year PJA (mean (SD))	8.15 (7.77)	4.49 (6.32)	0.058
PJK at Discharge (%)	1 (3.6)	1 (3.6)	1.000
PJK at 1 Year(%)	12 (42.9)	4 (14.3)	**0.038**

67. Utility of Computerized Tomography Hounsfield Unit Measurements to Predict Proximal Junctional Kyphosis in Adult Spinal Deformity Patients with Long Constructs

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Hypothesis
CT Hounsfield Units (CTHU) can be used to predict proximal junctional kyphosis (PJK). The levels proximal to the upper instrumented vertebra (UIV) can also play a role in predicting PJK.

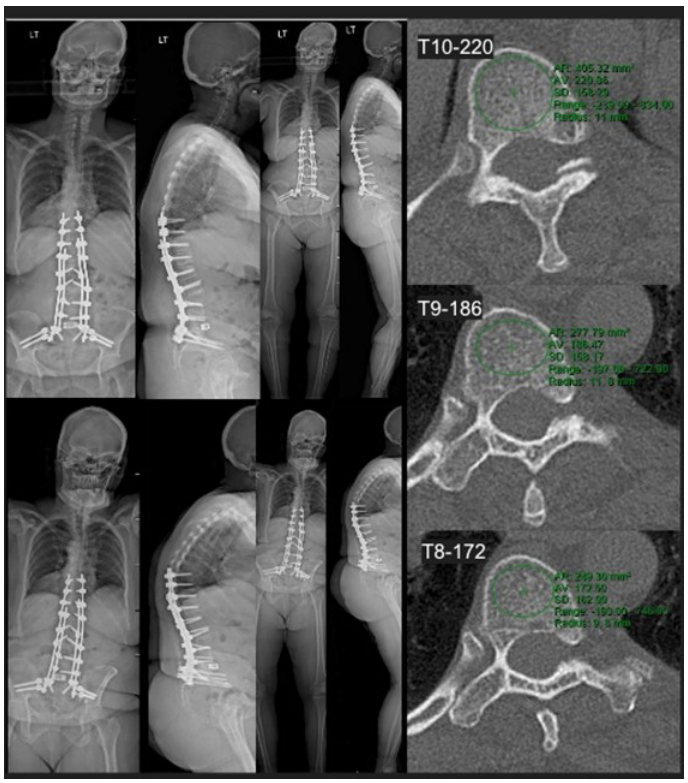
Design
Retrospective cohort

Introduction
Several studies have examined the relationship between low CTHU and postoperative complications. Low CTHU, specifically scores below 159, at the UIV and UIV+1 have been shown to increase the likelihood to develop PJK, pseudarthrosis, and pedicle screw loosening. In contrast, greater CTHU values have been associated with greater osteologic fusion potential at 1 year follow-up. For this study, we aimed to study the relationship of CTHU at the UIV, UIV+1, UIV+2 in patients with long constructs undergoing deformity correction and postoperative complications with a minimum two-year follow-up.

Methods
152 ASD patients were identified retrospectively at a single center. Patients with UIV distal to L2, prior anterior fusion at UIV, or UIV at C2 were excluded. CTHU were measured at the UIV, UIV+1, and UIV+2 of each patient. Statistical analysis was performed with significance set to p<0.05.

Results
152 patients were identified with 94 primary procedures and 58 revisions. 19 patients (12.5%) developed PJK. No significant differences in PJK rate were found based on gender (p=0.66) and BMI (p=0.202). Patients who developed PJK were significantly older than those who did not (p=0.006). Patients undergoing revision surgery had a higher rate of PJK 19.6% (11/56) compared to primary 7.3% (7/96) (p=0.006177). UIV ranged from C5-L2 with T2 the most common UIV (n=61). Average follow-up was 2.1 years. Most of the 19 patients that developed PJK were within 15 months, ranging from 1 week to 3 years postoperatively. For patients with a thoracic UIV who developed PJK, the CTHU at the vertebral levels proximal to UIV was lower on average by 17 per level than the UIV. In contrast, for patients who did not develop PJK, the CTHU was higher by 12 on average in the vertebral levels proximal to UIV (p<0.00001).

Conclusion
CTHU under 160 was identified as a risk factor for developing PJK. Patients with lower CTHU in vertebral bodies proximal to UIV are at a significantly increased risk of developing PJK in long fusion constructs. Surgeons should consider an alternate UIV in this situation.



Patient s/p T10-pelvis who developed PJK at 1 year postoperatively.

68. Intraosseous Injection of Bone Morphogenetic Protein-2 at The Uppermost Instrumented Vertebra for Prevention of Proximal Junctional Kyphosis Following Long Segment Fusion in Adult Spinal Deformity: A Preliminary Report

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Hypothesis
In surgical treatment for drop body syndrome (DBS), the injection of bone morphogenetic protein (BMP)-2 at the uppermost instrumented vertebra (UIV) is expected to have a positive effect on trabeculation rebuilding which can prevent proximal junctional fracture (PJFx) and early-onset proximal junctional kyphosis (PJK).

Design
A randomized controlled trial (RCT)

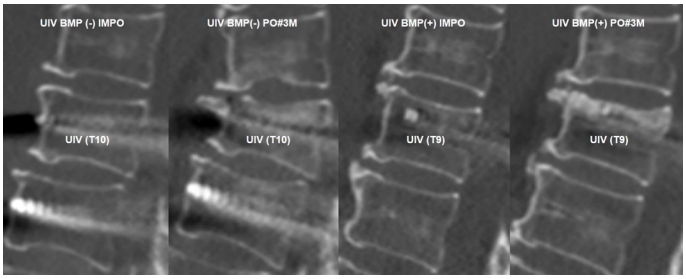
Introduction
PJFx after surgical treatment for adult spinal deformity have been reported with various prevalence. We designed a novel approach by injecting BMP-2 into the UIV in an attempt to prevent PJFx.

Methods
The study conducted a RCT including 66 patients (mean age 71.0 years) with DBS who underwent long-segment fusion, and followed for a minimum of 3 months. The

patients were divided into two groups: one group in which BMP-2 was injected into the UIV (BMP group, n=29) and the control group (n=37). Before and immediately after surgery, and at 3-month follow-up, spinopelvic parameters, anterior body height (ABH) of UIV, and Hounsfield unit (HU) of UIV-1, UIV, and UIV+1 were obtained from x-ray and CT sagittal image.

Results
The UIV was T9 (n=40) or T10 (n=26). PJK occurred in 13 cases (19.7%), while PJFx occurred in 8 cases (12.1%). Postoperative SVA (-40.7mm vs. -30.5mm) and PI-LL (-15.0º vs. -11.3º) showed no significant differences between the two groups. Regardless of the injection of BMP-2 or the presence of PJK, HU of UIV-1 and UIV increased, and UIV ABH decreased at the 3-month follow-up (p<0.001, respectively). When comparing the two groups, excluding patients with PJFx, there was no significant difference in UIV ABH reduction. However, specifically for the 13 patients with PJK, UIV ABH reduction was significantly lower in the BMP group (p<0.05).

Conclusion
In long segment fusion extending to T9 or 10, ABH reduction was observed at the UIV-1 and UIV. The injection of BMP-2 into the UIV is expected to help prevent PJFx or a revision surgery by preserving the ABH of the UIV in cases where PJK occurs.



69. Does the New Lenke Modular Radiographic Classification of Adult Idiopathic Scoliosis (ADIS) Reliably Dictate Preferred Treatment?

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Hypothesis
The new Adult Idiopathic Scoliosis (AdIS) classification proposed by Lin, Lenke et al. would be highly predictive of spinal regions to be included in the fusion.

Design
Retrospective single surgeon analysis of AdIS pts who underwent corrective surgery.

Introduction
In attempt to both classify AdIS and help predict treatment, Lin, Lenke et al. published a modification of the original triad modular Lenke AIS classification which includes 6 (same) curve types, Lumbosacral and Global Alignment modifiers. The purpose of this study is to assess if this modular classification can accurately recommend fusion regions of AdIS.

Methods
Pt demographics, periop data, and radiographic parameters were collected at baseline. Pts were then classified based on the new modular Lenke AdIS classification. Compliance with recommended treatment was then assessed on postop xrays with respect to whether structural regions were included in the fusion and nonstructural regions were not. Radiographic assessment of moderate to severe stenosis on lumbar MRI was added to the classification and reassessed if this improved compliance.

Results
153 pts were included [Type (T) 1 (30), T-2 (15), T-3 (24), T-4 (12), T-5 (39), T-6 (33)][127= F (83.6%)]. Median age was 45yrs, 13 pts (8.6%) had 3COs, and pelvic fixation was done on 82 pts (53.6%). Overall adherence of the original classification was 58.2%. When applying a lumbar MRI modifier, adherence increased to 62.7% (p=0.4131). Treatment adherence was lowest in T-1 (73.3%), 2 (66.7%), and 5 (30.8%) curves. Adherence was at its highest in T-3(95.8%), 4 (91.7%), 6 (90.9%) curves. When excluding T-5 curves, treatment adherence increased from 62.7% to 75.4% (p=0.0276). The vast majority of Type 5 non-adherence was due to inclusion of a "nonstructural" Main Thoracic curve due to other clinical criteria such as shoulder alignment. A structural LS curve resulted in pelvic fixation in 91.2% of pts. On the contrary, a nonstructural curve resulted in no pelvic fixation in 68.8% of pts. All pts w/ lumbar stenosis on MRI were decompressed and instrumented to the pelvis.

Conclusion
The new AdIS classification system had fairly good treatment recommendations for all curves (75.4%) except for Type 5 (only 31%) by this modular adaptation of the AIS system. The addition of a lumbar stenosis modifier on MRI predicted pelvic fixation w/ 100% accuracy.

Table 4. Treatment guidelines and overall adherence to guidelines per Lenke AdIS Classification System

Curve Type	Tx Guidelines	No. of Patients	Tx Not Adhered	Tx Adhered
Type 1	MT	30	8 (26.7)	22 (73.3)
Type 2	PT & MT	15	5 (33.3)	10 (66.7)
Type 3	MT & TLL	24	1 (4.2)	23 (95.8)
Type 4	PT, MT, & TLL	12	1 (8.3)	11 (91.7)
Type 5	TLL	39	27 (69.2)	12 (30.8)
Type 6	TLL & MT	33	3 (9.1)	30 (90.9)
Nonstructural LS Curve	No Pelvic Fixation	96	30 (31.3)	66 (68.8)
Structural LS Curve	Pelvic Fixation	57	5 (8.8)	52 (91.2)
Aligned	No Pelvic Fixation	115	54 (47.0)	61 (53.0)
Malaligned – Coronal	Pelvic Fixation	12	7 (58.3)	5 (41.7)
Malaligned – Sagittal	Pelvic Fixation	21	3 (14.3)	18 (85.7)
Malaligned – Both	Pelvic Fixation	5	0 (0.0)	5 (100.0)
Lumbar Stenosis - MRI	Pelvic Fixation	50	0 (0.0)	50 (100.0)
Overall Tx Adherence w/o MRI Component	Fusion & Pelvic Fixation	153	64 (41.8)	89 (58.2)
Overall Tx Adherence w/ MRI Component	Fusion & Pelvic Fixation	153	57 (37.3)	96 (62.7)

Podium Presentation Abstracts

70. Radiological Features and Postoperative Outcomes in Patients of Degenerative Lumbar Scoliosis with Pelvic Obliquity: The Application of a Novel Classification

Junyu Li, MD; Xie Bowen, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; *Miao Yu, MD*; Yan Zeng, MD; Weishi Li, MD; Bo Zhang, BS; John C. Clohisy, MD; Anthony Pajak, BS

Hypothesis
Patients can be categorized into types I and II based on the classification of PO that we proposed and should adopt different surgical strategies accordingly.

Design
Retrospective clinical study conducted in a tertiary hospital.Patients included was those who was diagnosed with DLS and underwent posterior scoliosis correction, internal fixation, and fusion surgery at our institution.

Introduction
Poor quality of life may result from Pelvic Obliquity (PO). Degeneration Lumbar Scoliosis (DLS) is a prevalent spinal condition with a high prevalence of PO. There aren't many researches that discuss the PO, its definition, or its effects on DLS patients.

Methods
Patients with PO (POA ≥3°) were divided into type I (n=48) and type II (n=48) patients (n = 42). The higher iliac spine of the pelvis was congruent with the direction of the the C7 plumb line(C7PL) offset in Type I, whereas in Type II, the higher iliac spine was opposite to the direction of the C7PL offset. A comparative analysis was performed between pre- and postoperative radiological parameters and patient-reported outcomes of various patients' types.

Results
90 patients (31%) had PO, of whom 48 were type I and 42 were type II. Compared to patients who had persistent postoperative PO, type I patients who recovered from PO had lower Apical vertebral translation(AVT)(13.27±2.59 vs. 20.34±7.32, p=0.025), while type II recovered patients had lower postoperative Sacral Obliquity Angle(SOA) (1.62±0.46 vs. 3.89±1.70, p=0.015). The percentage of intraoperative fixation to the sacrum was lower in type II patients with follow-up-recurrent-PO (15.8% vs. 60%, p=0.014).

Conclusion
Patients can be categorized into types I and II based on the classification of PO that we proposed and should adopt different surgical strategies accordingly. Intraoperative SOA correction and fixation to the sacrum in Type II patients are crucial for restoring long-term pelvic balance while improvement in Cobb angle and AVT after sugery are more important for correcting Type I PO.

71. Detecting Perioperative Body Composition Changes in Elective Spine Surgery Through Bioimpedance Analysis

Alex Coffman, BS; Catherine Olinger, MD; Cassim Igram, MD; *Sarah Ryan, MD*

Hypothesis
We hypothesize that obese (BMI >30) patients will demonstrate increased muscle wasting indicated by bioimpedance analysis compared to non-obese patients in the perioperative period.

Design
Prospective cohort study

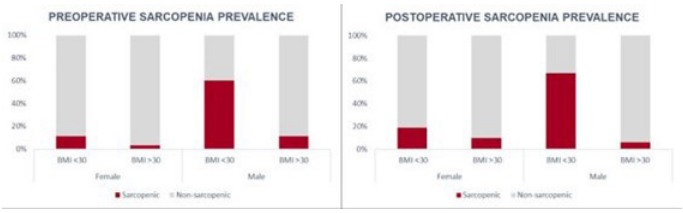
Introduction
Body mass index (BMI) is a common tool for perioperative risk assessment in spine patients but provides an incomplete picture of body composition. Sarcopenia, characterized as low muscle mass or quality, is an independent predictor of perioperative complications and mortality after spine surgery. In conjunction with elevated BMI, this is termed 'sarcopenic obesity'. The purpose of this study is to establish the prevalence of sarcopenia and sarcopenic obesity among elective spine surgery candidates using bioimpedance analysis and to monitor body composition trends in this patient cohort.

Methods
A total of 97 patients between ages 21-81 were enrolled. Patients underwent bioimpedance analysis (BIA) scans at the preoperative visit, which collects variables including weight, BMI, phase angle, and appendicular skeletal muscle index (ASMI). Sarcopenia is defined as ASMI <8.5 kg/m2 for men and 6.3 kg/m2 for women.

Results
The median age, BMI, and skeletal muscle index (SMI) of patients at enrollment were 61.35 ± 13.1 years, 31.67 ± 5.9 kg/m2, and 8.17 ± 1.45 kg/m2, respectively. Preoperatively, 19% of patients met the criteria for sarcopenia (n=18) and 4% for sarcopenic obesity (n=4). The percentage of sarcopenic patients increased to 21% at 2 weeks post-procedure and 25% at 6 weeks post-procedure. Prevalence of sarcopenia was highest among non-obese males (Figure 1) both pre and postoperatively. The mean skeletal muscle index decreased from 8.17 ± 1.45 kg/m2 pre-procedure to 7.82 ± 1.25 kg/m2 post-procedure. Patients experienced an average weight loss of 2.19 lbs (p=0.12), a decrease in SMM by 1.81 (p=0.36), and a decline in SMI by 0.43 (p=0.87).

Conclusion
Sarcopenia is prevalent among preoperative spine surgery patients at our institution, particularly among male patients of lower BMI. Although further data collection is needed to establish trends in body com-

position and correlation with surgical outcomes, this preliminary data identifies patients that might benefit from increased surveillance and targeted nutritional intervention in the perioperative period.



Prevalence of sarcopenia by gender among obese and non-obese patients at preoperative and postoperative time points.

72. A Regularized Linear Regression Equation Predicts Cranial SVA-Hip Alignment Without Full Body Radiographs

Sarthak Mohanty, BS; Fthimnir Hassan, MPH; Christopher Lai, BS; Christopher Mikhail, MD; Stephen Stephan, MD; Andrew Platt, MD; Joshua Bakhsheshian, MD; Zeeshan M. Sardar, MD; Joseph M. Lombardi, MD; Lawrence G. Lenke, MD

Hypothesis

Cranial SVA to the hip(CrSVAH) can be accurately predicted using spinal alignment from C2-Sacrum.

Design

Single center, retrospective study of 471 pts undergoing PSF for deformity with 2Y FU. Deformity defined as ≥1 criteria: PI-LL≥25°, TPA≥30°, SVA≥15cm, thoracic scoliosis≥70°, or thoracolumbar scoliosis≥50°.

Introduction

CrSVAH is superior to C7SVA in predicting HRQOL. 36-inch x-rays encompassing both the femoral heads and skull are often impossible to obtain.

Methods

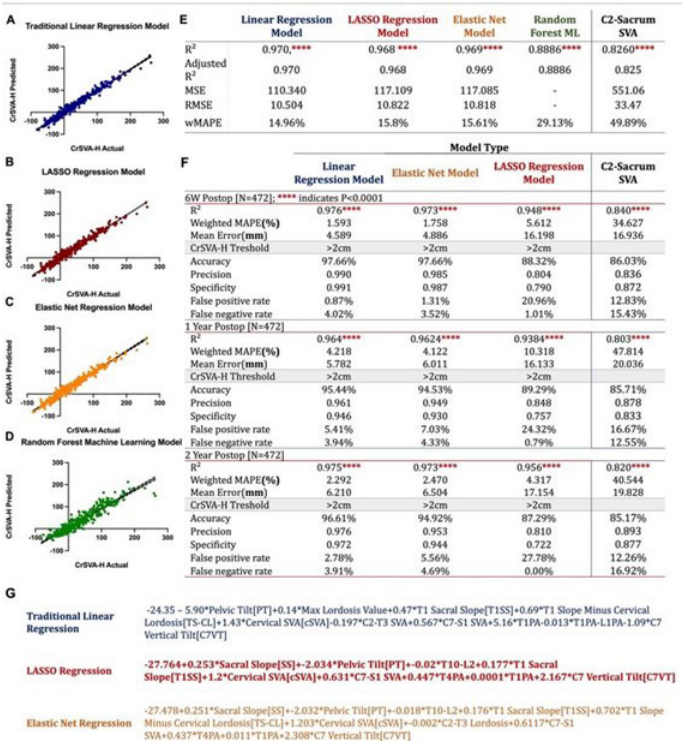
Models were built on preop CrSVAH and validated on postop CrSVAH at 6wk, 1yr, and 2yr. Model performance was assessed by R-squared(R2), weighted mean absolute % error(wMAPE)[% error b/w predicted & actual values] and mean absolute error(MAE) [mean error b/w predicted & actual values]. Models were tested to assess if they could predict which pts had global malalignment(CrSVAH<2cm vs >2cm). Four models were tested: traditional linear regression (LR) (Fig A); two data science techniques that minimize variance—LASSO regression(Fig B) and elastic net regression(ER)(Fig C); and Random Forest Classification(RF) (Fig D), a machine learning algorithm. C2-Sacrum(C2-S) SVA served as a control model.

Results

471 ASD pts had mean age 61.1(SD14.9) and CrSVA-H 37.2mm(SD60.3). Using preop CrSVAH observations, our experimental models outperformed C2-S SVA for predicting preop CrSVAH(all P<0.0001)[R2:LR=0.970, LASSO=0.968, ER=0.969, RF=0.890, C2-S=0.830]. C2-S SVA and RF had highest error between predicted and actual CrSVAH values; ER and LR had lowest[w-MAPE: LR=14.9%, ER=15.6%, RF=29.1%, C2-S=50%] (Fig E). Next, we tested performance of LR, LASSO, & ER models vs. control[C2-S SVA] at predicting postop CrSVAH. LR and ER predicted CrSVA-H with high accuracy at all postop timepoints. For example, elastic net regression(ER) had R2 of 0.96-0.97, wMAPE of 1.75-4.1%, and MAE of 4.9mm – 6.5mm at all timepoints (vs. C2-S SVA had R2 of 0.80-0.84, wMAPE 34.6-47.8%, MAE 16.9-20.0mm). Finally, the accuracy of predicting which pts had sagittal malignment was between 95.4%-97.7% for LR, 94.5%-97.7% for ER, and 85.2%-86.0% for C2-S SVA from 6W-2Y postop(Fig F). LR equation: CrSVAH=–24.35–5.90*PT+0.14*MaxLordosis+0.47*T1SS+0.69*[T1S-CL]+1.43*cSVA-0.197*C2-T3 SVA+0.567*C7-S1 SVA+5.16*T1PA-0.013*[T1PA-L1PA]-1.09*C7VT(All Equations- Fig G).

Conclusion

Specialized mathematical equations can predict preop and postop CrSVAH with 95% accuracy without full-body radiographs.



E

	Linear Regression Model	LASSO Regression Model	Elastic Net Model	Random Forest ML	C2-Sacrum SVA
R^2	0.970.****	0.968 ****	0.969****	0.8886****	0.8260****
Adjusted R^2	0.970	0.968	0.969	0.8886	0.825
MSE	110.340	117.109	117.085	-	551.06
RMSE	10.504	10.822	10.818	-	33.47
wMAPE	14.96%	15.8%	15.61%	29.13%	49.89%

F

Model Type	Linear Regression Model	Elastic Net Model	LASSO Regression Model	C2-Sacrum SVA
6W Postop [N=472]; **** indicates P<0.0001				
R^2	0.976****	0.973****	0.948****	0.840****
Weighted MAPE(%)	1.593	1.758	5.612	34.627
Mean Error(mm)	4.589	4.886	16.198	16.936
CrSVA-H Treshold	>2cm	>2cm	>2cm	
Accuracy	97.66%	97.66%	88.32%	86.03%
Precision	0.990	0.985	0.804	0.836
Specificity	0.991	0.987	0.790	0.872
False positive rate	0.87%	1.31%	20.96%	12.83%
False negative rate	4.02%	3.52%	1.01%	15.43%
1 Year Postop [N=472]				
R^2	0.964****	0.9624****	0.9384****	0.803****
Weighted MAPE(%)	4.218	4.122	10.318	47.814
Mean Error(mm)	5.782	6.011	16.133	20.036
CrSVA-H Threshold	>2cm	>2cm	>2cm	
Accuracy	95.44%	94.53%	89.29%	85.71%
Precision	0.961	0.949	0.848	0.878
Specificity	0.946	0.930	0.757	0.833
False positive rate	5.41%	7.03%	24.32%	16.67%
False negative rate	3.94%	4.33%	0.79%	12.55%
2 Year Postop [N=472]				
R^2	0.975****	0.973****	0.956****	0.820****
Weighted MAPE(%)	2.292	2.470	4.317	40.544
Mean Error(mm)	6.210	6.504	17.154	19.828
CrSVA-H Treshold	>2cm	>2cm	>2cm	
Accuracy	96.61%	94.92%	87.29%	85.17%
Precision	0.976	0.953	0.810	0.893
Specificity	0.972	0.944	0.722	0.877
False positive rate	2.78%	5.56%	27.78%	12.26%
False negative rate	3.91%	4.69%	0.00%	16.92%

G

Traditional Linear Regression	-24.35 – 5.90*Pelvic Tilt[PT]+0.14*Max Lordosis Value+0.47*T1 Sacral Slope[T1SS]+0.69*T1 Slope Minus Cervical Lordosis[TS-CL]+1.43*Cervical SVA[cSVA]-0.197*C2-T3 SVA+0.567*C7-S1 SVA+5.16*T1PA-0.013*T1PA-L1PA-1.09*C7 Vertical Tilt[C7VT]
LASSO Regression	-27.764+0.253*Sacral Slope[SS]+-2.034*Pelvic Tilt[PT]+-0.02*T10-L2+0.177*T1 Sacral Slope[T1SS]+1.2*Cervical SVA[cSVA]+0.631*C7-S1 SVA+0.447*T4PA+0.0001*T1PA+2.167*C7 Vertical Tilt[C7VT]
Elastic Net Regression	-27.478+0.251*Sacral Slope[SS]+-2.032*Pelvic Tilt[PT]+-0.018*T10-L2+0.176*T1 Sacral Slope[T1SS]+0.702*T1 Slope Minus Cervical Lordosis[TS-CL]+1.203*Cervical SVA[cSVA]+-0.002*C2-T3 Lordosis+0.6117*C7-S1 SVA+0.437*T4PA+0.011*T1PA+2.308*C7 Vertical Tilt[C7VT]

73. Novel Risk Factors and a Radiological Predictor Model for The Progression of Proximal Junctional Kyphosis in Osteoporotic Vertebral Compression Fracture with Kyphosis Following Posterior Corrective Surgery

Junyu Li, MD; Yinghong Ma, MD; Junjie Ma, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; Yan Zeng, MD

Podium Presentation Abstracts

Hypothesis
Thoracolumbar Slope(TLS) and L1 plumb line(L1PL) can be used to predict the occurrence of Proximal Junctional Kyphosis(PJK) in patients undergoing surgery for Osteoporotic Vertebral Compression Fracture(OVCF) and higher Global Alignment and Proportion(GAP) scores are associated with higher rates of PJK.

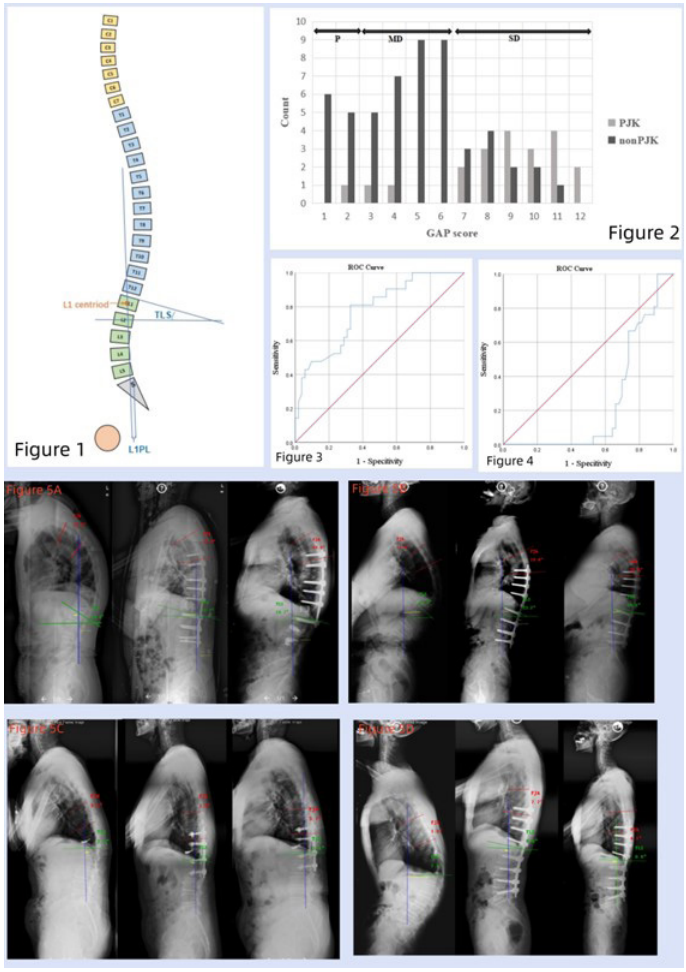
Design
Retrospective study.

Introduction
Due to advanced age, osteoporosis and paraspinal muscle degeneration, OVCF patients have a greater risk of surgery.How to develop a better surgical strategy is the focus of current research. This study aims to define the correlation of TLS and L1PL with the occurrence of PJK and evaluate the GAP Score'effect for PJK following OVCF correction surgery. Based on our findings, we aimed to further provide clinical recommendations on the current operational strategy for preventing PJK.

Methods
A total of 74 OVCF patients undergoing posterior corrective surgery between January 2008 and June 2021 with a minimum 2-year follow-up were included. These patients were divided into PJK and non-PJK groups. Spinopelvic parameters such as TLS and L1PL were measured preoperatively, postoperatively, and at follow-up. Between-group comparisons and tests of association were performed.Multivariate logistic analysis was performed on various risk factors as well as GAP score.

Results
Multiple comparisons showed that the proportion of PJK in the severely disproportioned group(the group of the highest GAP scores) and that of other two groups of lower GAP scores was statistically different. Potential risk factors for PJK included preoperative TK, TLS and postoperative TLS, L1PL. Postoperative TLS and L1PL were respectively independent as risk factors for PJK, with the cut-off values set at 8.6° and 10.4 mm to predict the occurrence of PJK.

Conclusion
TLS and L1PL can be used to predict the occurrence of PJK in patients undergoing surgery for OVCF and are crucial for preventing the progression of PJK. Achieving a proportionate GAP Score postoperatively seems to be a viable option as higher GAP scores were associated with higher rates of PJK.



L1PL and TLS;Distribution of the GAP grouped by PJK;ROC curve for immediate postoperative TLS and L1PL(3 and 4);L1PL,TLS,and PJA,in PJK patients.

74. Guttering Osteotomy for Removal of Retro-Corporeal Compressive Pathology During Anterior Cervical Discectomy and Fusion

Dong-Ho Lee, MD, PhD; Chang Ju Hwang, MD, PhD; Jae Hwan Cho, MD, PhD; *Sehan Park, MD*

Hypothesis
Guttering osteotomy can provide wider working space during anterior cervical discectomy and fusion (ACDF) for removal of retro-corporeal cord compressive lesion of cervical spine.

Design
Technical note with retrospective cohort study

Introduction
Various compressive pathologies including disc, bone spurs, and ossification of the posterior longitudinal ligament can cause cervical cord compression which could lead to cervical myelopathy. While these anterior compressive pathologies are more frequently located behind the disc space, they occasionally extend to retro-corporeal space which makes complete decompression by conventional ACDF impossible. The study was

conducted to describe construct stability and safety of guttering osteotomy as an adjunct to anterior cervical discectomy and fusion (ACDF) to provide remove retro-corporeal compressive lesions

Methods
Guttering is a technique that makes a tunnel through the vertebral body adjacent to the endplate to remove compressive pathologies behind the vertebral body. A total of 217 patients who underwent ACDF for the treatment of cervical myelopathy and were followed-up for ≥1 year were retrospectively reviewed. Fusion rate, subsidence, neck pain visual analog scale (VAS), arm pain VAS, and neck disability index (NDI) were assessed. Results were compared between the guttering group (patient whom guttering was performed) and non-guttering group (patients whom guttering was not performed).

Results
Thirty-five patients (16.1%) were included in the guttering group, while 182 patients (83.8%) were included in the non-guttering group. Fusion rate assessed by interspinous motion (p=0.559), and bone bridging on CT (p=0.541, and 0.715, respectively) were not significantly different between the two groups at one-year postoperative follow-up. Furthermore, neck pain VAS (p=0.492), arm pain VAS (p=0.099), and NDI (p=1.000) at postoperative one-year did not demonstrate significant intergroup difference. All patients in the guttering group showed healed gutter at postoperative one-year CT.

Conclusion
Guttering as an adjunct to ACDF could provide wider workspace for complete decompression when there is retro-corporeal extension of compressive pathology. This additional bone resection is not associated with increased pseudarthrosis or subsidence, nor related to aggravation of patient symptoms.

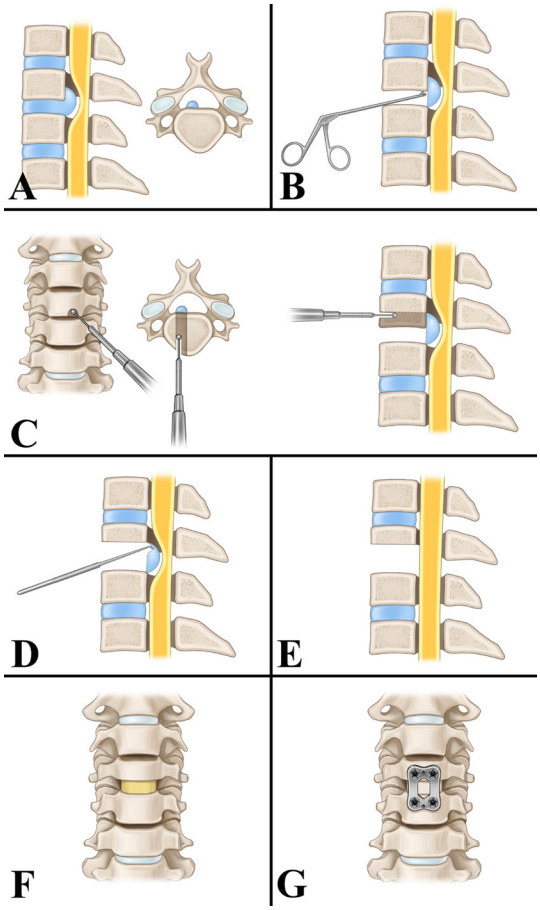


Figure. Surgical procedures of guttering technique.

75. Intraoperative C2 Slope Thresholds for Optimal Functional & Clinical Outcomes in Cervical Deformity Correction

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Hypothesis
C2 slope may have predictive value of attaining optimal outcomes.

Design
Retrospective cohort review

Introduction
It has not been determined whether intraoperative or immediate postoperative C2 and T1 slope and the magnitude of change from baseline correlate with health-related quality of life(HRQL) metrics and radiographic complications.

Methods
CD patients with UIV above C7 and with pre-(BL)/2-year(2Y) postop radiographic/HRQL data were included. Paired means comparison analysis and linear

regression analysis assessed the impact of absolute intraoperative/immediate postoperative(intra-op) radiographic measures or BL-normalized changes in radiographic measures on post-op outcomes. Univariate, multivariate backstep(MVA) logistic regression, and conditional inference tree(CIT) were used to determine radiographic thresholds for postop outcomes. Optimal outcome was defined as: 1) meeting Virk good clinical outcome criteria [≥2 of following: NDI<20 or meeting MCID, mild myelopathy(mJOA≥14), NRS-Neck≤5 or improved by≥2 points], and 2) not developing DJK/DJF by 2Y.

Results
178 CD patients met inclusion criteria (61.2±10.5yrs, 63%F, BMI 29.0±7.5kg/m2, CCI:1.00±1.31) and underwent surgery (levels fused 7.5±3.7, EBL 990mL, op time 547min). By approach, 19.3% anterior-only, 44.5% posterior-only, and 36.1% combined. Between BL-intra-op, paired analysis revealed significant mean decrease in C2S (Δ-9.30°) and TS-CL (Δ-12.03°), and mean increase in CL (Δ+14.06°)(all p<.001). Between intra-op-3M there was significant gain in C2S(Δ+7.98°), T1S(Δ+8.14°), and TS-CL(Δ+8.82°)(all p<.001). Between 3M-6M, there was significant improvement in T1S(Δ-2.36°,p=.047), and between 6M-1Y patients demonstrated moderately increased TS-CL(Δ+4.71°,p=.006). Between 1Y-2Y, there was notable decrease in C2S(Δ-3.01°,p=.001), T1S(Δ-3.15°,p=.001), CL(Δ-7.18°,p=.015), and TS-CL(Δ-3.99°,p=.001). Between BL-intra-op, absolute reduction in C2S of >13.70°(43.94%) was significantly associated with a decrease in DJF risk(p=.041). An increase in T1S of >8.0° at 3M was positively correlated with DJK(p=.032), as was increasing C2S, TS-CL, and cSVA at 6M (p=.001). Patients who had improvement in cSVA at 6M were significantly more likely to achieve optimal outcome by 2Y(p=.013).

Conclusion
This study demonstrates intra-operative reduction in C2 slope≥44% from baseline is significantly associated with reduced risk of distal junctional failure.

76. Range of Horizontal Gaze Following Multilevel Posterior Cervical Fusion Across the Cervicothoracic Junction

Clayton Hoffman, BS; Michael Nocek, BA; Zohaib Sherwani, MD; Vikas V. Patel, MD; Shahbaaz Sabri, MD; David C. Ou-Yang, MD; Christopher J. Kleck, MD

Hypothesis
In patients undergoing ≥3 level PCF, there is no significant difference in range of horizontal gaze between constructs that terminate at C7 vs. T1-T3.

Design
Retrospective chart review.

Introduction
Debate exists as to whether multilevel posterior cervical fusion (PCF) should cross the cervical thoracic junction (CTJ). Multiple studies have demonstrated typical spinal radiographic parameters are not significantly changed when patients are fused above vs. across the CTJ. Yet, there is a paucity of evidence examining how horizontal gaze is affected following cervical fusion.

Methods
Retrospective analysis was performed on patients 18-100 years old who underwent primary PCF involving ≥3 segments with caudal endpoints of C7-T3. McGregor slope (McGS) and C0-C2 cobb angle were measured on lateral cervical x-rays in flexion, extension, and neutral pre- and post-cervical fusion. Statistical analysis was performed to assess for significant change in these measures both pre- and post-fusion as well as between Group 1 and Group 2.

Results
A total of 44 patients were deemed eligible. In all patients, full range of horizontal gaze as measured by McGS in flexion – extension decreased by an average of 15.6° (p < 0.0001) while C0-C2 cobb angle extension – flexion increased by an average of 3.9° (p = 0.014) pre- vs. post-fusion. Fusion across the CTJ made no difference in range of horizontal gaze in either McGS or C0-C2 cobb angle when patients were separated into Group 1 vs. Group 2.

Conclusion
Our findings demonstrate that multilevel PCF significantly decreases full range of horizontal gaze. This loss is in-part compensated for by an increase in motion above the construct at C0-C2. We did not detect a significant difference in full range of horizontal gaze when constructs terminated at or above C7 vs. across the CTJ to T1-T3. Based on our findings, spine surgeons can expect multilevel PCF to significantly decrease their patients' range of horizontal gaze regardless of fusion across the CTJ.

Podium Presentation Abstracts

Total Population Pre- vs. Post-operative				
Characteristic	Follow-up	Mean	SD	P-value
McGS neutral	Preop.	-3.6°	8.69°	0.84
	Postop.	-3.3°	9.6°	
	Postop-preop.	0.3°	9.9°	
McGS flexion – extension	Preop.	73.8°	24.1°	<0.0001
	Postop.	58.3°	18.0°	
	Postop-preop.	-15.6°	22.5°	
C0-C2 neutral	Preop.	23.6°	10.1°	0.37
	Postop.	24.9°	10.9°	
	Postop-preop.	1.3°	9.4°	
C0-C2 extension – flexion	Preop.	25.4°	11.4°	0.014
	Postop.	29.3°	8.2°	
	Postop-preop.	3.9°	10.1°	

Fusion Termination at C7 vs. T1,2,3 Cohorts						
Characteristic	Follow-up	Subgroup	Results			
			N	Mean	SD	P- value
McGS flexion – extension	Preop.	C7	26	78.6°	24.3°	0.13
		T1,2,3	18	66.9°	22.7°	
	Postop.	C7	26	61.9°	17.6°	0.07
		T1,2,3	18	53.1°	17.8°	
	Postop.-preop.	C7	26	-16.8°	25.8°	0.67
		T1,2,3	18	-13.8°	17.2°	
C0-C2 extension – flexion	Preop.	C7	26	25.8°	11.9°	0.68
		T1,2,3	18	24.7°	10.8°	
	Postop.	C7	26	28.9°	8.2°	0.88
		T1,2,3	18	29.9°	8.3°	
	Postop.-preop.	C7	26	3.0°	11.4°	0.30
		T1,2,3	18	5.2°	8.0°	

Full range of McGS motion significantly decreased by 15.6° after ≥3 level PCF. This motion is partially compensated for by the increase in range of C0-C2 motion by 3.9°. Analysis between constructs terminating at C7 vs. T1-3 did not reveal significant difference in McGS or C0-C2 range of motion.

77. Utility of Pre-Flip Intraoperative Neurophysiologic Monitoring Baselines for Posterior Decompression and Fusion for Cervical Spondylotic Myelopathy

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Hypothesis

Obtaining pre-flip intraoperative neurophysiologic monitoring baselines in posterior decompression and fusion for cervical spondylotic myelopathy does not have an impact on neurologic outcomes.

Design

A single-institution retrospective review

Introduction

Intraoperative neurophysiologic monitoring (IONM) is widely used in spinal surgery. Yet, the utility of pre-flip baselines in posterior cervical decompression for central stenosis remains ambiguous. This study examines pre-flip baselines' impact on intraoperative alterations and postoperative neurological outcomes in cervical spondylotic myelopathy (CSM) surgeries.

Methods

A retrospective review of consecutive adult patients who underwent posterior cervical decompression and instrumented fusion for CSM with spinal cord compression from 2012 to 2022 was performed. Medical records and neurophysiology raw data sources were reviewed independently. Perioperative, 2-week, and 3-month neurologic status was compared between patients with and without pre-flip baselines.

Results

A total of 169 patients were included: no pre-flip (97) and pre-flip (72). Mean age was 65.5 years old and 61% were female. Overall, 50.9% of patients had preoperative weakness and 73.7% had T2 signal abnormalities with no difference in weakness (47.4% vs. 55.6%, p>0.05) or T2 signal (72.2% vs. 75.8%, p>0.05) between groups. Pre-flip cohort had significantly longer time to induction and time to incision, with mean of additional 22.1 minutes (p=0.040 and p=0.001, respectively). Overall, perioperative neurological deficit rate was 12.4% and 3-month neurological deficit rate was 4.7% (excludes palsies). Similar rates of neurological deficits were observed between the cohorts at each time point: perioperative (15.5% vs. 8.3%, p=0.228), 2 weeks (4.1% vs. 5.6%, p=0.793), and 3 months (5.2% vs. 4.2%, p=0.999). On subgroup analysis of the pre-flip group, there was no significant difference in incidence of neurological deficits at outcome time points among patients with (A) reliable IONM without signal change post-flip, (B) reliable IONM with signal change post-flip, and (C) no reliable IONM pre-flip baselines and postop flip.

Conclusion

With this retrospective data, there does not appear to be a clear neurological benefit to obtaining pre-flip baseline for CSM, but larger multicenter prospective studies are warranted.

78. Impact of Enhanced Recovery After Surgery (ERAS) Program on Post-Operative Course in Adult Cervical Deformity Patients

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Hypothesis

Enhanced Recovery After Surgery (ERAS) may help accelerate patient recovery after corrective cervical deformity (CD) surgery and assist hospitals in maximizing the incentives of bundled payment while maintaining high-quality care.

Design

Retrospective review of prospective CD database

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Introduction
A key component of an enhanced recovery pathway is the ability to predictably reduce inpatient length of stay, and reduce postoperative opioid use and complications. Here, we assess the impact of ERAS protocols on perioperative course in corrective CD surgery.

Methods
Operative CD patients with complete pre-(BL)/2-year(2Y) postop radiographic/HRQL data were stratified by enrollment in Standard-of-Care ERAS starting in 2020. Differences in demographics, outcomes, radiographic alignment, perioperative factors and complications were assessed via means comparison analysis.

Results
270 patients were included (58.11±11.97 years, 48% female, 29.13±6.89 kg/m2. 54(20.0%) received ERAS protocol recovery treatment post-operatively. At baseline, ERAS+ also had significantly higher NDI(p=.005) and EQ5D (p=.023), and significantly lower mJOA scores (p<.001). At BL, ERAS- patients were significantly more likely to utilize opioids than ERAS+ patients (p=.016). ERAS+ patients had significantly lower operative times overall, and if staged, ERAS+ patients had a significantly lower mean Stage 1 op time(both p<.021). Furthermore, ERAS+ patients also had significantly lower EBL overall(583.48 vs 246.51, p<.001), and required significantly lower doses of Propofol intraoperatively than ERAS- patients(p=.020). ERAS+ patients reported lower mean LOS overall(4.33 vs 5.84, p=.393) and were more likely to be discharged directly home ($\chi 2(1) = 4.974$, p=.028). ERAS+ patients were less likely to require steroids after surgery (p=.045), were less likely to develop neuromuscular complications(p=.025), and less likely experience venous complications or be diagnosed with venous disease post-operatively (p=.025).

Conclusion
Enhanced Recovery After Surgery (ERAS) programs in ACD surgery demonstrate significant benefit in perioperative outcomes. Patients undergoing ERAS-based protocols experience lower operative times, length of stays, and rates of opioid use, anesthetic dose, and post-operative complications. For ERAS-eligible patients, such programs may improve clinical outcomes and reduce cost burden for hospitals and patients.

79. Incorporation of Frailty Based Realignment Target Goals for Cervical Deformity Surgery in Adults Can Mitigate Mechanical Complications and Improve Perioperative Course

Jamshaid Mir, MD; Pooja Dave, BS; Peter Tretiakov, BS; Oluwatobi O. Onafowokan, MBBS, MS; Ankita Das, BS; Nathan Lorentz, MD; Matthew Galetta, MD; Stephane Owusu-Sarpong, MD; Tyler K. Williamson, MS, BS; *Peter G. Passias, MD*

Hypothesis
Assessing patient-specific targets accounting for frailty can improve outcomes in ACD.

Design
Retrospective cohort

Introduction
Assessing patient-specific goals accounting for frailty, can lead to greater rates of optimal outcomes in ACD.

Methods
Operative adult cervical deformity (ACD) patients with 2 year data were included. Patients were stratified based on mFI into not frail (NF), frail (F), and severely frail (SF). Good outcomes (GO) was defined as meeting all of the following parameters at 1Y and 2Y: 1) no DJF or mechanical failure, 2) met Virk et al. good clinical outcome, NRS-Neck ≤5 or improvement ≥2 points from BL], 3) improved in ≥1 Ames modifier, and 4) no worsening in Ames modifier. Those that did not meet GO were PO. ANCOVA used to control for baseline deformity, levels corrected, and age to assess radiographic alignment on earliest postoperative imaging. Logistic regression analysis followed by conditional inference tree (CIT) run forest analysis generated categorical thresholds.

Results
343 ACD patients were included (Age 59.6±12.4yrs, 46% females, BMI 28.6 ± 7.1kg/m2). Baseline HRQL's were NDI 53±19, ODI 48.5±17.5, mJOA 13.2 ± 2.6, Swal 89 ± 22, EQ-5D 0.54 ± 0.21. Baseline frailty categories: 21% Not Frail, 67% Frail, and 12% severely frail. Baseline deformity: TS-CL 36.1°±18.9°, cSVA 4.5±2.4cm, C2-C7 -3.9°±22.2°, C2-T3 -15.5°±21.5°, C2S 35.8°±19.9°, MGS 2.3°±13.0°, with greater deformity present as frailty increased. BL mJOA was worse in SF and in PO cohort (both p< 0.001). Overall by 2Y, 18.9% developed DJK, 7.9% DJF, 6.3% mechanical failure, 11% neurological complications, and 16.5% underwent reoperation, with 43.3% meeting GO. 52% of NF met GO, 42% of F, and 33% of SF. Analysis adjusted for baseline deformity depicted GO had increased correction relative to GO in NF and F, however for SF decreased correction in TS-CL (-6° vs -17°, p=0.047), C2S (-9° vs -19°, p=0.108), and MGS (-12° vs -13.5°, p=0.2).

Conclusion
Consideration of chronological age, in addition to physiological age, may be beneficial in management of operative goals to maximize clinical outcomes while minimizing junctional failure. This combination enables the spine surgeon to fortify a surgical plan for even the most challenging patients undergoing adult cervical deformity corrective surgery.

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80. Microbiome Study of Cervical Disc Using Next Generation Sequencing

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Hypothesis
To evaluate the microbiome in degenerative cervical intervertebral disc in comparison with the microbiome of degenerative lumbar disc.

Design
Prospective single center study of 42 patients with cervical disc degeneration undergoing elective anterior cervical discectomy and fusion (ACDF) were included in the study from February 2022 to February 2023

Introduction
Disc degeneration may result from biomechanical alterations in spine motion segments, genetic and environmental factors contributing to DDD. Recent studies of lumbar discs, have suggested a role of sub-clinical infections and the presence of a microbiome in intervertebral discs as a key factor determining disc degeneration. However no similar study has been done for the cervical spine.

Methods
Disc material collected from ACDF patients was washed, stored at -80ºC in cryo vials in phosphate buffer solution. DNA extraction was done using QIAGEN POWERSOIL PRO KIT. Next-generation sequencing then amplified the V3-V4 region via PCR technique, identifying abundant bacterial populations.

Results
In all 42 samples, we observed diverse bacterial colonies, totalling 1 kingdom, 32 phyla, 59 classes, 131 orders, 258 families, 557 genera, and 838 species. The taxonomic distribution included Proteobacteria, Firmicutes, and Actinobacteria as the top 3 phyla, Gammaproteobacteria, Bacilli, and Alphaproteobacteria as the top 3 classes, Bacillales, Rhizobiales, and Pseudomonadales as the top 3 orders, and Bacillaceae, Pseudomonadaceae, and Moraxellaceae as the top 3 families. Pseudomonas sp., Serratia sp., and Acinetobacter baumanii were the top 3 species with notable alpha and beta diversities. Pseudomonas had the highest prevalence (1.0) in all samples, while Fusobacteria showed the lowest prevalence. Three common phyla (Proteobacteria, Firmicutes, and Actinobacteria) and five bacterial species (Pseudomonas veronii, Acinetobacter, Propionibacterium acnes, Lactobacillus, Bacillus flexus) were common to both cervical and lumbar microbiomes. Among these variations, some bacteria were commensal, while others were potentially pathogenic.

Conclusion
This study is the first to detect a microbiome in the cervical intervertebral disc, with Pseudomonas sp., Serratia sp., and Acinetobacter Baumanni being the most prevalent species. The results imply a possible link between subclinical infection and cervical intervertebral disc degeneration, laying the groundwork for future research.

81. The Clinical Impact on Range of Motion for Occipito- and Sub-Axial Cervical Fusion: a Comprehensive Guide Based on over 1000 Motion Segments

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Hypothesis
Clinically significant range of motion (ROM) can be determined from standardized biomechanical testing.

Design
Cadaveric biomechanical study

Introduction
Understanding the relative contribution of each cervical motion segment is vital for assessing the impact of fusion on ROM. These values have historically been derived from work by Panjabi and White. However, these data were obtained from a low volume of subjects and methodological shortcomings have been identified. Herein, we sought to improve our understanding of segmental ROM using standardized biomechanical tests involving a large number of intact cervical spine cadaveric specimens.

Methods
Flexibility data from 1009 cervical spine motion segments (286 cadavers) spanning occiput-T1 were included. Specimens were subjected to standardized pure moment flexibility tests and loaded to 1.5 Nm in three anatomical axes: flexion-extension (FE), axial rotation (AR), and lateral bending (LB). Hypothetical ROM of fusion constructs assumes complete loss of segmental ROM across fused segments and lack of compensatory changes for unfused segments.

Results
The overall mean ROM for the entire cervical spine (Occ-T1) in FE, AR, and LB were 109.8°, 79.3°, and 37.7°, respectively. The greatest segmental contribution to FE was the Occ-C1 joint (24% of overall ROM) with 26.4° (6.4°) which differed from all levels ($p < 0.001$). In AR, C1-2 contributed 53% of overall ROM (41.6° [14.7°]) (all $p < 0.001$). C3-4 accounted for 16% of LB ROM (5.9° [1.9°]). The ROM following hypothetical occipital-C2 fusion was 59% in FE, 36% in AR, and 76% in LB. Fusion from C2-T1 maintained 41% of ROM in FE, 64% in AR, and 24% of LB. Increasing the number of segments involved in a sub-axial cervical fusion construct leads to a steady decrease in the remaining ROM in all 3 planes of movement.

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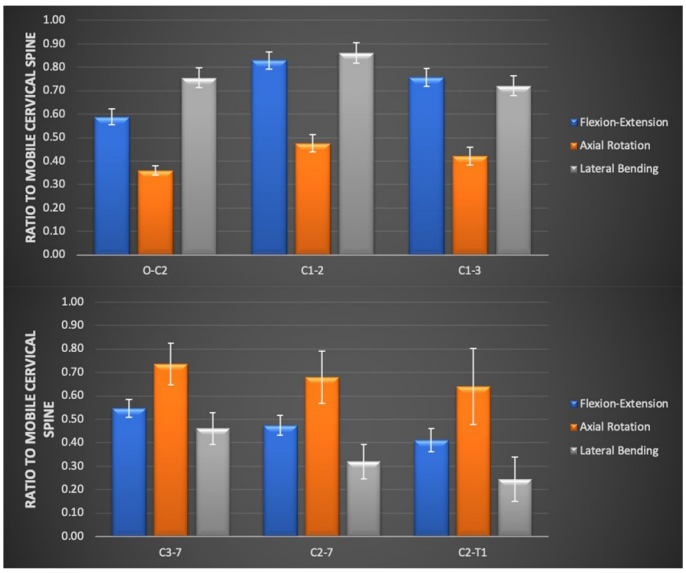
Conclusion
This study represents the calculated effects of various level fusions based on data from the highest volume of similarly tested cervical motion segments in the literature. It demonstrates the segmental ROM values of the normal intact cervical spine and provides a basis for predicting the clinical impact of cervical fusion constructs based on rigorous and standardized biomechanical testing. These findings are important for surgeons to plan and counsel patients regarding the clinical impact on ROM of cervical fusion.



ROM Following Cervical Fusion Constructs

82. Decreased Hounsfield Unit Measurements Are Associated with Cervical Corpectomy Subsidence More than Other Measures of Bone Mineral Density

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Hypothesis
Decreased Hounsfeld units can predict corpectomy subsidence over other measures of bone mineral density (BMD).

Design
Retrospective cohort study

Introduction
Corpectomy subsidence has been associated with loss of segmental lordosis, and recurrence of preoperative symptoms. While decreased bone strength is a risk factor for subsidence, the optimal bone quality assessment to predict corpectomy subsidence remains unknown. Prior cervical corpectomy subsidence studies were limited to imprecise measurements on postoperative lateral x-rays. The present investigation utilized CT-based subsidence assessment to define the incidence of anterior cervical corpectomy and fusion (ACCF) subsidence and determine the relative importance of preoperative and intraoperative subsidence risk factors.

Methods
All patients who underwent single-level ACCF at an academic center between 2018-2021 were retrospectively identified. Corpectomy subsidence at both the superior and inferior endplate was measured on CT scans obtained at 6 months to 1-year postoperatively. Subsidence groups were classified as mild-moderate <4mm or severe ≥4mm. Preoperative bone quality assessment included: CT Hounsfield units (HUs), MRI vertebral bone quality (VBQ), and dual-XR absorptiometry (DEXA) BMD, T-score, FRAX, and trabecular bone score. Univariate analysis compared patient demographics, preoperative bone assessments, and surgical factors between subsidence groups.

Results
Forty-four patients met inclusion criteria: 32 were mild-moderate subsidence, and 12 underwent severe subsidence. The mean superior and inferior endplate subsidence was 2.6mm and 1.7mm, respectively. The maximum subsidence occurred in superior endplate in 73% of patients and the inferior endplate in 27% of patients. Patient demographics, medical comorbidities, corpectomy level, corpectomy cage material and placement location did not differ significantly between groups. Decreased HUs of the inferior vertebral body was significantly associated with severe subsidence (244 vs 294, p=0.020). Other bone quality measures including superior vertebral HUs, cervical VBQ, and all DEXA metrics were not significantly associated with corpectomy subsidence.

Conclusion
Severe subsidence occurred in 27% of patients after ACCF. Subsidence most commonly occurred in the inferior direction with inferior vertebral body HUs as a significant risk factor.

83. Factors Associated with Postoperative Kyphosis and Loss of Range of Motion After Cervical Disc Replacement

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Hypothesis
To evaluate the risks associated with postoperative kyphosis and loss of range of motion after CDR.

Design
Single-center retrospective study

Introduction
One of the main benefits of CDR is that it maintains

physiological range of motion (ROM) and lordosis while achieving decompression. However, there are cases where patients experience loss in segmental ROM or have segmental kyphosis postoperatively. This study analyzes the radiographic outcomes of these patients.

Methods
Adult patients (>18 years of age) who underwent CDR were included. The cohort was separated into patients with poor x-ray outcomes (PXR) and successful x-ray outcomes (SXR). The PXR group was defined as patients who had a loss in segmental ROM (≥11° decrease in Δ Segmental ROM) after the CDR and/or had postoperative segmental kyphosis at the operative level. Radiographic measures were as follows: pre-and post-op segmental and regional sagittal alignment in neutral and flexion/extension, cSVA, disc height, implant distance to the center of the disc, and implant distance to the posterior endplate. Independent T-test analysis and $\chi 2$ test were used to analyze differences in radiographic surgical outcomes, with significance set at $p<0.05$.

Results
151 (PXR=47; SXR=104) patients met the inclusion criteria. Pre-and post-op segmental lateral cobb angles were more kyphotic in the PXR group (3.5° vs -1.4°, p<0.001; 2.6° vs -5.6°, p<0.001, respectively). There was a larger Δ in segmental lateral cobb angle in the SXR group (-4.2° vs -0.9°, p<0.001). The PXR group had a larger degree of flexion and a significantly smaller degree of extension at the segment (11.3° vs 6.5°, p<0.001; -2.2° vs -6.1°, p=0.049, respectively). There was a significant loss in post-op segmental ROM in the PXR group (-5.7° vs 1.5°, p<0.001). Pre-and post-op C2-C7 lateral cobb angles were more kyphotic in the PXR group (-1.2° vs -9.4°, p<0.001; -2.9° vs -13.9°, p<0.001, respectively). Pre-and-post-op cSVA were larger in the PXR group (29.6mm vs 25.3mm, p=0.047; 30.10mm vs 22.8, p=0.004, respectively).

Conclusion
Following CDR, patients who developed postoperative kyphosis or decreased range of motion were more likely to have less segmental and regional C2-7 lordosis and a larger preoperative and postoperative cSVA. Surgeons indicating CDR and counseling patients on the options for anterior cervical surgery should consider these preoperative parameters.

Cervical Disc Replacements			Poor X-Ray Outcomes (N = 47)	Successful CDR (N = 104)	p-value
Radiographic Analysis	Segmental Lordosis	Preop Segmental Lateral Cobb Angle at OP Levels* (deg)	3.5 ± 4.9	-1.4 ± 5.1	<0.001
		Postop Segmental Lateral Cobb Angle at OP Levels* (deg)	2.6 ± 4.1	-5.6 ± 5.7	<0.001
		Δ Segmental Lateral Cobb Angle at OP Levels (deg)	-0.9 ± 4.4	-4.18 ± 0.554	<0.001
		Preop Segmental Range of Motion at OP Levels (deg)	13.5 ± 14.8	12.67 ± 8.45	0.675
		Postop Segmental Range of Motion at OP Levels (deg)	9.9 ± 11.1	13.5 ± 7.8	0.061
		Δ Segmental Range of Motion at OP Levels (deg)	-5.7 ± 11.6	1.5 ± 7.4	<0.001
	C2-C7 Lordosis	Preop C2-C7 Lateral Cobb Angle* (deg)	-1.2 ± 13.3	-9.5 ± 11.8	<0.001
		Postop C2-C7 Lateral Cobb Angle* (deg)	-2.9 ± 10.9	-13.9 ± 10.1	<0.001
		Δ C2-C7 Lateral Cobb Angle (deg)	-1.7 ± 10.7	-4.4 ± 9.7	0.125
		Preop C2-C7 Range of Motion (deg)	47.8 ± 17.7	42.1 ± 19.1	0.083
		Postop C2-C7 Range of Motion (deg)	38.5 ± 24.6	40.4 ± 17.9	0.613
		Δ C2-C7 Range of Motion (deg)	-10.4 ± 26.6	-1.6 ± 21.7	0.068
	cSVA	Preop cSVA (mm)	29.6 ± 12.2	25.3 ± 12.4	0.047
		Postop cSVA (mm)	30.1 ± 16.8	22.8 ± 12.8	0.004
		Δ cSVA (mm)	0.4 ± 13.5	-2.5 ± 10.3	0.196
	Disc Height	Preop Disc Height (mm)	4.9 ± 1.1	5.3 ± 1.2	0.046
		Postop Disc Height (mm)	6.0 ± 1.6	6.1 ± 1.4	0.942
		Δ Disc Height (mm)	1.1 ± 1.6	0.8 ± 1.3	0.106

* (+) Lateral Cobb Angles indicate Kyphosis, (-) Lateral Cobb Angles indicate Lordosis

Subanalysis PreOp Segmental Kyphosis: Outcomes	PreOp Segmental Kyphosis (N=59)	Non-Kyphotic (N=94)	p-value
Loss in ROM (≥ 11° decrease in the Δ of Segmental ROM) (% of patients)	18 (30.5%)	19 (20.2%)	0.106
Disc Height Collapse (% of patients)	14 (23.7%)	28 (29.8%)	0.265
Postop Segmental Kyphosis (% of patients)	34 (57.6%)	16 (17.0%)	<0.001
Postop C2-C7 Kyphosis (% of patients)	18 (30.5%)	5 (5.3%)	<0.001
Poor X-Ray Outcomes CDR (% of patients)	30 (50.8%)	17 (18.1%)	<0.001

85. Can Non-Operative Treatment with Brace and Scoliosis Specific Exercises Be Effective for Severe Scoliotic Curves Exceeding 40o at Peak of Growth?
Nikos Karavidas, Physiotherapist

Hypothesis
A combination of brace and Physiotherapeutic Scoliosis Specific Exercises (PSSE - Schroth) can effectively treat severe scoliosis

Design
Prospective cohort

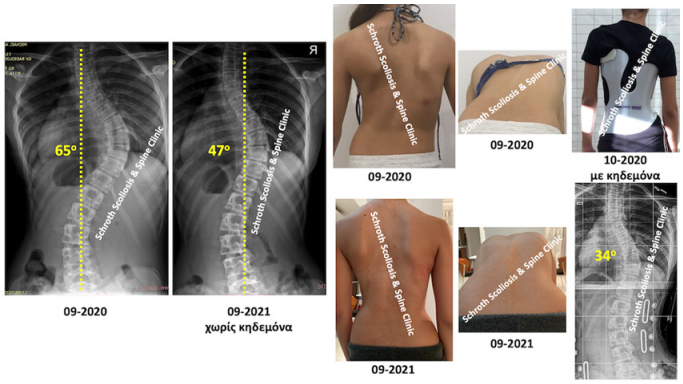
Introduction
According to Scoliosis Research Society (SRS) surgical indication for Adolescent Idiopathic Scoliosis (AIS) is above 40o. Our purpose was to investigate the efficacy of a combined therapy with brace and Physiotherapeutic Scoliosis Specific Exercises (PSSE) in severe scoliosis.

Methods
48 patients (47 females and 1 male) received treatment by Cheneau type brace and PSSE - Schroth exercises. Our inclusion criteria were at least one structural curve with Cobb angle >40o, Risser 0-2, age >10 years, less than 1 year after first menstruation and no prior treatment. Average Cobb angle was 55.3o for thoracic curves (41o – 85o) and 52.6o (40o – 78o) for lumbar curves, mean Risser 0.6 and age 12.4 years. 10 curves were single and 38 double. Outcome parameters were Cobb angle post-treatment, Angle Trunk Rotation (ATR), TRACE scale, SRS-22 questionnaire score, and number of patients required operation. Mean follow-up was 36.3 months. Statistical analysis performed by paired t-test.

Results
Totally, 24 (50%) subjects remained stable, 13 (27.1%) improved > 5o and 11 (22.9%) progressed > 5o. Cobb

angle post-treatment significantly improved (52.8o, p=0.05 for thoracic and 47.4o, p= 0.02 for lumbar curves). A statistically significant reduction was reported for ATR, thoracic reduced from 12.8o to 10.3o (p=0.01) and lumbar from 11.6o to 9.7o (p=0.02). TRACE scale also significantly decreased from 8.4 to 6.2 (p=0.008) and SRS-22 total score improved from 73.4 to 79.6 (p=0.004). Mean in-brace correction (IBC) was 32.3% for thoracic and 27.4% for lumbar curves. In double curves progression rate was 28.9% and in single curves 0% (p=0.0003). 9 patients (18.7%) underwent spinal fusion.

Conclusion
Conservative treatment achieved a success rate of 77.1% in scoliotic curves above 40o in a group with a high risk of progression at the peak of growth. A significant improvement was detected for trunk rotation (ATR), body symmetry measured by TRACE scale and quality of life measured by SRS-22 questionnaire. Non-operative treatment by bracing and PSSE can effectively treat severe scoliosis and reduce the need for surgery. The results were significantly better in single than double curves.



Treatment result by brace and PSSE

84. Spinal Surgery in Achondroplasia: Causes of Re-Operation and Reduction of Risks

Arun R. Hariharan, MD, MS; Hans K. Nugraha, MD; Aaron J. Huser, DO; David S. Feldman, MD

Hypothesis
Pseudoarthrosis and PJK is the most common cause of re-operation and longer spinal constructs have a lower revision rate.

Design
Retrospective case series

Introduction
Individuals with achondroplasia are prone to symptomatic spinal stenosis requiring surgery. Revision rates are thought to be high, but, the causes and rates of re-operation are unknown. The primary aim of this study was to investigate the causes of re-operation. Additionally, we report on surgical techniques aimed at reducing the risks of these re-operations.

Methods
Retrospective review over an 8-year period of all patients with achondroplasia at a single institution. Demographics and surgical/revision details were recorded. Type of surgery was placed into four categories: decompression only, decompression with a short fusion (T10), decompression with a midlevel fusion (T7–T9) and decompression with a long fusion (T2–T4). Use of interbody cage was documented. Descriptive statistics and Fisher's exact test were performed.

Results
148 patients were identified, 33 underwent spinal surgery (22.2%) at a mean age of 17.6 years. 21 patients were included, 12 were excluded for lack of follow up. 16 revisions were performed on 9 patients (43%), 4 required multiple revisions. 14 (67%) primary surgeries were done at our institution and 4 (29%) required revision. On average the time from initial surgery to revision was 1.9 years. Some revision surgeries were performed for multiple reasons: 8 pseudarthroses, 7 PJK, 7 new neurologic findings. The mean follow-up from the index procedure was 5.8 years. Short fusions were more likely to develop PJK with an OR of 31.2 (p = 0.007). Short fusions without a caudal interbody were also more likely to develop a caudal pseudarthrosis when compared with long and mid-fusions without a caudal interbody (p=0.044). To date, none of the initial long fusions with interbody have required revision.

Conclusion
This is the largest study of operative spinal deformity in patients with achondroplasia. The rate of surgery for is 21.5% and the risk of revision is 32.1%. This is primarily due to pseudarthrosis, PJK, and recurrent neurologic symptoms. Surgeons should consider discussing spinal surgery as part of the patient's life plan and should consider wide decompression of the stenotic levels and fusion from T4-L4 with use of interbody cage at the caudal level in all patients to reduce risks of revision.

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Table 1. Characteristic of Revision Cases

No	Age at Surgery (years)	Surgery number	Surgery	Months before revision/since last surgery	Reason for revision	Revision Type
1	14.1	1	T12-L4 PSF, Decompression	12.0	PJK, L3-L4 PA	pE
	15.1	2	T4-L1 PSF	95.7	PJK	pE
	23.1	3	T2-T4 PSF	14.2	-	IF
	24.3	4	L3-L4 IF	1.0	-	-
2	14.2	1	T9-S1 PSF, Decompression	48.0	L5-S1 PA	IF
	18.3	2	L5-S1 IF, Reinstrumentation T9-S1	85.2	-	-
3	7.9	1	T11-L4 PSF, Decompression	69.4	PJK, L3-L4 PA	pE, IF
	13.7	2	T2-L2 PSF	12.8	-	-
	14.6	3	L3-L4 IF	1.2	-	-
4	25.8	1	T4-L4 PSF	41.6	N	rD
	26.9	2	T12-S1 rD	45.8	-	-
5	51.1	1	T4-S1 PSF	34.8	L2-L3, L3-L4, L4-L5, L5-S1 PA	IF
	54.0	2	L4-L5, L5-S1 IF, L4-S1 PSF	16.1	-	IF
	55.4	3	L2-L3, L3-L4 IF, L1-S1 PSF	4.5	-	-
6	30.6	1	T9-L3 PSF, Decompression	6.0	L2-L4 PA, N	rD, dE
	31.2	2	L2-L4 PSF, Decompression	5.2	L3-L4 PA, N	rD,
	31.6	3	L3-L4 PSF, Decompression	18.6	L3-L4 PA	IF
	33.2	4	L3-L4 IF	57.8	-	-
7	16.0	1	L2-L5 Decompression	12.0	PJK, N	PSF
	17.0	2	T10-L5 PSF, Decompression	32.0	L4-L5 PA, PJK, N	-
8	11.1	1	T10-L4 PSF, Decompression	17.3	PJK,N	pE, IF
	12.5	2	T2-T10 PSF, L3-L4 IF	28.0	-	-
9	29.5	1	L1-S1 Decompression	12.8	PJK, N	PSF, IF
	30.6	2	T8-L4 PSF, L3-L4 IF, Decompression	2.2	-	-

* O = Outside institution; L = Author institution; PSF = Posterior Spinal Fusion; IF = Interbody Fusion; PA = Pseudoarthrosis; PJK = Proximal Junctional Kyphosis; N = Neurologic Symptoms; pE = proximal extension; dE = distal extension; rD = re-Decompression

Characteristic of Revision Cases

90. A Novel External Hinge Correction System for Vertebral Column Resection of Severe Angular Kyphosis

Hong Zhang, MD; David Ross, MFA; Daniel J. Sucato, MD, MS

Hypothesis

The incorporation of an adjustable and controllable hinge mechanism at the apical region is crucial for both protecting the spinal cord and enhancing the correction of severe angular kyphosis (SAK) in the vertebral column resection (VCR) procedure.

Design

Introducing a novel external hinge (EH) correction system for VCR to correct SAK and evaluating its effectiveness using a simulated sawbones model.

Introduction

Neurological complications often occur during VCR procedures, especially in patients with primary or secondary spinal kyphotic malalignments, with the highest susceptibility seen in cases of SAK. The current VCR implant strategy carries a potential risk of intraoperative deficits because of spinal segment instability.

Methods

The EH was introduced and tested on a sawbones model simulating severe angular kyphosis (Figure 1). We created a simulated 83° thoracolumbar angular kyphosis with the apex at T11 in the sawbones spine model. Subsequently, we used the EH to correct the deformity and determine the optimal hinge position for VCR in reducing severe angular kyphosis.

Results

Initially, the thoracolumbar angular kyphosis averaged 82.7±0.5°, and it was successfully corrected to 0°, achieving a 100% correction rate. The optimal hinge position, identified as the posterior vertebral body wall (PVBW), allowed for spinal cord preservation with a slight 3% shortening. Conversely, hinge positions situated posterior to the PVBW resulted in a substantial 42% lengthening of the spinal cord, while more anterior positions led to a significant 27% shortening.

Conclusion

The EH demonstrates its effectiveness in providing consistent stability to spinal segments and serving as an adjustable, controllable hinge for correcting SAK in the sawbones model. Positioning the hinge pivot at the PVBW level effectively preserves the spinal cord, preventing excessive shortening or lengthening during VCR for SAK correction.

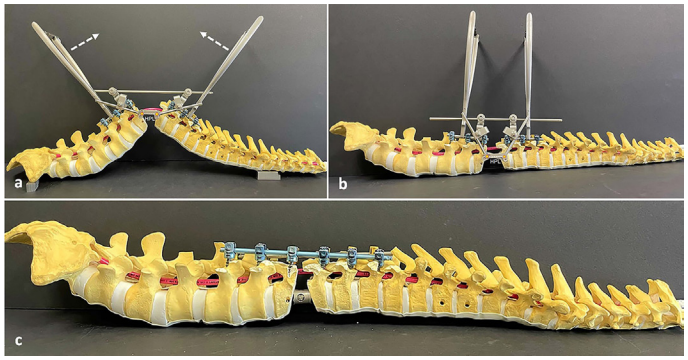


FIG.1

91. Y Shaped Osteotomy in The Apical Vertebra for Treating Congenital Complex Rigid Scoliosis: at Least 2 Year Follow Up

Xuhong Xue, MD, PhD; Sheng Zhao, MD

Hypothesis

Y shaped osteotomy in the apical vertebra can receive good clinical and radiological outcomes for treating congenital complex rigid scoliosis.

Design

Retrospective study

Introduction

Many techniques have been described for the surgical treatment of congenital scoliosis, but none is well adapted to the complex rigid congenital scoliosis. The study aimed to investigate the clinical outcome of the coronal Y shaped osteotomy in the apical vertebra for treating congenital complex rigid scoliosis.

Methods

A retrospective study was conducted on 66 cases who underwent Y shaped osteotomy treatment for congenital complex rigid scoliosis in the apical vertebra from June 2007 to August 2020. There were 19 males and 47 females, with an age of (13.1±5.3) years (range: 2 to 30 years). There were 25 cases (37.9%) with rib malformations. 45 cases (68.2%) were complicated with spinal cord malformation. The main radiological parameters included Cobb angle of the main curvature, Cobb angle of the segmental curve, apical vertebral translation,

trunk shift, thoracic trunk shift, radiographic shoulder height, coronal balance and sagittal vertebral axis. The preoperative, postoperative immediately, and last follow up radiological parameters were collected. The operation time, blood loss, hospitalization time, and complications were recorded. Data were compared by repeated measure ANOVA and paired t test.

Results
The mean operative time was (221.4±52.8) minutes, and the blood loss was (273±41.8) ml. The length of hospital stay was (8.8±1.7) days. Unilateral fixation was performed in 19 cases (28.8%), while bilateral fixation was performed in 47 cases (71.2%). The fused segments were 7.5±13.0, and the vertebral pedicle screw density was 68.5%. The follow up time for the 66 patients was (36.7±17.0) months (range: 24 to 102 months). The main curve Cobb Angle was improved from (58.5±18.9) ° before surgery to (23.6±15.3) °after surgery and was (23.6±15.3) ° at the last follow up. A total of 5 patients underwent staged surgery, all of which were residual scoliosis aggravated after the primary surgery and had good prognosis after re-vision surgery.

Conclusion
Y shaped osteotomy for the treatment of congenital rigid scoliosis results in good clinical and radiological outcomes without serious complications. This procedure can be considered as an option for the treatment of congenital complex rigid scoliosis.

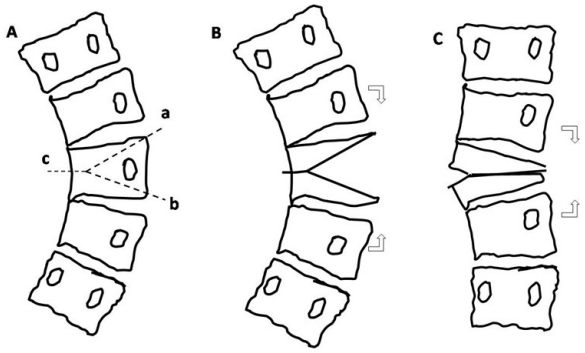


Figure 1. Schematic figure of Y-shape osteotomy in coronal plane: the apex vertebra was selected as center of osteotomy (**A**). Lamina, superior and inferior articular process, and pedicle, as well as 3/4 vertebral body on the convex side were removed (**B**). After gradually compression, convexity closing, concavity opening and a quarter of concave side preserving as the hinge, forming an inverted Y-shape (**C**).

Y shaped osteotomy

86. New Artificial Intelligence (AI) Driven Surface Topography Phone Application Help Screen Spinal Deformity Patients: Early Results from One Institution

Marjolaine Roy-Beaudry, MSc; Marie Beausejour, PhD; Justin Dufresne; Rachelle Imbeault; *Stefan Parent, MD, PhD*

Hypothesis
Imaging technology can be used to measure and can be correlated to the magnitude of spinal deformity and the evidence of curve progression of scoliosis.

Design
Prospective observation study.

Introduction
Radiation-free techniques such as scoliometers, spinal ultrasound and Moiré topography have had limited success in screening and monitoring patients with Adolescent Idiopathic Scoliosis (AIS). The purpose of such modalities was to decrease serial spinal x-rays. A new digital health application leverages advanced 3D surface topography technology coupled with AI to predict scoliotic Cobb Angles. The objective of this study is to validate the accuracy and reliability of this technology.

Methods
A single-center observational study was conducted in the outpatient scoliosis clinic. One hundred and twenty-five patients were recruited with confirmed or suspicion of scoliosis. Once consented, two 3D surface topography scans (upright and bent forward positions) were performed on an Apple iPhone 12. Demographic and radiological parameters were collected to determine their influence on the validity of the automated measurement. Validity and reproducibility of the applications Cobb Angle predictions were compared to radiographic measurements.

Results
Of the 125 patients recruited, 20 poor quality scans were discarded, 69 were randomly assigned to the training set and 38 were used to validate the algorithm. To normalize the distribution of the training set, 12 additional control patients were added to the training set. The algorithm predicted Cobb Angle (bellow 50) with overall correlation of 0.89 and mean average error of 6.2 degrees. The app screened for AIS (10 degrees threshold) with a sensitivity of 0.92, specificity of 0.75, and area under the curve (AUC) of 0.94. At 25 degrees, the threshold for the initiation of brace interventions, a sensitivity of 0.71, specificity of 0.90 and AUC of 0.97 was noted and at 50 degrees (surgical threshold), 0.50, 1.00 and 0.94, respectively.

Conclusion
The implementation of 3D topography combined with AI seems of improve the accuracy of the classic surface topography to predict scoliotic Cobb Angles. The applications' availability on smartphones facilitates frequent at-home remote monitoring of scoliotic deformities to avoid unnecessary hospital visits and spinal X-rays, potentially detecting early curve progression as well.

Podium Presentation Abstracts

87. Comparison of Disc Height Restoration and Subsidence Rates Between Static Versus Expandable Titanium Interbodies for Lateral Lumbar Interbody Fusion

Kimberly Ashayeri, MD; *Sean N. Neifert, MD*; Darryl Lau, MD

Hypothesis
Expandable lateral lumbar inter body fusion cages provide similar subsidence rates with better disc height correction than static cages.

Design
Retrospective review

Introduction
Lateral lumbar interbody fusion (LLIF) is effective for treating degenerative disease and spinal deformity. Expandable interbody cages can improve disc and foraminal height but may lead to more subsidence; this has not been compared in expandable and static LLIF. This study compares disc height restoration and subsidence rates between expandable and static LLIF cages.

Methods
A single-institution review comparing patients who received expandable and static LLIF with one-year follow-up was performed. Radiographic metrics included pre- and post-operative posterior disc height, change in disc height, and percent increase in disc height. Subsidence at six months and one year and fusion rates at one year were measured with radiographs. Propensity matching accounted for demographic and surgical differences.

Results
187 LLIFs were included (147 static, 40 expandable). There were no differences in preoperative demographics, including age, gender, BMI, smoking status, or osteoporosis. The preoperative (3.9 v 5.3mm; p<0.001) and postoperative disc heights (7.2±1.9 v 8.9±2.4mm; p<0.001) were greater in the expandable cohort, although disc height percentage increase was smaller (118.5% v 86.2%; p=0.011). There were no differences in disc height change (3.2±2.1 v 3.6±1.9mm; p=0.355), six-month (6.8% v 10.2%; p=0.467) or one-year (10.9% v 7.9%, p=0.588) subsidence rates, or one-year fusion rates (92.4% v 96.8%; p=0.382). After propensity matching (39 in each cohort), the postoperative disc height (7.4±1.9 v 8.9±2.4mm; p=0.005) and change in posterior disc height (2.2±2.3 v 3.6±1.9mm; p=0.004) were greater in the expandable cohort. There were no significant differences in percent change in posterior disc height (70.1±1.0% v 86.2±6.8%; p=0.410, six-month (10.3% v 10.3%; p=1.000) and one-year (15.4% v 10.3%; p=0.306) subsidence, or one-year fusion rates (94.9% v 96.8%; p=0.884).

Conclusion
Expandable LLIF cages in propensity-matched cohorts led to increased disc height restoration without increased rates of subsidence or pseudarthosis at one year. Further studies investigating these conclusions in larger cohorts are needed.

88. Biomechanics of Cage Subsidence

Anna-Katharina Calek, MD; Frederic Cornaz, MD; Mauro Suter; Marie-Rosa Fasser, MSc; Mazda Farshad, MPH; *Jonas Widmer, MSc*

Hypothesis
The purpose of this study was to analyze the effect of endplate weakness prior to PLIF or TLIF cage implantation and compare it to the other intact endplate of the same vertebral body. In addition, the influence of bone quality on endplate resistance was investigated.

Design
Biomechanical cadaveric study

Introduction
The use of intervertebral cages in fusion surgery has increased significantly in recent years. The biomechanical effect of endplate weakening associated with cage insertion has not been quantified yet.

Methods
Twenty-two lumbar vertebrae were tested under uniaxial compression in a ramp-to-failure test. One endplate of each vertebral body was tested intact and the other after weakening with a shaver (over an area of 200 mm2). Either a TLIF or PLIF cage was then placed on the endplate and the compression load was applied across the cage until failure of the vertebral body. Failure was defined as the first local maximum of the force measurement. In addition, the bone quality of each vertebral body was assessed by determining the Hounsfield units (HU) on CT images.

Results
With an intact endplate and a TLIF cage, the median force to failure was 1276.3 N (693.1 - 1980.6 N). Endplate weakening reduced axial endplate resistance to failure by 15% (0-23%). With an intact endplate and a PLIF cage, the median force to failure was 1057.2 N (701.2 - 1735.5 N). Endplate weakening reduced axial endplate resistance to failure by 36.6% (7 - 47.9%). Bone quality correlated linearly with the force at which endplate failure occurred. Both intact and weakened endplates showed a strong positive correlation with bone quality of p = 0.939 (p = 9.3E-11) and p = 0.840 (p = 1E-06), respectively.

Conclusion
Weakening of the endplate during cage bed preparation significantly reduces the axial resistance of the endplate to failure: endplate load capacity is reduced by 15% with TLIF and 37% with PLIF. Bone quality

correlates with the force at which endplate failure occurs. Endplate weakening during cage bed preparation should be avoided whenever possible, as cortical bone compromise is associated with significant loss of resistance to axial compression.

89. The in vivo Immune Response of Peek Spinal Interbody Device Materials with and without Supplemental P-15 Peptides as a Osteobiologic Bone Graft Material

Isaac Swink, MS; Patrick Schimoler, PhD; Daniel Altman, MD; Praveer Vyas, MD, MPH; *Boyle Cheng, PhD*

Hypothesis
The P15 peptide is hypothesized to modulate the immune response in a rabbit model.

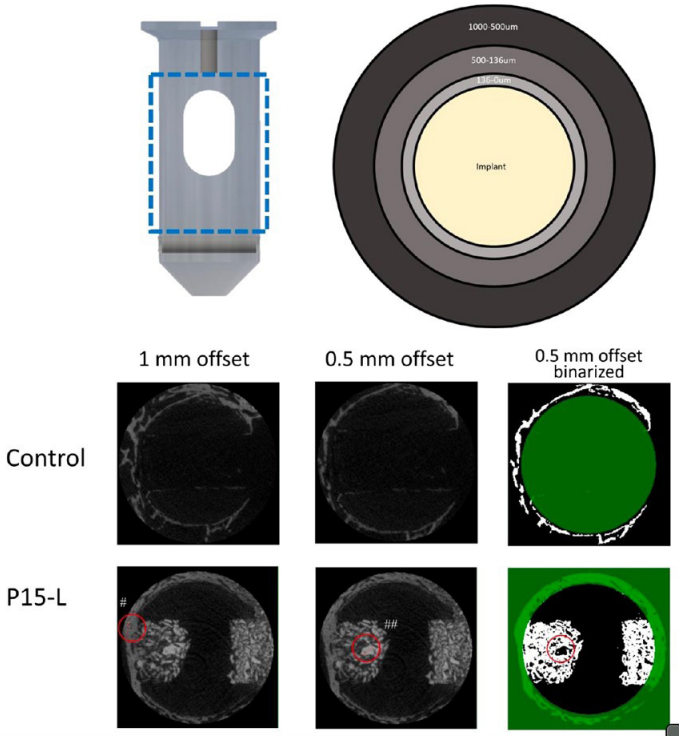
Design
Rabbit distal femur model to measure the inflammatory response at both 4 and 8wks post implant.

Introduction
Osteoimmunology, the study of the relationship between the musculoskeletal system and immune system, has emerged as an important consideration. With the appropriate immune modulating components, e.g., P-15 bone grafting material, the potential adverse events associated with specific design materials may be mitigated. Studies involving the cytokine response provide insight on the mechanism of fibrous capsule formation anecdotally reported with PEEK implants. The results from animal models would potentially weave a better understanding of PEEK fibrous encapsulation around retrieved implanted PEEK devices. It was hypothesized that IL-1β, IL-6, and TNF-α cytokine expression levels, results would be different for PEEK and PEEK devices in the presence of a P-15 granules.

Methods
The two primary endpoints for the study were bony apposition and the immune response for tissue adjacent to the implants. MicroCT was used for the quantification of mineralized bone and tissue homogenate ELISAs were used to determine cytokines expression inside the implant graft window.

Results
This data suggest P-15 promotes healing by modulating the immune response in favor of bony apposition. There was a significant increase in bone volume at the ROI closest to the bone-implant interface in samples containing P-15 when compared to PEEK alone at 8 weeks (p= 0.050). In the graft window samples, there was a significant difference in the expression of IL-1β and IL-2 (p=0.0093 and p=0.0179) between control and P-15 samples at 4-weeks post implantation. There was also a significant decrease in both cytokines at 8 week post implantation (IL-1β: p=0.0008 and IL-2: p=0.0407).

Conclusion
Significant differences in concentration of IL-1β and IL-2 between cohorts and between time points. In the control PEEK cohort, there was no change in cytokine concentration from 4 to 8 weeks, suggesting the different stages of healing were not initiated. In the P-15 cohort as a part of the implanted PEEK device, a positive modulated cellular response was evident by changes in cytokine expression patterns and the increased bony apposition at the bone implant interface compared to the PEEK surface alone.



PEEK Implant

with a total of 9 keypoints: 3 on L1, 2 on S1, and 1 each on C7, T1, and both femoral heads. The convolutional neural network utilizes a two-stage approach to keypoint detection: object detection followed by landmark localization in that particular object.

92. Gradual Anterior Column Lengthening at The Level of PVCR Provides Both Regional and Global Ideal Sagittal Alignment and Prevents Iatrogenic Neurological Deficit

Hamisi M. Mraja, MD; Baris Peker, MD; Halil Gok, MD; Cem Sever, MD; Tunay Sanli, MA; Selhan Karadereler, MD; *Meric Enercan, MD*; Azmi Hamzaoglu, MD

Hypothesis
Gradual sequential posterior compression and simultaneous anterior column lengthening technique after PVCR provide safe and ideal correction for rigid kyphosis and kyphoscoliosis (RKK) deformity in adults

Design
Retrospective study

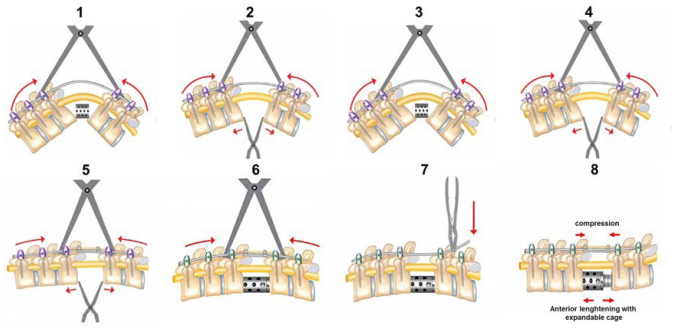
Podium Presentation Abstracts

Introduction
The correction technique of RKK should be different from the correction of the relative flexible deformity. RKK causes pain, deformity progression, and deteriorating neurological deficit. We aimed to evaluate the efficacy, safety, and clinical results of gradual sequential posterior compression and simultaneous anterior lengthening technique following PVCR for the correction of RKK deformity

Methods
From 2000 through 2021, an analysis of pts who underwent PVCR for severe RKK were evaluated. Following PVCR, the correction technique included anterior column lengthening with gradual posterior compression sequentially and placement of an expandable cage anteriorly to prevent any dural buckling. Preoperative, postoperative and f/up clinical and radiological analyses were performed

Results
73 pts(23M,50F), mean age 46 (20-81)yrs & f/up was 8.9 (2-23)yrs. Etiologies included posttraumatic kyphosis(26), neglected kyphosis and kyphoscoliosis(23), congenital kyphosis(11), and proximal junctional failures(13). RKK deformity was located at the cervicothoracic-upper thoracic(11), thoracic(25), thoracolumbar(32), and lumbar(5) spine. 39 pts had undergone primary surgery and 34 pts had revision surgery. Preop local kyphosis angle was restored from 62.4° to 16.9° (72.7%) and preop thoracic kyphosis was restored from 76.6° to 42.3°. All sagittal parameters including SVA, cSVA, C2 slope, T1 slope and TPA improved significantly. 28 pts who had preoperative neurologic deficit (14 ASIA D, 8 ASIA C, 6 ASIA B) had at least one-grade improvement at the final f/up. The most common complication was dural tears in 12 (16%) pts. Oswestry functional scores decreased from a mean of 62 to 14. Solid fusion was achieved in all pts without significant loss of correction at f/up

Conclusion
Gradual anterior column lengthening at the level of PVCR provides both regional and global ideal sagittal alignment and avoids iatrogenic neurologic deficit by preventing dural bucking. This technique provides ideal restoration of kyphosis, decompression of neural structures, and improves preoperative neurological deficit and iatrogenic neurological deficit



93. De-Novo Neurological Deficits Relative to Intraoperative Neuromonitoring (LOMN) Alerts and Surgical Events in Complex, Cord-Level Spinal Deformity Corrections: A Prospective International Study from the AO Spine Knowledge Forum Deformity

Alekos A. Theologis, MD; Kenny Y. Kwan, MD; Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Zeeshan M. Sardar, MD; Justin S. Smith, MD, PhD; Ferran Pellisé, MD, PhD; So Kato, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Kristen E. Jones, MD, FAANS; Anastasios Charalampidis, MD; Brett Rocos, FRCS; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCS(C); AOSpine Knowledge Forum Deformity

Hypothesis
Post-operative neural deficits are associated with intra-operative neuromonitoring (IONM) changes, which occur secondary to specific intra-operative surgical techniques/events.

Design
Prospective, international, multi-center cohort analysis.

Introduction
The purpose of this study is to evaluate rates of new neural deficits relative to IONM alerts in cord-level spinal deformity operations.

Methods
20 international centers prospectively documented IONM (EMG, SSEP and MEP), demographics, radiographic findings, and surgical events of patients (10-80 years) undergoing spinal deformity correction. Inclusion criteria: neurologically intact, spinal deformity correction with major Cobb>80° or involving any osteotomy. IONM change was defined as loss of amplitude>50% in SSEP or MEP from baseline or sustained EMG activity lasting>10 seconds. Neural examination was performed post-op.

Results
546 patients were recruited into the study, of which 349 involved cord-level operations. Overall, IONM alerts occurred in 57 of the cord level operations (16.3%). For cord level surgeries, 44 cases had unilateral and 34 had bilateral MEP changes. The most com-

mon surgical event prior to an unilateral MEP change was an osteotomy/release (57.9%) whereas a bilateral MEP change was correction/rod placement (64%). Unilateral changes were associated mostly with a type 2 osteotomy (68.2%) whereas bilateral changes were associated more with a type 5 or 6 osteotomy (66.7%). IONM alert occurred more frequently during decompression on the concave side (76.5%) in unilateral MEP changes. For non-surgical events that preceded any alert in cord level surgeries, technical was most frequent (9.1%) in unilateral changes, whereas anaesthesia (26.5%) and technical (23.5%) were most frequent in bilateral MEP changes. Rapid corrective actions (i.e elevating blood pressure, transfusion, anesthesia adjustments, rod and/or implant removal, steroid administration, lessen correction, decompression) reversed 80% of the MEP changes. Postop, there was an 7.7% incidence of new neural deficits in cord-level operations. In patients with any IONM alert, 22.8% had a new neurological deficit. Of the patients who had new post-op neural deficits, 51.9% had no IONM change. New neurological deficits occurred in 4.9% of cord-level operations in which there were no IONM alerts (i.e. false negatives).

Conclusion

In complex, cord-level spinal deformity operations in this multi-center, international prospective study, IONM alerts were common (16.3%). Osteotomy/release most frequently occurred prior to unilateral MEP changes whereas correction/rod placement was more frequently associated with bilateral MEP changes. That the majority (80%) of IONM alerts were reversed with a rapid response resulting in preserved spinal cord function makes IONM an extremely valuable tool for spinal cord monitoring in these high-risk patients. However, its 4.9% false negative rate speaks to its limitations and highlights the need for more sensitive detection modalities to complement the current multi-modal IONM strategies for spinal deformity operations.

Table 1. Post-operative neural function based on presence or absence of IONM alerts.

	All patients (n=532)		Cord Level (n=339)		Non-Cord Level (n=193)	
IONM Alert During Surgery	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
	460 (86.4%)	72 (13.5%)	287 (84.7%)	52 (15.3%)	173 (89.6%)	20 (10.4%)
New Neuro Deficit						
No	422 (91.7%)	50 (69.4%)	273 (95.1%)	39 (75.0%)	149 (86.1%)	11 (55.0%)
Yes	**38 (8.3%)**	22 (30.6%)	**14 (4.9%)**	13 (25.0%)	**24 (13.9%)**	9 (45.0%)
Sensitivity	36.7%		48.2%		27.3%	
Specificity	89.4%		87.5%		93.1%	

Table 1

94. Intraoperative Surgical Events and Neuromonitoring (Ionm) Alerts in Relation to Post-Operative Neurological Deficits in Complex, Non-Cord-Level Spinal Deformity Corrections: Results from a Multi-Center Prospective Spinal Deformity Intraoperative Monitoring (Sdim) Study

Zeeshan M. Sardar, MD; Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Alekos A. Theologis, MD; Kenny Y. Kwan, MD; Justin S. Smith, MD, PhD; Ferran Pellisé, MD, PhD; So Kato, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Kristen E. Jones, MD, FAANS; Anastasios Charalampidis, MD; Brett Rocos, FRCS; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCS(C); AOSpine Knowledge Forum Deformity

Hypothesis

In non-cord level spinal deformity operations, post-operative neural deficits are incompletely associated with intra-operative neuromonitoring (IONM) changes.

Design

Prospective, international, multi-center cohort analysis.

Introduction

The purpose of this study is to evaluate rates of new neural deficits relative to intra- IONM alerts in non-cord-level spinal deformity operations.

Methods

20 international centers prospectively documented IONM (EMG, SSEP and MEP), demographics, radiographic findings, and surgical events of patients (10-80 years) undergoing spinal deformity correction. Inclusion criteria: neurologically intact, spinal deformity correction with major Cobb>80° or involving any osteotomy. IONM change was defined as loss of amplitude>50% in SSEP or MEP from baseline or sustained EMG activity lasting>10 seconds. Neural examination was performed post-op.

Results

Of 197 patients undergoing surgery at a non-spinal cord level, 11.2% had an IONM alert. A higher percentage of patients were undergoing revision surgery when an alert was observed when compared to those with no alert (40.9% vs. 18.9%, p = 0.026). The odds ratio of observing an IONM alert in patients undergoing revision surgery versus those undergoing primary surgery was 3.0. There were a total of 26 alerts in 22 patients - 4 patients (18.2%) had 2 IONM alerts, while the other 18 (81.8%) had 1 IONM alert. MEPs were affected in 21 out of 26 alerts (80.8%). 23.8% of MEP alerts were bilateral, whereas 76.2% were unilateral MEP alerts. The most frequent event was an osteotomy/release prior to both unilateral (50%) and bilateral (66.7%) MEP changes, and types 2, and 3,4 osteotomies had similar rate of IOMN alerts. For non-surgical events that preceded any alert in non-cord level surgeries, technical (25%) was most frequent in unilateral

changes, whereas systemic events such as low blood pressure or anaemia (20%) and technical (20%) were found in bilateral MEP changes. In 61.5% of alerts, only MEP changes were seen without an effect on the EMG or SSEP. SSEPs were affected in 30.7% of alerts. In 11.5% of alerts, only SSEP changes were seen. Lastly, EMGs were affected in only 7.7% of alerts and were not seen in conjunction with MEP or SSEP changes. 16.8% of patients developed a new postoperative neurological deficit. Of these patients, 72.7% had no IONM alert. In the presence of an IONM alert, 45.0% had a new neural deficit despite 71.4% of MEP changes being recovered intraoperatively. New neurological deficits occurred in 12.2% of non-cord-level operations in which there were no IONM alerts (i.e. false negatives).

Conclusion

In this prospective study of complex spinal deformity correction at a non-cord level, IONM alerts occurred in 11.2% of patients. Revision surgery had a 3.0 odds ratio of an IONM alert compared to primary surgery. Osteotomy/release was the most frequent surgical maneuver that triggered an IONM alert. MEP alerts were most common, whereas EMG was the least reliable IONM modality and should not be used in isolation. A new postoperative neurological deficit was observed in 16.8% of patients. Unfortunately, the sensitivity of IONM alerts remains less than 50% for non-cord level surgery even when accounting for "potential saves" and highlights the need for further refinement of IONM techniques and alert criteria for non-cord level surgery.

E-Point Presentation Abstracts

100. Risk Factors for Tether Breakage After Two Row Vertebral Body Tethering (2RVBT) in AIS

Abel De Varona Cocero, BS; Fares Ani, MD; Camryn Myers, BA; Constance Maglaras, PhD; Themistocles S. Protopsaltis, MD; *Juan Carlos Rodriguez-Olaverri, MD*

Hypothesis
There is an increased chance of tether breakage if postoperatively, the second structural curve over-compensates for the correction of the primary structural curve.

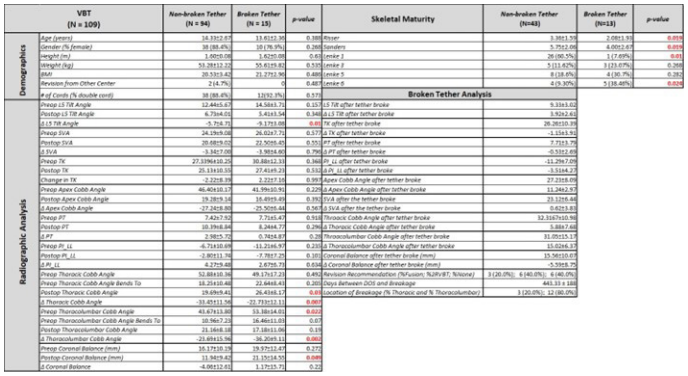
Design
Single-center retrospective cohort study.

Introduction
Even though the incidence of tether breakage decreases with two row vertebral body tethering (2RVBT), there is still around an 18% change of breakage. This study compares non-broken 2RVBT cases to cases whose tether broke after the index surgery with more than 2 years follow up of index surgery.

Methods
Patients with AIS whose curves were <65 degree, and residual curves after correction were <30 degrees were included. The cohort was separated into non-broken tether (NBT) cases or broken tether (BT) cases. Outcome measures: Age, height, weight, BMI, Risser, Sanders, Lenke, location of cord breakage, days between DOS and date of breakage, and follow-up revision rates. Radiographic analysis included pre-op, post-op, and post-breakage apex, thoracic (T), and thoracolumbar (TL) cobb angles, coronal balance, SVA, L5 slope, thoracic kyphosis (TK), pelvic incidence lumbar lordosis mismatch (PI-LL), and pelvic tilt (PT).

Results
109 (NBT=94; BT=15) patients met the cohort criteria. There was a significantly larger change in the L5 Angle tilt in the BT group between the pre- and post-op measurements (-5.70±4.71 vs -9.17±3.08; p=0.01). The post op T cobb angle was significantly greater in the BT group (26.43±8.17 vs 19.69±9.41; p=0.03). There was a significantly smaller change in T cobb angle in the BT group (-22.733±12.11 vs -33.45±11.56; p=0.007). There was a significantly larger pre op TL cobb angle in the BT group compared to to the NBT group (53.38±14.01 vs 43.67±13.80, p=0.022). There was a significantly larger change in TL cobb angle in the BT group (-36.20±9.11 vs -23.69±15.96; p=0.002). There was a significantly larger coronal imbalance in the BT group (21.15±14.55 vs 11.94±9.42; p=0.049). The majority of broken tethers were located in the TL curve 10 (76.9%) versus T curve 3 (23.1%).

Conclusion
The main preoperative risk factors for tether breakage after 2RVBT in flexible patients, with residual correction of less than 30 degree are patients that have a difference of more than 10 degree between the two curves and coronal imbalance of more than 4 mm.



VBT (N = 109)	Non-broken Tether (N = 94)	Broken Tether (N = 15)	p-value
Demographics			
Age (years)	14.33±2.67	13.61±2.36	0.386
Gender (% Female)	38 (88.4%)	10 (76.9%)	0.268
Weight (m)	1.60±0.08	1.62±0.08	0.43
Weight (kg)	53.28±12.22	55.61±9.82	0.535
BMI	20.53±3.42	21.27±2.96	0.489
Revision from Other Center	214.7%	0	0.485
# of Cords (% double cord)	38 (88.4%)	12(92.3%)	0.579
Radiographic Analysis			
Preop L5 Tilt Angle	12.44±5.67	14.58±3.71	0.157
Postop L5 Tilt Angle	6.73±4.01	5.41±3.54	0.346
Δ L5 Tilt Angle	-5.7±4.71	-9.17±3.08	0.01
Preop SVA	24.19±9.08	26.02±7.71	0.577
Postop SVA	20.68±9.02	22.50±6.45	0.551
Δ SVA	-3.34±7.08	-3.98±4.69	0.796
Preop TK	27.339±10.25	30.88±12.33	0.368
Postop TK	25.13±10.33	27.41±9.23	0.515
Change in TK	-2.22±8.39	3.22±7.16	0.994
Preop Apex Cobb Angle	46.40±10.17	41.99±10.91	0.228
Postop Apex Cobb Angle	19.28±9.16	16.40±9.49	0.392
Δ Apex Cobb Angle	-27.24±8.80	-25.50±6.44	0.545
Preop PT	7.42±7.92	7.71±5.47	0.918
Postop PT	10.39±6.84	8.24±4.77	0.296
Δ PT	2.98±5.72	0.76±4.87	0.26
Preop PI_LL	-6.71±10.69	-11.21±6.97	0.233
Postop PI_LL	-2.80±11.76	-7.78±7.25	0.181
Δ PI_LL	4.27±9.48	2.67±6.73	0.64
Preop Thoracic Cobb Angle	52.88±10.36	49.17±17.23	0.491
Preop Thoracic Cobb Angle Bends To	18.23±10.46	22.64±8.43	0.203
Postop Thoracic Cobb Angle	19.69±9.41	26.43±8.17	0.03
Δ Thoracic Cobb Angle	-33.45±11.56	-22.733±12.11	0.007
Preop Thoracolumbar Cobb Angle	43.67±13.80	53.38±14.01	0.022
Preop Thoracolumbar Cobb Angle Bends To	20.96±7.23	16.46±11.03	0.07
Postop Thoracolumbar Cobb Angle	21.16±8.18	17.18±11.06	0.19
Δ Thoracolumbar Cobb Angle	-23.69±15.96	-36.20±9.11	0.002
Preop Coronal Balance (mm)	16.17±10.19	19.57±12.47	0.272
Postop Coronal Balance (mm)	11.94±9.42	21.15±14.55	0.049
Δ Coronal Balance	-4.86±12.61	1.17±15.71	0.22

Skeletal Maturity	Non-broken Tether (N=43)	Broken Tether (N=13)	p-value
Risser	3.36±1.59	2.08±1.93	0.019
Sanders	5.75±2.06	4.00±2.67	0.019
Lenke 1	26 (60.5%)	1 (7.69%)	0.01
Lenke 2	5 (11.62%)	3 (23.07%)	0.268
Lenke 5	8 (18.6%)	4 (30.7%)	0.282
Lenke 6	4 (9.30%)	5 (38.48%)	0.026
Broken Tether Analysis			
Δ L5 Tilt after Tether Broke	9.33±3.02		
Δ L5 Tilt after Tether Broke	3.92±2.61		
Δ TK after Tether Broke	26.28±10.39		
Δ TK after Tether Broke	-1.15±3.91		
Δ PT after Tether Broke	7.77±3.75		
Δ PT after Tether Broke	-0.53±2.69		
Δ PI_LL after Tether Broke	-11.29±7.09		
Δ PI_LL after Tether Broke	-3.31±4.27		
Δ Apex Cobb Angle after Tether Broke	27.23±8.09		
Δ Apex Cobb Angle after Tether Broke	11.24±2.97		
Δ SVA after the tether broke	23.12±6.66		
Δ SVA after the tether broke	0.62±3.83		
Thoracic Cobb Angle after tether broke	32.316±10.96		
Δ Thoracic Cobb Angle after tether broke	5.88±7.66		
Thoracolumbar Cobb Angle after tether broke	31.05±15.17		
Δ Thoracolumbar Cobb Angle after tether broke	15.02±6.87		
Coronal Balance after tether broke (mm)	15.56±10.07		
Δ Coronal Balance after tether broke (mm)	-5.59±6.75		
Revision Recommendation (%Fusion; %PrVBT; %None)	3 (20.0%); 6 (40.0%); 6 (40.0%)		
Days Between DOS and Breakage	441.33 ± 186		
Location of Breakage (% Thoracic and % Thoracolumbar)	3 (20.0%); 12 (80.0%)		

101. The Importance of Surgeon Dashboarding for Comparative Quality and Safety Outcomes when Adopting Robotics in Practice

Alexa P. Bosco, BA; Nicole Welch, BA; Maty Petcharaporn, BS; Michelle Claire Marks, PT, MA; Shanika De Silva, PhD, MS; *Daniel J. Hedequist, MD*

Hypothesis
Adoption of robotics coupled with navigation (RAN) for pedicle screw placement in adolescent idiopathic scoliosis (AIS) may be done effectively with similar intraoperative performance and safety profile when compared to freehand (FH) technique. Evaluation of these measures over time is greatly aided by surgical dashboarding.

Design
A prospective cohort study of pediatric patients who underwent posterior spinal fusion for AIS by one surgeon from 2016 to 2023 and who were enrolled in the Surgeon Performance Program (SPP) Quality Improvement Registry.

Introduction
Dashboarding is useful to track and examine intraoperative and postoperative outcomes over time. The aim of this study was to utilize SPP metrics to compare quality and safety outcomes using RAN versus FH in AIS surgery.

Methods
Demographics and radiographs were summarized with descriptive statistics. Surgical measures, radiographic outcomes, and complications from the SPP were compared between groups as well as against national means using appropriate statistical tests including t-tests, Wilcoxon tests, Fisher's exact tests, and chi-squared tests based on data distribution.

Results
The cohort included 215 patients (121 FH, 94 RAN). Demographics and preoperative radiographic measures did not differ between groups. The mean age at surgery was 15.3 years, and most patients were female (82%). Dashboarding revealed RAN had significantly

longer mean surgical times (240 m vs. 192 m; p<0.001), similar EBL, and higher curve correction (70% vs. 60%; p=0.003) than FH patients. There were no differences in complication rates found between RAN and FH (p=0.3). Compared to national averages in SPP, quartiles for surgical time, EBL, and complications were the same for each group. There were no deep infections, neurologic deficits, or return to OR for malpositioned screws in either group. See Table 1.

Conclusion
This is the first reported pediatric series documenting the importance of dashboarding when adopting robotic technology into surgical practice. RAN was associated with an in increased surgical time, however EBL and safety profiles were similar.

Table 1. Comparison of Outcomes between RAN and FH surgery cohorts

Characteristic	Overall[1] (N=215)	FH[1] (N=121)	RAN[1] (N=94)	p[2]
Demographics				
Age at surgery (years)	15.0 (2.8)	15.0 (2.7)	15.0 (2.9)	0.9
Sex				0.2
Female	176	103	73	
Male	39	18	21	
BMI	21.9 (4.5)	22.4 (4.6)	21.3 (4.5)	0.06
Pre-operative Cobb angle (°)	59.0 (51.0, 65.0)	58.0 (52.0, 63.0)	60.0 (50.0, 66.0)	0.7
Surgical measures				
Implant density (screws/level fused)	1.9 (1.8, 2.0)	2.0 (1.9, 2.0)	1.9 (1.8, 2.0)	0.007
Surgical time (mins)	213.1 (54.4)	192.3 (46.9)	239.7 (51.8)	<0.001
EBL (ccs)	160 (150, 300)	200 (144, 300)	150 (150, 250)	0.4
Postoperative radiographic measures				
Curve correction (%)	60 (10)	60 (10)	70 (10)	0.003
Post-op Cobb angle (°)	21.1 (9.2)	22.5 (8.9)	19.4 (9.3)	0.016
Postoperative complications				
Occurrence of 90-day complications	4	3	1	0.6
Complication type (n=4)				>0.9
Medical	1	1	0	
Surgical Site/Incision	3	2	1	
Complication status (n=4)				0.3
Resolved	4	3	1	
Readmittance	2	1	1	0.9

1. Median (IQR); Mean (SD)
2. Wilcoxon rank sum test; Welch Two Sample t-test; Fisher's exact test; Pearson's Chi-squared test

Table 1. Comparison of outcomes between RAN and FH surgery cohorts

103. Posterior Dynamic Distraction Device for the Treatment of Adolescent Idiopathic Scoliosis: Preliminary Results from a Prospective Clinical Study

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Hypothesis
A novel Posterior Dynamic Distraction Device (PDDD) is a safe and effective treatment of Adolescent Idiopathic Scoliosis (AIS).

Design
Multicenter prospective study.

Introduction
After receiving Humanitarian Use Device approval from the US FDA in 2019, a prospective study was undertaken to evaluate the safety and effectiveness of a PDDD for use in AIS. This report presents safety data for all patients treated to date and efficacy data for those with a 2-year follow-up.

Methods
149 patients with AIS (Lenke 1 and 5), major Cobb 35 to 60°, less than or equal to 30° on side bending, and kyphosis less than 55°, were prospectively enrolled from 13 US sites between June 2020 and April 2023. Demographics, safety and deformity data were tracked.

Results
Safety and perioperative data were available for 149 patients, mean age 14.8 years and 75% female. On average, the procedure time was 112±34 min and estimated blood loss was 38.1±33.9 ml. The preoperative Cobb angle was 47.5°±7.3° with flexibility to 17.6°±6.6°. The Cobb angle at the first erect visit was 18.7°±7.0°. Mean hospitalization was 1.3 days. 2 patients were admitted to the ICU for 1 day. 21 patients (14.1%) had 23 reoperations, which included 14 PDDD revisions (9.4%) and 7 PDDD removals (4.7%). 2 patients were converted to posterior spinal fusion (1.3%). The main reasons included implant breakage (n=8), curve progression (n=4), infection (n=3), and screw migration or misplacement (n=3). One patient had a dural leak and was also admitted one-month post-surgery for wound irrigation and debridement. Both events resolved without sequelae. No major neurologic issues were noted. 25 patients had minimum 2-year follow-up, 16 of them Lenke 1 and 9 Lenke 5. The subgroup characteristics were similar to the entire cohort. (Table 1). At 2 years, curve correction to ≤30° was noted for 92% of the cohort and was maintained at the last follow-up (P=0.629). 5 of the 25 patients (20%) had revision surgery, 3 implant revisions and 2 implant removals.

Conclusion
PDDD correction of Cobb angles was significant and durable at 2-year follow-up for the majority of patients, with revision rates similar to those reported for other non-fusion scoliosis procedures and shows promise in the avoidance of spinal fusion. Ongoing study is needed to determine the true incidence of long-term complications.

	Pre-op	Immediate Post-op	6 months	12 months	24 months	P-value[1]
Primary Cobb Mean±SD (range)	47.5°±7.3° (34°-61°)	19.3°±5.9° (7°-31°)	19.3°±8.3° (4°-33°)	17.9°±8.4° (0°-37°)	20.2°±9.3°[2] (1°-39°)	P<0.005
Secondary Cobb Mean±SD (range)	30.1°±7.8° (14°-45°)	16.9°±10.0° (2°-35°)	18.4°±10.6° (1°-37°)	17.0°±10.7° (1°-36°)	18.2°±11.3° (2°-41°)	P<0.005
Kyphosis (N= 16, Lenke 1 patients) Mean±SD (range)	22.7°±10.1° (2°-42°)	31.3°±8.5° (15°-46°)	35.4°±7.7° (21°-47°)	37.2°±9.3° (17°-51°)	34.8°±8.8° (19°-53°)	P<0.005
Lordosis (N=9,Lenke 5 patients) Mean±SD (range)	59.9°±14.6° (46°-86°)	50.6°±12.3° (37°-73°)	54.3°±13.2° (35°-77°)	52.3°±11.8° (38°-77°)	56.7°±11.8° (38°-71°)	P=0.52
SVA Mean±SD (range)	-5.9±32.5 mm ([-61.7]-[57.8] mm)	-0.6±35.7 mm ([-75.4]-[58.8] mm)	-16.6±34.7 mm ([-89.7]-[52.0] mm)	-16.3±34.4 mm ([-75.2]-[50.0] mm)	-12.9±25.8 mm ([-59.0]-[30.0] mm)	P=0.18

SD, Standard Deviation
[1] P-value calculated by paired sample t-test for pre-op and 24 months follow-up.
[2] P=0.629, calculated by Friedman Rank Test between immediate and 24 months follow-up.

Radiographic patient results N=25

104. Clinical Utility of Ultrasonography for the Assessment of Skeletal Maturity Based on the Sanders Radiological Classification in Patients with Adolescent Idiopathic Scoliosis

Aranzazu Pedraza Corbí, MD

Hypothesis
Ultrasound allows determining skeletal maturity based on Sanders' radiological classification. New test for the diagnosis of skeletal maturity

Design
Reliability study, consecutive sampling

Introduction
Adolescent idiopathic scoliosis (AIS) involves a three-dimensional deformity of the spine whose progression is directly related to growth stages. The definition of skeletal maturity constitutes a key factor in the prognosis and treatment of the disease. Currently, Sanders radiological classification has been the most used tool to define it, however, technological advances in the field of ultrasound have opened a new window of opportunity. Thus, the main objective of this study was to evaluate the usefulness of ultrasound to determine the state of skeletal maturity based on the Sanders radiological classification.

Methods
A case-control study was carried out, including as cases those patients between 10 and 16 years old with a diagnosis of adolescent idiopathic scoliosis; and in the control group including those with diagnoses not related to AIS. Skeletal maturity was determined in each patient using the Sanders classification using radiography and ultrasound. Each ultrasound parameter was evaluated by 4 researchers, with the objective of controlling the interobserver error of the measurement. Data were collected on sheets designed specifically for the study. Statistical analysis was performed using IBM SPSS Statistics software.

Results
A sample of 70 patients was obtained between cases and controls, analyzing the demographic data of both groups without obtaining statistically significant differences. Regarding both radiological and ultrasound measurement and classification based on the Sanders skeletal maturity evaluation method, no statistically significant differences were found. Excellent agreement was obtained when evaluating interobserver variability in ultrasound classification based on the Sanders method.

Conclusion
The state of skeletal maturity can be determined using the Sanders classification both radiographically and ultrasonographically. Ultrasound measurement has a small learning curve and is easily reproducible if performed consistently.

105. Early Outcomes in Hybrid Spine Fixation for Adolescent/Juvenile Idiopathic Scoliosis: Posterior Spinal Fusion with Combined Anterior Vertebral Body Tethering

Daniel M. Cherian, MD; *Amer F. Samdani, MD*; Joshua M. Pahys, MD; Alan Stein, MD; Alexander J. Schupper, MD; Steven W. Hwang, MD

Hypothesis
A combined approach of PSF with VBT is a safe and effective approach for idiopathic scoliosis.

Design
Single center retrospective

Introduction
Anterior vertebral body tethering (VBT) and posterior spinal fusion (PSF) are both options for patients with idiopathic scoliosis with the former having a higher reoperation rate balanced with maintained motion. Combining both procedures in patients with double curves where a PSF is performed for the thoracic curve and VBT for the lumbar curve provides maximal correction of the thoracic curve with a theoretical maintenance of motion for the lumbar spine.

Methods
A retrospective chart review of 19 patients at a single pediatric institution with a diagnosis of idiopathic scoliosis who have undergone thoracic PSF combined with lumbar VBT were included. Demographic, clinical and radiographic variables were collected, and univariate statistics were compared via t-test analysis.

Results
19 patients were identified with an average age of 12.7±1.6 years (female=68.4%) with an average follow-up of 8 months (range 1-24). These patients were skeletally immature (Sanders 3.8±1.8) with the following Lenke curve types: 6 (11), 3 (6), and one each of 4C and 1C. All patients underwent staged PSF and VBT procedures, and of the 17 patients who had both procedures in the index admission, procedures were performed with an average 3.4±2.1 days apart. PSF

procedures took an average of 273±63 minutes, and VBT procedures had a duration of 275±55 minutes. Estimated blood loss (EBL) was 121.8±80.6 mL for VBT procedures and 426.6±294.0 mL for PSF procedures. Following hybrid correction, thoracic Cobb angles improved from 66.9° to 17.9° (p<0.001), and lumbar Cobb angles improved from 65.0° to 20.4° (p<0.001). In patients with 1-year follow-up, Cobb angles did not progress in either thoracic (p<0.001) or lumbar (p<0.001) regions. No patients required revision surgery, and there were no major perioperative complications.

Conclusion
A combined approach of PSF with VBT is a safe and effective approach for idiopathic scoliosis. This approach applies the gold standard of performing a selective thoracic fusion with the purported benefits of motion preservation of VBT for the lumbar spine. Hopefully, this study will continue to refine indications for VBT to where it is most impactful.

Table. Patients undergoing hybrid tether/fixation correction

Number of patients	19	
Average age (years)	12.7 ± 1.6	
Female, n (%)	13 (68.4)	
Lenke Curve type, n (%): 1C	1 (5.3)	
3C	6 (31.6)	
4C	1 (5.3)	
6C	11 (57.9)	
Sanders score (avg.)	3.8 ± 1.8	
Avg. days between procedures	3.4 ± 2.1	
	PSF	**VBT**
Surgical time (minutes)	263 ± 63	275 ± 55
Estimated blood loss (mL)	426.6 ± 294.0	121.8 ± 80.6
	Thoracic	**Lumbar**
Pre-op coronal curve angle	66.9°	65.0°
Post-op coronal curve angle	17.9°	20.4°
p-value	<0.001	<0.001

PSF = posterior spinal fusion
VBT = vertebral body tethering

Table

106. The Use of Allograft in Posterior Spine Fusion for Adolescent Idiopathic Scoliosis - Does It Add Value?

Emily Hu, MD; Ignacio Pasqualini, MD; Yuta Umeda, MD; Gabrielle Scariano, BS; David P. Gurd, MD; Ernest Y. Young, MD; Thomas E. Kuivila, MD; *Ryan C. Goodwin, MD*

Hypothesis
Our hypothesis is that there would be no significant differences in the achievement of successful spinal fusion rates in patients with AIS, regardless of whether AT or AL is utilized.

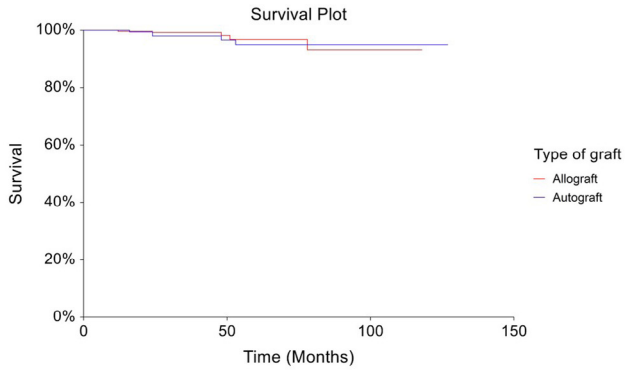
Design
A retrospective comparative cohort

Introduction
Long-term bony fusion after PSF for AIS is crucial to preserve deformity correction, while pseudarthrosis represents a concerning potential complication. Debate continues over the necessity of allograft bone grafting to achieve cost-effective spinal arthrodesis

Methods
A retrospective comparative cohort study was performed in patients who underwent a primary PSF for treatment of AIS between 2010 and 2021 at a single tertiary institution. Exclusion criteria were age <10 years old, non-idiopathic scoliosis, non-posterior fusion approaches, or <3 month follow-up. Pseudoarthrosis was defined as radiographic loss of correction greater than 10°, or direct visualization of nonunion during re-operation. Patients were grouped according to whether allograft (AL) plus local autograft or local autograft only (AT) were used. The cost of 30 mL of allograft bone at the completion of this study was $404.00 per case.

Results
A total of 657 patients (80.2 % female) with a mean follow-up of 32.5 months were included. Overall, 415 were treated with AL and 242 with AT. There were no differences in the rate of pseudoarthrosis between groups (AL: 1.2% (n=5) vs AT: 2% (n=5), p =0.384). Survivorship for developing pseudoarthrosis was 93.1% and 95% at 105 months for AL and AT, respectively (p=0.596). The development of pseudarthrosis was not affected by the type of graft used (HZ 3.04 95% CI 0.65-14.12).

Conclusion
PSF for AIS achieves high fusion rates exceeding 90% survivorship free of pseudarthrosis at 9 years post-operatively, regardless of whether local AT or AL are utilized. Moreover, AL does not appear to substantially increase the overall costs of surgery compared to AT harvest.



Survivorship curve based on pseudoarthrosis between groups.

E-Point Presentation Abstracts

107. The Impact of Operating Room Process Versus Process and Team Standardization on Outcomes in Pediatric Spinal Deformity Surgery

Vishal Sarwahi, MD; Katherine Eigo, BS; *Sarah Trent, MD*; Alex Ngan, MD; Aravind Patil, MBBS; Brian Li, BS; Victor Koltenyuk, BS; Yungtai Lo, PhD; Terry D. Amaral, MD

Hypothesis
A standardized process alone can have a significant impact on operative outcomes compared to the employment of a standardized process in conjunction with a dedicated OR team for pediatric spinal deformity surgery.

Design
Retrospective Cohort Study

Introduction
OR standardization positively impacts outcomes in many surgical fields. In a previous study, our group demonstrated that standardization in adolescent idiopathic scoliosis (AIS) surgery improves patient outcomes such as operative time, blood loss (EBL), superficial infection rate and length of stay (LOS).Standardization in our previous study was accomplished by both systemizing procedural steps and by assembling a consistent team. The present study seeks to investigate the impact that process standardization has independently from a standard team.

Methods
In 2020, a standardized team was established with 5 anesthesiologists, 3 OR technicians, 3 nurses, and 3 neurophysiologists. A standardized process was established as well by eliminating various surgical steps. Data for the standardized team group was therefore 2020-2022 AIS cases who underwent a posterior spinal fusion. In 2023, new OR rooms in a different location opened, while the standardized process remained, a dedicated team did not. This created our standardized process group, AIS cases who underwent a posterior spinal fusion in 2023. Continuous variables were expressed as medians with interquartile range (IQR) values. Kruskal-Wallis test was used. Categorical variables were expressed as percentages and p-values were obtained from Chi-squared test.

Results
A total of 267 pediatric spinal deformity cases were included. 185 patients underwent surgery with the standard team whereas 82 patients with the standard process utilized. There was no difference between groups in demographic variables or preop Cobb angle, levels fused and number of fixation points. Postop Cobb angle ($p<0.001$), anesthesia time ($p<0.001$) and surgery time ($p=0.002$) demonstrated significant differences favoring the standard process. There was no significant relationship between standardization method and EBL, LOS, 30-day or 90-day complications.

Conclusion
This study examines efficiency of a standardized process versus a standardized process and team. Most institutions may not be able to standardize a team, but a standardized process can be easily implemented and shows to have beneficial results.

108: Abstract withdrawn

109. Dystrophinopathy in Paravertebral Muscle of Adolescent Idiopathic Scoliosis: A Prospective Cohort Study

Junyu Li, MD; Zheng Danfeng, MD; Zekun Li, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Yan Zeng, MD; Zhang Yingshuang, MD; Weishi Li, MD; Miao Yu, MD

Hypothesis
Adolescent Idiopathic Scoliosis(AIS) is commonly associated with paraspinal muscle pathology based on previous studies, but the patients did not show typical symptoms of decreased limb muscle strength and respiratory muscle function limitation. So AIS may be a particular kind of core myopathy, and we infer that the pathological changes of paravertebral muscles are involved in the development and evolution of AIS, especially the proteins therein.

Design
prospective cohort study

Introduction
AIS's mechanism remains unknown.Based on the hypothesis that the onset and clinical progression of AIS may be associated with certain neuromuscular diseases, we used pathological methods to further analyze paraspinal muscle changes in AIS patients and introduced immunohistochemical antibody markers used in neuromuscular disease diagnosis through routine morphology. And we are particularly interested in the Dystrophin protein.

Methods
A total of 40 patients with AIS, 20 patients with Congenital Scoliosis (CS) and 20 patients with Spinal Degenerative Disease (SDD) have been enrolled so far. All patients underwent open posterior surgery in our hospital, and paravertebral muscle (multifidus muscle) biopsy was performed during the operation. Many indexes describing muscle were included in this study, especially dystrophin staining. The above pathological results were compared among AIS, CS and SDD groups. The correlation between Cobb Angle and Nash-Moe classification and the above pathological findings was analyzed in AIS patients.

Results
There were significant deletions of dystrophin-1 ($P<0.001$), dystrophin-2 ($P<0.001$) and dystrophin-3 ($P<0.001$) in AIS group compared with both CS group

and SDD group. The higher the Nash-Moe classification in the AIS group, the more significant the loss of dystrophin-2 (P=0.042) in the convex paraspinal muscles. In addition, there was a positive correlation between the degree of dystrophin-1 and 2 deletion on the concave side of AIS group and Cobb Angle, and there was a significant correlation between dystrophin-2 and Cobb Angle (P=0.011).

Conclusion
Dystrophin protein deletion of paraspinal muscles plays an important role in the formation and development of AIS. The severity of scoliosis is correlated with the degree of dystrophin deletion in paravertebral muscle of AIS patients. Therefore, dystrophin dysfunction may contribute to the occurrence and development of AIS.

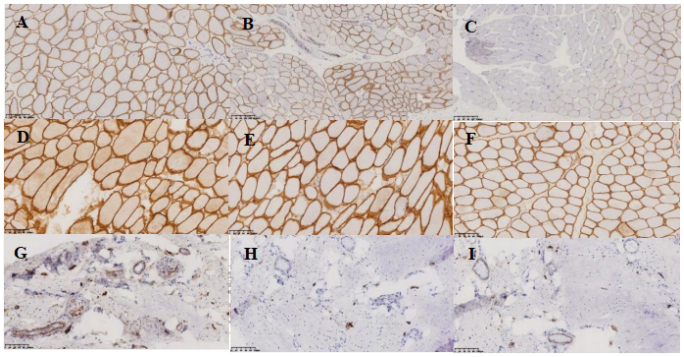


Figure of AIS(A-C), CS(D-F) and SDD (G-I) groups.

110. A Numerical Analysis of The Biomechanical Effects of Vertebral Body Tethering

Jil Frank; Miguel Pishnamaz, MD; Maximilian Praster, PhD

Hypothesis
Can a numerical simulation show the effects of growth on compression and tether force in a tethered spine?

Design
Numerical analysis using multi-body simulation

Introduction
Vertebral Body Tethering (VBT) is a growth-friendly, mobility-preserving, non-fusion surgical technique for scoliosis correction. By tensioning an elastic tether on the convex side of the spinal curve, the spine is straightened. Although the good post-operative results, the biomechanics in the spine and the tether device in a growing, living organism aren´t fully understood. The analysis of spinal biomechanics and VBT device in in-vivo or cadaveric experiments is vague and has several weaknesses. Thus, another approach is chosen, namely the multibody simulation.

Methods
A flexible growing spine model with implanted VBT device is developed from an existing validated thoracolumbar model. Various spinal movements (lateral bending, axial rotation, flexion-extension) are simulated, and the effects of growth are analyzed. The resulting tether tension and intervertebral compression force can be calculated with respect to the human anatomy and material properties of the VBT device.

Results
During growth, the tether and compression forces increase continuously. (Fig. 1) The highest tether force is measured at 50° lateral bend between L1 and L2 at 200 N pre-tension (♀ 937.15 N; ♂ 961.67 N). The compression forces in a tethered spine are during adolescence up to twice higher than in a healthy spine. Between, the time of surgery (Ø 12.5 years) and the age of 18, the compression force between L1 and L2 in upright position increases by up to 25.39% in boys and up to 10.53% in girls.

Conclusion
The new VBT spine model helps to better understand spinal biomechanics after VBT surgery and during growth. The study has shown that both, compression and tether forces increase during growth. To conclude, the remaining growth potential should be considered for the tether´s fixation. Furthermore, tether forces reach values that can potentially destroy its integrity, which may explain the most common complication, tether breakage. A future vision is to define the ideal VBT fixation options for each patient based on their individual predispositions and to find more suitable materials that can adapt to the growing effects.

E-Point Presentation Abstracts

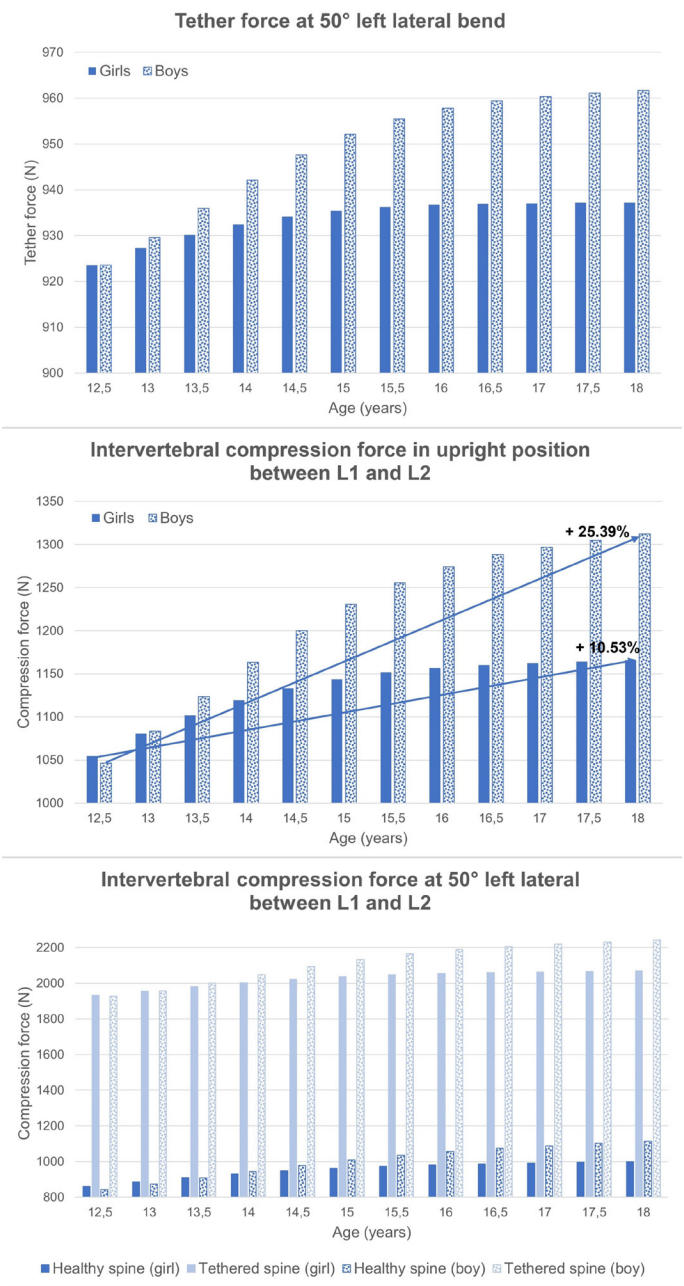


Fig. 1: Tether and compression forces during growth

111. A Novel Concept and Device for Automation of 3D Correction of Spinal Deformities: Digital Fabrication and Finite Element Analysis.

Hazem B. Elsebaie, MD, FRCS; Darryl D'Lima, MD, PhD; Behrooz A. Akbarnia, MD; Robert K. Eastlack, MD; Muhammad T. Abdalrahman, MBBS; Gregory M. Mundis Jr., MD

Hypothesis

A novel device (Segmental Coupler) allows controlled and calculated correction of individual vertebral deviations; the device is designed to withstand the loads required for deformity correction.

Design

Digital Fabrication and Biomechanical Finite Element Analysis

Introduction

Segmental fixation and the concept of 3D correction of spinal deformities were introduced in the eighties. Since then, realigning the vertebrae along contoured solid rods has remained the principal surgical strategy. During correction maneuvers, rigid rods restrict and alter vertebral motion significantly complicating the procedure. Furthermore, the forceful reduction of the rod into pedicle screws' heads is technically demanding and risky. To overcome these difficulties, we developed an interpedicular device capable of correcting individual vertebral deviations. These deviations, represented as digital entries (angles and distances acquired from 3D radiographs), are dialed into the device to correct the corresponding deformity. Digitization, a step towards automation, has a potential to revolutionize spinal deformity surgery.

Methods

We designed a Computer Aided Model of a Coupler (to be attached to pedicle screws) incorporating 3 uniaxial joints, each is selectively mobilized by a separate screw-head to deliver a calculated angle (rotation), or distance (linear displacement). This corrects vertebral deviations in axial rotation, sagittal angulation, and coronal tilt to achieve a pre-calculated target position. A physical functional prototype was fabricated for proof of concept and validation. FEA was used to test the device's structural strength.

Results

The prototype delivered the predicted directions and degrees of motion. FEA indicated that applying correction force of 120 Newton to the pedicle screw produced values of maximum von Mises stresses < 30% of the Coupler's material (Ti-6Al-4V) yielding strength. The highest stresses were located at the enclosures and around contact areas of the threads of the self-locking mechanisms.

Conclusion

The Segmental Coupler allows controlled, calculated, and reproducible motions capable of segmental 3D correction of vertebral deviations. FEA revealed that the device can structurally withstand the loads required for deformity correction. In vitro testing will be conducted before it is ready for clinical trials.

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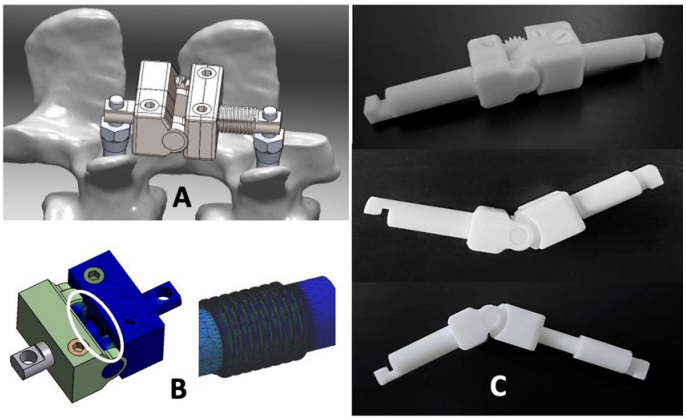

A. CAD Image B. Maximum Stresses in FEA C. Prototype

112. Assessing The Economic Benefit of Robotic and Navigational Assistance in Surgical Treatment of L4-L5 Spondylolisthesis

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Hypothesis
Higher upfront equipment cost may be worth the operative and safety benefits of robotic and navigational assistance.

Design
Retrospective review of prospective MIS database

Introduction
Minimally-Invasive Surgery(MISS) reduces operative time, increases patient safety, and aids in surgical accessibility. There remain gaps in the literature regarding the cost-effectiveness of robotic or navigational guidance in surgical treatment of L4-L5 spondylolisthesis.

Methods
MISS patients with L4-L5 spondylolisthesis and baseline/2-year postop radiographic/HRQL data were included. Patients classified as operated on using robotic/navigational guidance(Robotic+) or not(Robotic-). Means comparison analysis assessed differences at BL, 1Y, and 2Y postop. Costs were calculated using PearlDiver database through Medicare estimates in a 30-day window, including estimates of postoperative complications, outpatient healthcare encounters, revisions and medical readmissions. Quality-adjusted life years(QALYs) were calculated using NDI mapped to SF6D using validated methodology accounting for decline to life expectancy.

Results
88 patients(54.40±12.49 years, 40% female, 30.93±6.52 kg/m2, mean CCI: 2.23±1.55) with L4-5 spondylolisthesis were included. At baseline, patients were comparable in age, gender, BMI, and CCI, and baseline regional nor global radiographic deformity (all p>.05). Robotic+ patients were significantly less likely to undergo corpectomy(p=.006), and also demonstrated significantly lower EBL(p=.013) and operative time(p=.009). Economic analysis revealed broad cost savings for Robotic patients. Robotic+ patients had increased utility gained per QALYs at 1Y(p=.028) & Life Expectancy QALYs(p=.002). Robotic+ patients were also more likely to demonstrate increased QALYs gained by 2Y(p=.029). Overall cost per QALY by 2Y was significantly higher for Robotic- patients, resulting approximately 6x greater cost per QALY ($76,848 vs $11,839). Robotic+ patients demonstrated significantly higher cost-effectiveness by 2Y(p<.001).

Conclusion
Corrective procedures for L4-L5 spondylolisthesis have seen considerable uptake of robotic or navigational assistance. Though such technologies have a significantly higher upfront costs, our findings demonstrate that reductions in intraoperative invasiveness and OR time pay great dividends, demonstrating the cost-effectiveness of robotics in MISS ASD surgery.

113. Sagittal Alignment Correction in Adult Spinal Deformity Through Anterior Column Techniques: Matched-Cohort Comparison of Lateral ACR and Prone Lateral LIF

Antoine G. Tohmeh, MD; Peyton Van Pevenage, BS; Kelli Howell, MS

Hypothesis
Prone lateral LIF results in equivalent sagittal correction compared to LIF ACR, with fewer complications.

Design
Retrospective analysis of a prospectively collected database; observational cohorts matched by pre-op alignment

Introduction
Prone transpsoas (PTP) lateral lumbar interbody fusion (LIF) is a single-position alternative to traditional LIF technique performed in lateral decubitus. Several reports to-date have reported excellent lordosis correction via prone positioning. An advanced method for increased lordosis correction in LIF includes ALL resection and use of a hyperlordotic spacer, aka anterior column reconstruction (ACR). This study compares sagittal correction results using these two LIF techniques.

Methods
At a single institution, all consecutive LIFs were captured via prospective institutional registry. Retrospective database analysis identified 34 ACR and 120 PTP patients. The PTP cohort was narrowed to 34 by matching to the ACR cohort based on preoperative sagittal alignment parameters.

Results
Group demographics were similar (mean age: 63 PTP v 66 ACR; mean BMI: 29 both; p>0.05), except sex (female 65% PTP v 38% ACR, p=0.0290). Pre-op spinopelvic parameters were matched, except baseline pelvic incidence (PI: 57.4 PTP v 53.2 ACR, p=0.0391). The number of LIF levels was not different across groups (p=0.7392): PTP=73 LIF + 2 TLIF levels (L5-S1). ACR= 70 LIF (48 of those were ACR) + 15 ALIF levels. Inclusion of L4-5 was greater in PTP (85.3% v 52.9%, p=0.0039). OR time, EBL, and hospital stay were all significantly less in PTP (175 v 246 min, p=0.0010; 150 v 370 ml, p=0.0008; 2.6 v 5.8 days, p<0.0001). Complication rate trended higher for ACR, but was not statistically different (20.6% v 29.4%, p=0.4406). Visceral and vascular complications occurred only in ACR, prolonging hospitalization; none occurred in PTP. Follow-up averaged 15 mo for PTP (range 1.5-38 mo) and 25 mo for ACR (range 5-85 mo). Significant alignment improvements were achieved by both procedures pre-op to average 1-yr post-op, with no significant differences across groups (Table 1).

Conclusion
Matched cohort comparison of PTP and ACR LIF showed significant, and equivalent, sagittal alignment correction. Complication rates were similar but more severe in ACR. PTP resulted in shorter OR time, less blood loss, and shorter hospitalization.

N=34 each group (PTP v ACR)	Mean pre-post difference -PTP *p<0.05	Mean pre-post difference -ACR *p<0.05	P value (comparing groups) *p<0.05
LL	+9.1°*	+7.8°*	0.7463
PI	0.01°	+0.93°	0.0602
PI-LL	-9.2°*	-10.2°*	0.5368
PT	-3.3°*	-3.8°*	0.0876
L4-S1	+6.1°*	+3.0°*	0.8040

Table 1.

114. Analysis of Personalized Interbody Implants in the Surgical Treatment of Adult Spinal Deformity

Justin S. Smith, MD, PhD; Gregory M. Mundis Jr., MD; Joseph A. Osorio, MD, PhD; Rodrigo Nicolau, MD; Michele Temple-Wong, PhD; Renaud Lafage, MS; Shay Bess, MD; Christopher P. Ames, MD

Hypothesis
3D-printed personalized interbody spacers are associated with improved rates of achieving surgeon goal alignment following adult spinal deformity (ASD) surgery.

Design
Retrospective cohort study

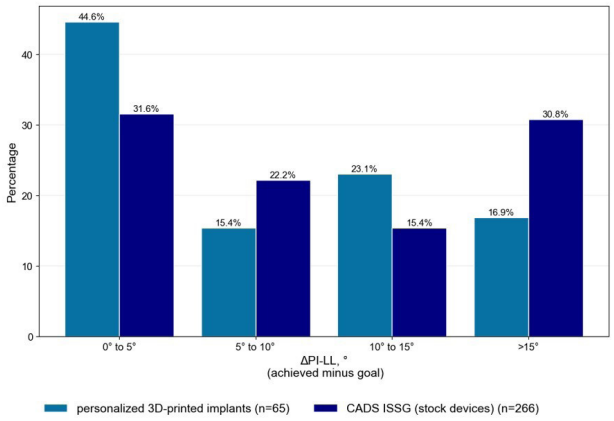
Introduction
Malalignment following ASD surgery can negatively impact outcomes and risk of mechanical complications. A recent report from the International Spine Study Group (ISSG; DOI: 10.1177/21925682231161304) noted that surgeons failed to achieve their sagittal alignment goals in nearly two-thirds of 266 complex adult deformity surgery (CADS) cases. We assess whether use of 3D-printed personalized interbody spacers is associated with improved rates of achieving goal alignment following ASD surgery.

Methods
Consecutive ASD patients from 11 centers were included if their surgery utilized personalized interbody spacer(s) (aprevo®, Carlsmed) and they met ISSG CADS inclusion criteria. Planned alignment was personalized by the surgeon during interbody planning. Planned versus achieved alignment was assessed and compared with the ISSG CADS series that used stock interbodies.

Results
For 65 patients with personalized interbodies, 62% were women, mean age was 70.3 years (SD=8.3), mean instrumented levels was 9.9 (SD=4.1), and the mean number of personalized interbodies per patient was 2.2 (SD=0.8). Segmental alignment was achieved close to plan for levels with personalized interbodies, with mean difference between goal and achieved as follows: intervertebral lordosis=0.9° (SD=5.2°), intervertebral coronal angle=0.1° (SD=4.7°), and posterior disc height=-0.1mm (SD=2.3mm). Achieved pelvic incidence-to-lumbar lordosis mismatch (PI-LL) correlated significantly with goal PI-LL (r=0.668, p<0.001). Compared with the ISSG CADS cohort, utilization of personalized interbodies resulted in significant improvement in achieving PI-LL <5° of plan (p=0.046) and showed a significant reduction in cases with PI-LL >15° of plan (p=0.012) (Figure).

Conclusion
Even among experienced deformity surgeons, it remains challenging to achieve preoperative goal alignment in ASD surgery. This study supports use of personalized interbodies as a means of better achieving goal segmental sagittal and coronal alignment and significantly improving achievement of goal PI-LL compared with stock devices.

Figure. Percentage distribution of the magnitude of offsets of the PI-LL achieved compared to the plan for subjects treated with personalized implants based on a 3D preoperative plan compared to patients treated with stock implants in the ISSG CADS analysis.



|ΔPI-LL| Group	Personalized Implant Patients (n)	ISSG CADS Patients (n)	p-value
0° to 5°	**29**	**84**	**0.046**
5° to 10°	14	59	0.903
10° to 15°	12	41	0.541
>15°	**10**	**82**	**0.012**

115. Long-Term Minimum 5-Year Results, of Circumferential Minimally Invasive Surgical (CMIS) Correction for Adult Spinal Deformity (ASD): Radiological and Functional Outcomes

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Hypothesis
Long term results are not sustainable with CMIS for ASD correction.

Design
Retrospective study

Introduction
CMIS has become increasingly popular for the treatment of ASD. This study looks at a minimum 5-year FU, focusing on spinal alignment, functional scores, and quality of life.

Methods
A prospectively collected database of all patients who underwent CMIS correction of ASD from Jan 2011 to November 2017 was studied. Inclusion criteria was instrumentation of 5 + levels with UIV:T12 and above, LIV:L5 and below in patients with ASD (Cobb>20, SVA>50mm, PI-LL>10, or PT>20),and at least 5year (60m+/- 8 weeks) follow-up (FU). 78 patients were identified. 4 patients had passed away from natural causes. 31 patients had a last data point between 2 to 5 years FU with 3 other patients lost to FU after 6 months. 40 patients had > 5 year complete radiological and clinical data and were included for this study. Pre-operative, post-operative, and ≥5 years radiographic parameters (Cobb, CVA, SVA, LL, PI, PT, SS, PI-LL mismatch),clinical outcomes (VAS, ODI, SRS-22),-complications and readmissions were analyzed.

Results
Mean age: 64.5 years (35-84, SD 9.2) with an average 80 months FU(52-133 months, SD 25).L Minimum 5 year FU demonstrated sustained significant improvements in all radiographic measures including Cobb angle (39.1 to 16.7), TK (36.5 to 46.4), LL (38.3 to 45.6), and PI-LL mismatch (16.5 to 11.3). Significant improvements were also noted in clinical outcomes including back pain VAS score (6 to 3.7) ODI(42.5 to 28.7) and SRS-22(2.9 to 3.8). There were 9 readmissions for complications that needed revision surgery: 3 Adjacent segment degeneration, 1 Painful hardware, 1 PJK, 2 Pseudarthrosis, 1 stenosis, and 1 broken hardware. No patient was ever admitted to the ICU and no patient had any long-term medical complications related to the surgery. Of the 31 patients who had 2-to-5-year data 1 patient has had revision surgery for Prominent Proximal Hardware.

Conclusion
Our study would suggest that CMIS correction of ASD patients yields substantial and enduring improvements in spinal alignment, pain relief, and quality of life. This is the first long term study providing valuable insights into the comprehensive and sustainable effects of minimally invasive surgical techniques in the management of ASD.

Complications and Revision surgeries

Adjacent segment degeneration L5-S1	2 years	L5-S1 ALIF and L4 to pelvis posterior instrumentation and fusion + bilateral iliac screws
Adjacent segment degeneration L5-S1	3yrs	L5-S1 instrumentation, and fusion
Adjacent segment degeneration L5-S1	3.5yrs	ALIF of L5-S1
Hardware Prominence (Painful hardware)	2yrs	Removal of hardware, right L5, S1 and pelvis
PJK	2.5yrs	C2-T4 Posterior and posterolateral fusion, SPO C7-T2
Pseudarthrosis T11-T12, L5-S1), HW failure (Rod Fracture)	3yrs	ROH, Reinstrumentation of right S1 and iliac screw and bilateral T11 screws and T11-S1 posterior instrumentation
Pseudarthrosis T12-L1 (Loose hardware right pedicle screw, T12)	4yrs	Interbody fusion at T11-12 and T12-L1 AND Removal of hardware, T12 screws bilaterally AND T11-L2 posterior spinal instrumentation
Stenosis (Heterotopic ossification) L5-S1	1yrs	Removal of hardware, left S1 pedicle screw and iliac screw, Left laminoforaminotomy, L5-S1
Traumatic hardware failure (Broken right iliac screw after a fall)	1.5yrs	Removal of the iliac screw and rod (iliac bolt)

Clinical Outcomes

	Pre-op	Post-op	≥ 5 years	P VALUE
VAS	6 1-9 SD 2.2	3.2 0-9 SD 2.9	3.7 0-8 SD 2.7	<0.0001
TIS	53.5 0-92 SD 21.4	35.9 8-85 SD 26.3	19.6 0-76 SD 25.1	<0.0001
ODI	42.5 13.3-76 SD 21.4	44.4 0-97.8	28.7 0-82 SD 21.1	0.01
SRS22	2.9 2.1-3.8 SD 0.5	3.3 1.4-4.5 SD 1	3.8 1.7-5 SD 0.8	0.01

Radiographic outcomes

	Pre-op	Post-op	≥ 5 years	P VALUE
Cobb	39.1 10-70 SD 14.3	15.8 0-50.7 SD 10	16.7 0-37.5 SD 9.7	<0.0001
CVA, Coronal alignment	33.6 5.4-157 SD 33.3	22.1 0-61.9 SD 17.3	22.2 0-48.7 SD 11.6	0.180
SVA	56.8 11.5-239.5 SD 48	28.4 0-88 SD 23.2	41.3 0-110 SD 30.2	0.07
Lumbar Lordosis	38.3 9-78.2 SD 14.5	50.3 28.1-76.5 SD 10	45.6 21-70.2 SD 10.5	0.0003
TK	36.5 7.9-83.8 SD 16.6	46.1 20.6-69.8 SD 12.5	46.4 26.5-70.2 SD 12.5	0.0009
PI-LL Mismatch	16.5 1-49.3 SD 13	9.6 0.4-24.3 SD 6.2	11.3 0.30.9 SD 8.2	0.002

117. Single Cell RNA Sequencing Unveils Aberrant NF90-HOX4E Axis in NF90- Bone Marrow Mesenchymal Stem Cells Sub-Cluster of AIS Patients Leads to Clinical Osteopenia

Qianyu Zhuang, MD; Yuechuan Zhang, MD; Terry Jianguo Zhang, MD

Hypothesis

Dysfunction of specific sub-clusters of BM-MSCs may lead to clinical osteopenia in adolescent idiopathic scoliosis patients. The aberrant NF90-Hox4E axis in NF90- BM-MSCs sub-cluster may contribute the potential mechanism of the abnormalities.

Design

Single Cell RNA sequencing approach, bioinformatic analysis and functional experiments

Introduction

The pathogenesis of AIS and the accompanying generalized osteopenia remain unclear. Our previous study (2023 SRS) reported preliminary results of single-cell RNA sequencing in bone marrow mesenchymal stem cells (BM-MSCs) of AIS patients.

Methods

In this study, we used Seurat 3.0 to define a NF90- BM-MSCs subcluster based on single cell RNA sequencing results of AIS patients and healthy individuals. We then knockdown NF90 in normal BM-MSCs, and used flow cytometry to select NF90- BM-MSCs. We used CCK8 assay, scratch assay to define the proliferation ability of BM-MSCs, and qRT-PCR to examine the expression level of related stemness genes and osteogenic genes. We then performed alkaline phosphatase (ALP) staining and alizarin red staining to test the osteogenic ability of BM-MSCs after induced osteogenic differentiation. Finally, we used CHIP-seq to target the downstream interacting genes.

Results

NF90- BM-MSCs showed significantly reduced proliferation ability. The knockdown of NF90 resulted in downregulation of stemness related genes and osteogenic genes. ALP staining and alizarin red staining proved the osteogenic ability of NF90- BM-MSCs was significantly reduced. The overexpression of RUNX2 in NF90- BM-MSCs rescued the osteogenic ability, indicating that NF90 downregulation may affected RUNX2 expression level and resulted in BM-MSCs differentiation deficiency. Furthermore, CHIP-seq analysis revealed that NF90 specifically interacted with Hox4E, a downstream gene of NF90, which may play an essential role in AIS pathogenesis and accompanied osteopenia.

Conclusion

This study reports a novel BM-MSCs subcluster at single-cell level in AIS patients and corresponding mechanisms. The NF90- BM-MSC subcluster has reduced differentiation ability and osteogenic ability, which might play a significant role, in not only the causal mechanism of osteopenia in AIS, but also the AIS initiation and development.

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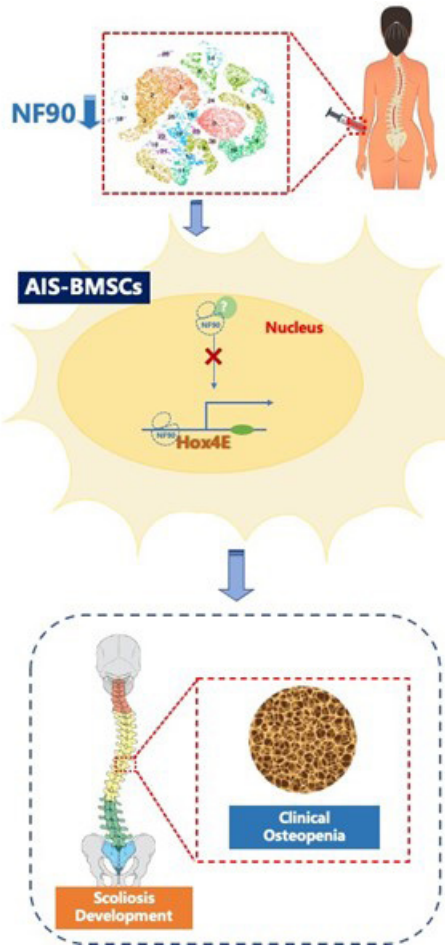


The illustrate diagram of the regulation mechanism of aberrant NF90-Hox4E Axis in AIS-MSCs

118. Mechanical Stability of Mediolaterally Misplaced Pedicle Screws

Christos Tsagkaris, MD; *Marie-Rosa Fasser, MSc*; Caroline Passaplan, MD; Frederic Cornaz, MD; Mazda Farshad, MD, MPH; Jonas Widmer, MSc; José M. Spirig, MD

Hypothesis
It was hypothesized that pedicle screw hold in the vertebral bone is heavily impacted by medial and lateral pedicle perforation, with the latter having a major detrimental effect on fixation.

Design
Biomechanical cadaveric study.

Introduction
Pedicle screws are frequently used implants for posterior spine fixation. Inaccurate screw positioning resulting in cortical perforation of the pedicle can lead to severe complications such as neurovascular damage and mechanical instability causing unsuccessful fusion. This study aimed at investigating the extent to which medial and lateral screw malpositioning in the transverse plane affects mechanical screw hold.

Methods
Pedicle screw (mis)placement was planned for a total of 144 pedicles of twelve cadaveric thoracolumbar spines with the help of computed tomography (CT) scans. The screw malpositioning in the transverse plane ranged from completely outside the pedicle medially to a full screw exposure on the lateral side. After screw implantation with 3D-printed template guides, post-instrumentation CT scans were used to quantify the actual perforation of the pedicles. Axial pull-out tests were performed to determine the screw fixation strength. A Gaussian process regression model was fitted onto the results to obtain a continuous prediction of the fixation strength across the entire spectrum of considered misplacement.

Results
Screws that did not perforate the pedicle resisted pull-out forces of 837 N. The pull-out strength of screws medially misplaced by 2mm, 4mm, and 6mm was 985 N, 968 N, and 822 N, respectively. For screws laterally misplaced by 2mm, 4mm, and 6mm the maximal pull-out force was 605 N, 411 N, and 334 N, respectively.

Conclusion
Clinical and radiological criteria have been used to evaluate the risks associated with pedicle screw misplacement, but the biomechanical consequences and their connection to screw loosening still needed to be quantified. The results of this study show that increasing lateral malposition of screws leads to a continuously decreasing fixation strength. On the other hand, medial misplacement is associated with a tendentially increased axial screw hold compared to control screws and laterally misplaced screws. Hence, in a clinical setting, the reinsertion of medially misplaced screws should primarily aim at preventing neurological complications while the reinsertion of lateral misplaced screws should aim at preventing screw loosening.

119. How Much Tension is Generated by a Vertebral Body Tethering System for Scoliosis?‡

Vidyadhar V. Upasani, MD; Christine L. Farnsworth, MS; Jason Caffrey, MD, PhD; Tony Olmert, MD; Erin M. Mannen, PhD; Ian Brink; Phoebe Cain

Hypothesis
Use of an extension spring tube alters the tension applied to a vertebral body tether (VBT).

Design
Biomechanical study to quantify forces applied using VBT instrumentation with and without an extension tube.

Introduction
VBT is an alternate treatment for Juvenile Idiopathic Scoliosis. A flexible tether is affixed across the curve convexity with segmental tension applied. Quantifying

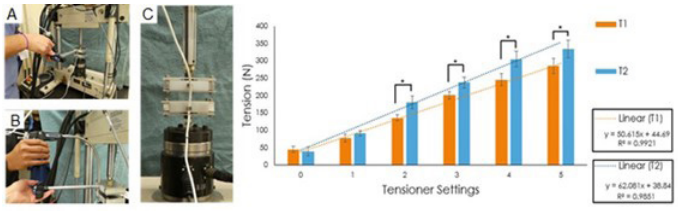
‡ = SRS Funded Research Grant

this tension may aid in treatment understanding. An extension tube may be added for access, especially since VBT is often performed thoracoscopically.

Methods
Titanium bone screws were inserted into two polyethylene blocks, mimicking cortical bone. Fixtures were rigidly mounted to a testing frame (MTS858), screws 45mm apart, allowing continuous uniaxial force measurement through the tether. We first affixed the tether to the bottom bone screw with a set screw, then applied tension using a tensioner and counter-tensioner alone (method T1, FigA) or by adding an extension spring tube (method T2, FigB). Eight orthopedic surgeons used T1 and T2 at 6 tensioner settings (0–5) in randomized orders. After tensioning, surgeons secured the top set screw. Force was recorded for 2 minutes (128Hz). One surgeon completed 3 trials for intra-rater assessment. We calculated force means, standard deviations, and confidence intervals during the 90–120 second interval. Intra- and inter-rater reliabilities were calculated using intraclass correlation coefficients (ICC); ICC>0.90 was excellent agreement. T1 and T2 forces were compared at each setting ($p<0.05$).

Results
Methods T1 and T2 exhibited linear tension-setting relationships, with high determination coefficients (R2>0.95). T2 consistently produced higher forces (62.1N/setting), compared to T1 (50.6N/setting). Inter-rater reliability between all 8 surgeons showed excellent agreement (T1: ICC=0.951, T2: ICC=0.943), as did intra-rater reliability (ICC=0.971).

Conclusion
We quantified the tension in a VBT system through the tension range using 2 methods. Establishing VBT forces is useful for targeting patient- and level- specific tensions. Excellent inter- and intra-rater reliability permits generalizing these findings to other surgeons. The complex biomechanics of the in vivo spine are omitted, which likely affect these forces. Quantifying forces will aid surgeons to standardize techniques amongst VBT suppliers and to more predictably plan treatment.



120. Acute Effects of Natural Standing on Diffusion Properties of Human Lumbar Intervertebral Discs: A Post-Contrast MRI Study in Supine and Standing.

J. Naresh-Babu, MS

Hypothesis
Findings suggest that act of standing can have a discernible impact on nutrition and solute transport within intervertebral discs highlighting the importance of posture and mechanical loading in maintain spinal health Results of this study could help elucidate the long term implications of loading on intervertebral disc diffusion.

Design
Retrospective Study

Introduction
Intervertebral disc health is crucial for maintaining spinal function and overall wellbeing. Disc degeneration is multifactorial and alterations in nutrition is considered as one of the main reason. Serial post contrast MRI studies have thrown light on the diffusion properties of intervertebral disc in supine position. The effects of natural standing and load bearing on disc diffusion is largely unknown. This study investigates the acute effects of standing on solute transport across the intervertebral disc

Methods
15 healthy volunteers representing various age groups formed the study group. Diffusion over 24 hours following intravenous gododiamide injection (0.3mmol/kg) was studied at precontrast,10minutes and 2,4,12 and 24hrs after contrast injection in supine ,standing posture and followed by in recovery supine position. The enhancement percentage, time taken to achieve peak enhancement and time intensity curves were utilised to understand the diffusion properties of the intervertebral disc in Supine and standing.

Results
The mean peak enhancement percentage in Recovery supine and Standing for of Centre Nucleus Pulpous were 30 and 15 ,25 and 12 for superior nucleus pulpous was and for inferior nucleus pulpous was 40 and 20 respectively. Overall 50% higher peak enhancement (EPmax) than standing.

Conclusion
For the first time, Acute effects of standing on intervertebral disc nutrition and solute transport were observed through Post Contrast MRI, provides valuable insights into dynamic nature of spinal health. The findings suggest that act of standing can have a discernible impact on nutrition and solute transport within intervertebral discs highlighting the importance of posture and mechanical loading in maintain spinal health Results of this study could help elucidate the long term implications of loading on intervertebral disc diffusion.

E-Point Presentation Abstracts

121. Crossing the Cervicothoracic Junction: A Biomechanical Investigation of C7 vs T1 Caudal Selection's Effect on Adjacent Segments

Eren Kuris, MD; *Christopher L. McDonald, MD*; Daniel Alsoof, MBBS; Bassel G. Diebo, MD; Alan H. Daniels, MD

Hypothesis

Global spine range of motion will significantly decrease after posterior cervical instrumentation but this would not differ between constructs that terminate at C7 versus T1.

Design

Biomechanical Cadaveric Study

Introduction

Deciding whether to terminate multi-level posterior cervical fusion constructs at C7 or extend them across the cervicothoracic junction remains a controversial issue. This study aims to evaluate the biomechanical effects of multi-level fusion constructs that terminate at C7 compared to those that terminate at T1.

Methods

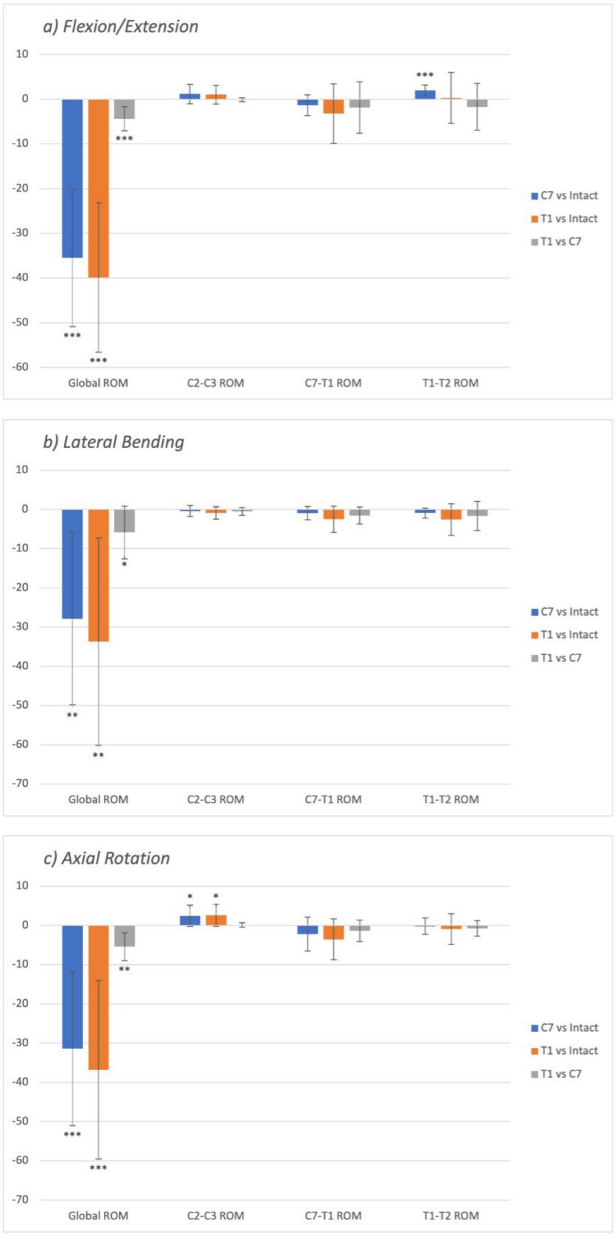
Six fresh-frozen cadaveric specimens underwent biomechanical testing. Range of motion (ROM) was assessed in flexion-extension, lateral bending, and axial rotation both globally and at cranial and caudal adjacent segment levels. Testing occurred in the intact state and after instrumentation with constructs starting at C3 and terminating at either C7 or T1.

Results

Biomechanical testing revealed a significant decrease in global flexion/extension by both C7 (-35.5°, p=0.002) and T1 (-39.8°, p=0.002) instrumentation compared to the intact spine. T1 instrumentation had significantly lower (-4.3°, p=0.008) flexion/extension ROM compared to C7 instrumentation. There were significant decreases in axial rotation by both C7 (-31.4°, p=0.009) and T1 (-36.8°, p=0.009) instrumentation compared to the intact spine, but no significant differences were observed between the two. There were no differences in lateral bending between the intact and instrumented spines. No significant differences were observed in ROM at cranial or caudal adjacent segments between constructs terminating at C7 and those extending to T1.

Conclusion

This biomechanical investigation demonstrates that constructs that cross the cervicothoracic junction experience less global spinal motion in flexion-extension compared to those that terminate at C7. However, contrary to prior in vivo studies there is no difference in cranial and caudal adjacent segment motion. Surgeons should make clinical decisions regarding the distal extent of fusion in multi-level posterior cervical fusions without major concerns about adjacent segment motion. Further clinical research should consider patient-specific factors and surgical indications to provide comprehensive guidance for this challenging region of the spine.



Graphical Comparison of Intact and Instrumented Spines

122. Prenatal Counselling for Spine Anomalies - Algorithm of Management - from the Genesis to Treatment

Hriday Acharya, MBBS, MS; Abhay Nene, MBBS, MS; Prashant Acharya, MD, MBBS

Hypothesis

Various spine anomalies like scoliosis, kyphosis, Hemivertebra,tethered cord anomalies,spina bifida can be diagnosed even before birth. This early diag-

nosis would help in providing the correct treatment to the child in a structured fashion avoiding the delay in diagnosis due to late presentation of symptoms and thereby preventing related complications.

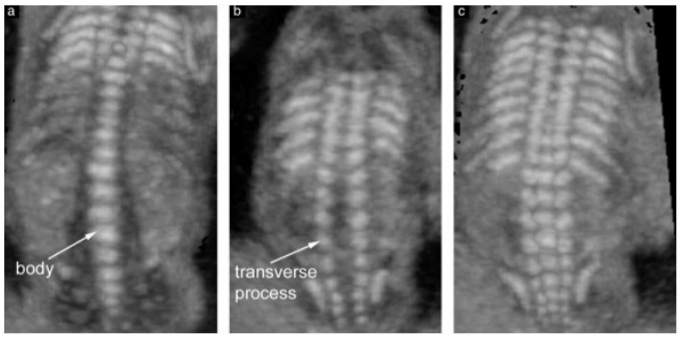
Design
Retrospecitve observational study.

Introduction
Early diagnosis and prevention of spine anomaleis can be a boon to spine surgeons to educate and counsel the parents to minimise the physical deformity and prevent the child's problem by early management. We can followup the child since the very day he/she is born, it gives us a lead time in early management of any disorders or complications, which would develop in the life to come. It can provide the child with a better future. Here, we propose an algorithm in management of these spine anomalies from their diagnosis intrauterine till management after birth.

Methods
We studied over 10,000 fetal scans and the most commonly diagnosed spine anomalies were isolated. The management of each of those anomalies ranging from their intrauterine, postnatal, treatment in early childhood and adulthood were reviewed. An algorithm was formulated by a team of spine surgeon, fetal medicine specialist and an obstretician which took into consideration the time of diagnosis by a fetal medicine specialist,the follow up till the birth of the fetus by the obstretician and management of those anomalies from an spine surgeons point of view.

Results
Early diagnosis of spine anomalies like hemivertebra and other segmentation defects along with spina bifida could be easily diagnosed at 12 weeks & other anomalies like tethered cord syndrome, kyphosis, scoliosis or CNS anomalies can be identified by 20 weeks. After a primary diagnosis of the fetal spine by the fetal medicine expert the parents are couselled by a team of spine surgeon and an obstretician.The spine surgeon would manage anomalies by either intra uterine or post natal management as early as possible,in coordination with the obstretician,to prevent any sequela of the condition.

Conclusion
This algorithm gives us a lead time in diagnosing and management of spinal anomalies. This would help in providing the correct treatment to the child in a structured fashion avoiding the delay in diagnosis due to late presentation of symptoms and thereby preventing related complications.



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123. Abstract withdrawn

124. Analysis of Capabilities and Utilization of Artificial Intelligence in Adult Cervical Deformity Surgery

Peter Tretiakov, BS; Pooja Dave, BS; Jamshaid Mir, MD; Ankita Das, BS; Oluwatobi O. Onafowokan, MBBS, MS; Stephane Owusu-Sarpong, MD; Djani Robertson, MD; Jared C. Tishelman, MD; M. Burhan Janjua, MD; Paul Park, MD; Dean Chou, MD; Pawel Jankowski, MD; *Peter G. Passias, MD*

Hypothesis
Artificial intelligence and machine learning algorithms may play a crucial role in cervical deformity surgery.

Design
Retrospective cohort review

Introduction
Artificial intelligence (AI) and machine learning analytics offer enhanced preoperative planning, intraoperative robotic or navigational guidance, and prediction of postoperative complications. There remains a paucity of literature in regards to the utility of AI in adult cervical deformity surgery.

Methods
Operative CD patients with complete pre-(BL)/2-year(2Y) postop radiographic/HRQL data were stratified by primary utilization AI-based patient-specific rod customization and robotic or navigational assistance in pre-/peri-operative course(AI+) or not(AI-). Differences were assessed via means comparison analysis. ANCOVA assessed postoperative complications while controlling for BL age and CCI.

Results
270 patients were included (58.11 ± 11.97 years, 48% female, 29.13±6.89 kg/m2). 32(11.9%) were classified as AI+. Patient groups were comparable in BL age, gender, BMI, and CCI(all p>.05). At BL, AI+ patients presented with increased radiographic global deformity(p<.001), though remained similar in segmental regional deformity(all p>.05). Surgically, AI+ patients had significantly shorter operative times overall(p=.022) and decreased EBL, regardless if the procedure was

staged or same-day(p=.033). Though length of stay was equivalent between groups(p>.05), AI+ patients were significantly more likely to be discharged to home vs. acute/subacute rehab centers(p<.001). AI+ patients with custom rods were noted to have significantly improved segmental alignment in terms of decreased pelvic tilt(S1PT) and pelvic incidence(S1PI) (both p<.018), and improved global alignment per decreased PI-LL and SVA by 2Y(both p<.001). Adjusted complications analysis revealed that AI+ patients were significantly less likely to experience any post-operative complication by 2Y(p<.001), radiographic complications(p=.002), or operative complications such as dysphasia(p=.047). Adjusted analysis of HRQLs also revealed that AI+ patients improved in NDI more rapidly by 1Y vs. AI- patients(p=.011).

Conclusion
This study demonstrates that when using AI-based technologies, patients demonstrated lower intra-operative invasiveness, increased likelihood of reaching radiographic alignment targets, improvement in patient-reported outcomes, and decreased complication rates by 2Y.

125. Does Posterior Cord Compression by the Ligamentum Flavum Influence Clinical Outcomes Following Anterior Cervical Discectomy and Fusion?

Dong-Ho Lee, MD, PhD; Chang Ju Hwang, MD, PhD; Jae Hwan Cho, MD, PhD; *Sehan Park, MD*

Hypothesis
Anterior cervical discectomy and fusion (ACDF) may not bring optimal clinical outcome when ligamentum flavum buckling or hypertrophy contributes to cord compression.

Design
Retrospective cohort study

Introduction
Although ACDF effectively removes anterior cord compressive pathologies, including herniated discs and bone spurs, it cannot address posterior compressive pathologies. Whether ACDF could result in favorable outcomes when CCLF is present remains unclear. The current study was conducted to clarify whether the outcomes of ACDF differ according to presence of posterior cord compression by the ligamentum flavum (CCLF).

Methods
We retrospectively reviewed 195 consecutive patients who had undergone ACDF and had been followed-up for >2 years. CCLF was graded on a scale of 0-2 based on MRI findings. Patients with CCLF grade 2 were classified into the CCLF group, while patients with CCLF grade 0-1 were classified into the no-CCLF group. Patient characteristics, cervical sagittal parameters, neck pain visual analog scale (VAS), arm pain VAS, and Japanese Orthopedic Association (JOA) score were assessed.

Results
One-hundred and sixty-seven patients (85.6%) were included in the no-CCLF group, while the remaining 28 (14.4%) were included in the CCLF group. Among the patients in the CCLF group, 14 (50.0%) achieved clinical improvement, while 14 (50.0%) did not. JOA score significantly improved in the no-CCLF group after the operation (p<0.001) but not in the CCLF group (p=0.642). JOA score at 3 months (p=0.037) and 2 years (p=0.001) postoperatively was significantly higher in the no-CCLF group. JOA recovery rate at 2 years postoperatively was also significantly higher in the no-CCLF group (p=0.042). Multiple regression analysis showed that CCLF was significantly associated with JOA recovery rate at 2 years postoperatively (p=0.045).

Conclusion
ACDF performed in patients with CCLF grade 2 showed inferior JOA score improvement compared to those of patients with CCLF grade 0 or 1. ACDF cannot remove posterior compressive pathology, limiting its applicability when the ligamentum flavum significantly contributes to cord compression.

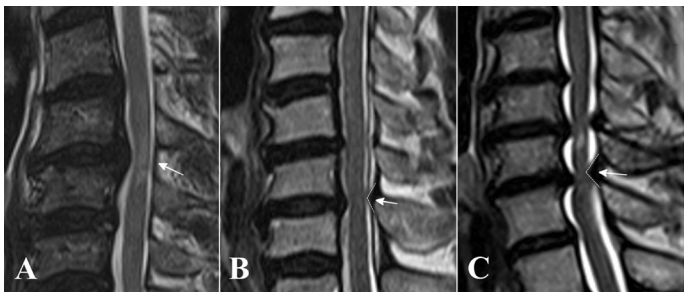


Figure 1. (A) Grade 0, no ligamentum flavum buckling or hypertrophy. (B) Grade 1, mild ligamentum flavum buckling. CSF space posterior to the spinal cord is obliterated. (C) Grade 2, ligamentum flavum buckling and hypertrophy.

126. Long-Term Outcome and Survival Analysis of Adult Cervical Deformity Patients with 10-Year Follow-Up

Peter Tretiakov, BS; Jamshaid Mir, MD; Ankita Das, BS; Stephane Owusu-Sarpong, MD; Pooja Dave, BS; Oluwatobi O. Onafowokan, MBBS, MS; Pawel Jankowski, MD; Matthew Galetta, MD; Justin S. Smith, MD, PhD; Praveen V. Mummaneni, MD, MBA; Dean Chou, MD; Paul Park, MD; *Peter G. Passias, MD*

Hypothesis
Patients with fewer comorbidities and milder physiologic burden will be at lessened risk of death for a greater length of time after undergoing adult cervical deformity surgery.

E-Point Presentation Abstracts

Design
Retrospective review

Introduction
Previous studies have demonstrated adult cervical deformity patients may be at increased risk of death in conjunction with increased frailty or weakened physiologic state. However such studies have often been limited by follow-up duration, and longer-term studies are needed to better assess temporal changes in ACD patients and associated mortality risk

Methods
Operative ACD patients ≥18yrs with pre-(BL) and ten-year (10Y) data were included. Patients were stratified as Expired vs Living, as well as temporally grouped by Expiration prior to 5Y or between 5Y and 10Y. Group differences were assessed via means comparison analysis. Backstep logistic regression identified mortality predictors. Kaplan-Meier analysis assessed survivorship of expired patients. Log rank analysis determined differences in survival distribution groups.

Results
66 total patients were included (60.97 ± 10.19 years, 48% female, 28.03 ± 7.28 kg/m2). Within 10Y, 12 (18.2% of ACD cohort) expired. At baseline, patients were comparable in age, gender, BMI, and CCI total on average (all p>.05). Furthermore, patients were comparable in BL HRQLs (all p>.05). However, patients who expired between 5Y and 10Y demonstrated higher BL EQ5D and mJOA scores than their earlier expired counterparts at 2Y (p<.021). Furthermore, patients who presented with no CCI markers at BL were significantly more likely to survive until the 5Y-10Y follow-up window. Surgically, the only differences observed between patients who survived until 5Y was in undergoing osteotomy, with longer survival seen in those who did not require it (p=.003). Logistic regression revealed independent predictors of death prior to 5Y to be increased BMI, increased frailty, and increased levels fused (model p<.001). KM analysis found that by Passias et al. frailty, not frail patients had mean survival time of 170.56 weeks, versus 158.00 in frail patients (p=.949).

Conclusion
Our study demonstrates that long-term survival after cervical deformity surgery may be predicted by baseline surgical factors. By optimizing BMI, frailty status, and minimizing fusion length when appropriate, surgeons may be able to further assist ACD patients in increasing their survivability post-operatively

127. Predictive Analysis of Mechanical Failure in Adult Cervical Deformity Patients

Peter Tretiakov, BS; Jamshaid Mir, MD; Pooja Dave, BS; Ankita Das, BS; Oluwatobi O. Onafowokan, MBBS, MS; Nathan Lorentz, MD; Bassel G. Diebo, MD; Shaleen Vira, MD; Pawel Jankowski, MD; Paul Park, MD; Rohan Desai, MD; Nathan S. Kim, BS; *Peter G. Passias, MD*

Hypothesis
There may be predictors of mechanical complications, which present a serious, debilitating risk to patients undergoing cervical deformity (CD) surgery

Design
Retrospective cohort study

Introduction
There is a paucity of literature describing rates, outcomes, and predictors of mechanical complications and failure.

Methods
CD patients with pre-/two year radiographic/HRQL data were assessed. Patients were categorized as having suffered mechanical failure(Failed) or not(Not Failed) after index surgery. Mechanical failure was defined as: instrumentation failure (rod fracture/screw failure), bony failure, pseudarthrosis, or junctional failure [DJK/DJF]. Differences were assessed via means comparison analyses. Conditional backstep binary regression analysis identified predictive factors for mechanical failure. Conditional inference tree determined thresholds for significant predictors.

Results
115 CD pts met inclusion criteria(60.97±10.19yrs, 70%F, BMI:28.03±7.28kg/m2). 10.6% underwent 3-column osteotomy. By 2Y post-op, 18(15.6%) patients experienced mechanical failure with 11.1% (n=20) suffering instrumentation failure. At BL, Failed patients had more comorbidities(p=.002), but were equivalent in BL radiographic markers(all p>.05). However, Failed patients reported significantly worse BL NSR Neck & Back pain scores(both p<.006) compared to Not Failed patients. Surgically, Failed patients were more likely to undergo combined approach(p=.023). BMP use was higher in the junctional failure cohort (p=.020). By rod material/size, instrumentation failure patients were implanted with 3.5 and 6.0 mm cobalt chrome rods,both of which fractured at 6M and required reoperation. Failed patients demonstrated increased upper extremity paresthesia at 6M (p=.012). Though 4(22%) of Failed patients required reoperation, 2Y reoperation rate was comparable between groups(p>.05). Regression analysis revealed the six most significant predictors of mechanical complication overall to be BL BMI>28.6, undergoing PSO, VCR, or 3CO,BL TS-CL>19° and BL C2SS>50°(model p=.001, AUC=81.2%).

Conclusion
While patients with mechanical failure demonstrate increased reoperation rates overall, rates do not differ significantly between patients with instrumentation versus junctional failure. Predictive modeling revealed increased BMI, increased osteotomy grades, and severe baseline cervical radiographic parameters to be associated with mechanical failure within 2Y of surgery.

128. Reduction of Neck Pain is Comparable Between ACDF and CDR in Patients with Significant Neck Pain

Tomoyuki Asada, MD; Yeo Eun Kim, BS; Cole Kwas, BS; Kasra Araghi, BS; Myles Allen, MBchB; Olivia Tuma, BS; Max Korsun, BS; Eric Mai, BS; Avani S. Vaishnav, MBBS; Joshua Zhang, BS; Nishtha Singh, BS; Amy Lu, BS; Eric Kim, BS; *Chad Simon, BS*; James E. Dowdell, MD; Sheeraz Qureshi, MD; Sravisht Iyer, MD

Hypothesis
Cervical disc replacement (CDR) can show similar outcomes to anterior cervical discectomy and fusion (ACDF) in patients with significant neck pain.

Design
Retrospective review of a prospectively collected multi-surgeon registry.

Introduction
While ACDF has been considered the preferred treatment for neck pain, recent studies have suggested favorable outcomes in patients after undergoing CDR. However, there is a lack of research comparing the clinical outcomes of ACDF and CDR specifically in patients with significant neck pain.

Methods
Patients undergoing ACDF or CDR with significant neck pain, which was defined as those with VAS neck ≥ VAS arm, were included in this study. Data collected were patients' demographics and patient-reported outcome measures (PROMs) including VAS neck, VAS arm, Neck Disability Index (NDI), 12-item Short Form Survey Physical (SF-12 PCS) and Mental Component Score (SF-12 MCS), and Patient-Reported Outcomes Measurement Information System-Physical Function (PROMIS). Three post-operative time points for PROMs were defined namely preoperative, ≤ 3 months postoperative, and ≥1 year postoperative time point, which was assessed with two-way repeated measure ANOVA.

Results
A total of 119 patients were included in the study, with 40 undergoing CDR and 79 undergoing ACDF. Both groups exhibited significant improvement in NDI (P<0.001) and VAS neck (P<0.001). Both groups experienced a worsening of SF-12 PCS scores until the ≤3 months time point (P=0.028). As a result, there were no significant differences in overall clinical courses observed between the two groups in terms of NDI (P=0.098) and VAS neck (P=0.457) as well as SF-12 PCS (P=0.751), SF-12 MCS (P=0.242), and PROMIS (P=0.515). Both groups experienced a worsening of SF-12 PCS scores until the ≤3 months time point (P=0.028). (Fig.1)

Conclusion
CDR demonstrated a significant clinical improvement in all PROMs comparable to ACDF. CDR can be a viable option as a treatment for cervical degenerative disease with prominent neck pain.

129: Abstract withdrawn

130. Lower Hounsfield Units at the Planned Lowest Instrumented Vertebra is an Independent Risk Factor for Complications Following Adult Cervical Deformity Surgery

Tyler K. Williamson, MS, BS; Pooja Dave, BS; Ankita Das, BS; Jamshaid Mir, MD; Justin S. Smith, MD, PhD; Peter Tretiakov, BS; Oluwatobi O. Onafowokan, MBBS, MS; Virginie Lafage, PhD; Renaud Lafage, MS; Stephane Owusu-Sarpong, MD; Bailey Imbo, BA; Rachel Joujon-Roche, BS; M. Burhan Janjua, MD; Themistocles S. Protopsaltis, MD; Heiko Koller, MD; Bassel G. Diebo, MD; Andrew Schoenfeld, MD; Shaleen Vira, MD; Kimberly McFarland, BS; Oscar Krol, BS; Jordan Lebovic, MD, MBA; Djani Robertson, MD; Rohan Desai, MD; Jared C. Tishelman, MD; Paul Park, MD; *Peter G. Passias, MD*

Hypothesis
Low bone mineral density is a risk factor for complications and can be assessed quantitatively by CT scan Hounsfield units

Design
Retrosepctive review

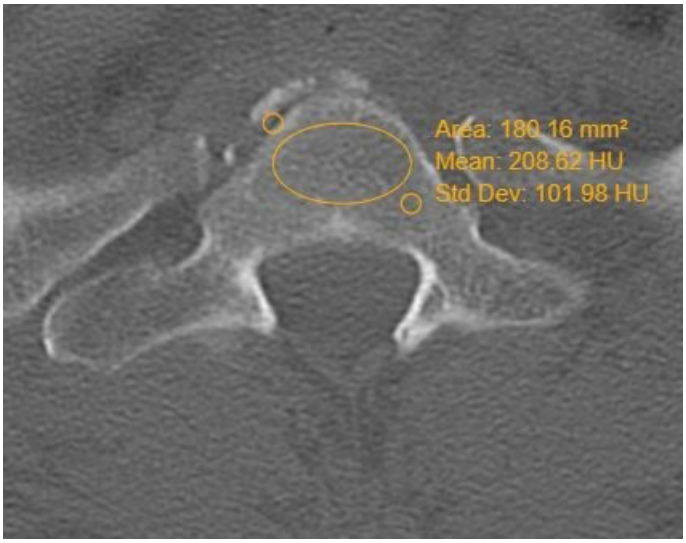
Introduction
The association of Hounsfield units (HU) and junctional pathologies in adult cervical deformity (ACD) surgery have not been elucidated. The purpose of this study is to assess if bone mineral density of the LIV, as assessed by HUs, is prognostic for the risk of complications after CD surgery.

Methods
HUs were measured on preoperative CT scans. Means comparison test assessed differences in HUs based on occurrence of complications, linear regression assessed correlation of HUs with risk factors, and multivariable logistic regression followed by conditional inference tree derived a threshold for HUs based on increased likelihood of developing a complication.

Results
Included: 107 CD patients. 31 patients (29.0%) developed a complication (18.7% perioperative), with 20.6% developing DJK and 11.2% developed DJF. There was a significant correlation between lower LIVs and lower HUs (r=.351, p=.01), as well as age and HUs at

the LIV. Age did not correlate with change in the DJK angle (p>.2). HUs were lower at the LIV for patients who developed a complication and an LIV threshold of 190 HUs was predictive of complications (OR: 4.2, [1.2-7.6]; p=.009).

Conclusion
Low bone mineral density at the lowest instrumented vertebra, as assessed by a threshold lower than 190 Hounsfield units, may be a crucial risk factor for the development of complications after cervical deformity surgery. Preoperative CT scans should be routinely considered in at-risk patients to mitigate this modifiable risk factor during surgical planning.



Hounsfield Units Measured Within the LIV

131. Are There Differences in 2-Year Outcomes Between Two-Level ACDF Versus Single-Level ACCF to Treat Cervical Myelopathy?

Connor Berlin, MD; Sufyan Ibrahim, MD; Andrew K. Chan, MD; Praveen V. Mummaneni, MD, MBA; Dean Chou, MD; Kai-Ming G. Fu, MD, PhD; Mohamad Bydon, MD; Erica F. Bisson, MD, MPH; Christopher I. Shaffrey, MD; Mark E. Shaffrey, MD; Oren Gottfried, MD; Domagoj Coric, MD; Eric A. Potts, MD; Kevin T. Foley, MD; Michael Y. Wang, MD; Michael S. Virk, MD, PhD; Scott Meyer, MD; John J. Knightly, MD; Paul Park, MD; Cheerag D. Upadhyaya, MSc; Chun-Po Yen, MD; Luis M. Tumialán, MD; Jay D. Turner, MD; Regis W. Haid Jr., MD; Anthony L. Asher, MD; *Timothy J. Yee, MD*

Hypothesis
Is there a difference in Patient Reported Outcome Measures (PROMs) when comparing 2-level ACDF with single-level anterior cervical corpectomy and fusion (ACCF) procedures for treatment of cervical spondylotic myelopathy (CSM).

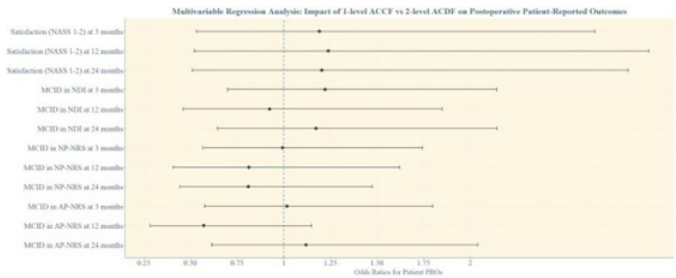
Design
Retrospective analysis of prospectively collected data from the Quality Outcomes Database CSM cohort comparing two-level ACDF and single-level ACCF at 3-months, 12-months, and 24-months.

Introduction
Due to lack of data on PROMs, we sought to compare 2-level anterior cervical discectomy and fusion (ACDF) with single-level anterior cervical corpectomy and fusion (ACCF) procedures for treatment of cervical spondylotic myelopathy (CSM).

Methods
After adjusting for baseline demographics, multivariate logistic regression was used to determine the impact of one-level ACCF versus two-level ACDF on PROMs. MCID thresholds were assessed for the following PROMs: NRS arm pain, NRS neck pain, and Neck Disability Index (NDI). NASS satisfaction scores and Euro-Qol 5D for Quality Adjusted Life Years (QALYs) was also assessed.

Results
330 patients were included (236 ACDF, 94 ACCF), and the follow up rate was 82% at 2 years. Baseline demographics demonstrated the ACCF cohort had a significantly higher age, ASA grade, proportion of diabetes, osteoarthritis, ambulation dependence, and myelopathy severity. The ACCF group had significantly greater length of stay (LOS) (2.0 ± 1.6 vs. 1.2 ± 1.6, p<0.01) and average intraoperative blood loss (102 ml vs. 50 ml, p < 0.01). At 2 years, there were no significant differences between reoperation rate (19.5% ACCF vs 14.3% ACDF, p = 0.26). At all time-points, both groups had similar rates of MCID achievement for PROMs and NASS satisfaction. There was no difference in QALYs by 2-years (0.72 ACCF vs 0.76 ACDF, p = 0.15).

Conclusion
Patients undergoing ACCF are older, have more comorbidities, and worse myelopathy than those undergoing two-level ACDF. Those undergoing corpectomy have more blood loss and longer LOS, but no difference in reoperation rate at 2-years. Our study suggests that both ACDF and ACCF procedures for CSM are able to achieve similar improvements in PROMs by 2-year follow-up. ACCF is effective for patients with more severe myelopathy and compression dorsal to the mid vertebral body.



Forest plot of multivariate regression analysis on the impact of type of surgery – single level ACCF vs two-level ACDF on PROMs

E-Point Presentation Abstracts

132. Decision Tree-Based Prediction of Decompression Versus Decompression and Fusion Selection in QOD Lumbar Spondylolisthesis Patients

Eunice Yang, BS; Praveen V. Mummaneni, MD, MBA; Dean Chou, MD; Mohamad Bydon, MD; Erica F. Bisson, MD, MPH; Christopher I. Shaffrey, MD; Steven D. Glassman, MD; Kevin T. Foley, MD; Eric A. Potts, MD; Mark E. Shaffrey, MD; Domagoj Coric, MD; John J. Knightly, MD; Paul Park, MD; Michael Y. Wang, MD; Kai-Ming G. Fu, MD, PhD; Jonathan R. Slotkin, MD; Anthony L. Asher, MD; Michael S. Virk, MD, PhD; Giorgos Michalopoulos, MD; Jian Guan, MD; Regis W. Haid Jr., MD; *Andrew K. Chan, MD*

Hypothesis
To use tree-based machine learning to predict the decision for decompression versus decompression with fusion and assess the most strongly weighted preoperative variables that influence current surgical decision making.

Design
Retrospective analysis of prospectively-collected data

Introduction
The ideal surgical approach for degenerative lumbar spondylolisthesis remains unclear. This is underscored by the significant variation in practice.

Methods
Data was obtained from the prospective Quality Outcomes Database spondylolisthesis cohort, which includes patients who underwent single-segment surgery for grade 1 degenerative lumbar spondylolisthesis at 12 sites between 2014 and 2016. Based on pre-operative demographic and clinical characteristics, we developed classification and regression tree (CART), random forest, and XGBoost classifiers to predict the surgical decision—decompression alone versus decompression with fusion. Models were trained and evaluated on an 80/20 split of the dataset, with grid search used for hyperparameter tuning.

Results
A total of 608 patients were included—140 (23.0%) receiving decompression alone and 468 (77.0%) receiving decompression with fusion. The CART decision tree, random forest, and XGBoost models were able to predict the surgical decision with accuracies of 0.836, 0.820, and 0.779, respectively. Interpreting the plot of the CART decision tree, patients >74 years old had a 65.8% chance of undergoing decompression alone. Age was the pre-operative factor with the greatest feature importance in random forest analysis, followed by Oswestry Disability Index, NRS back pain, BMI, and dominant presenting symptom.

Conclusion
In this study, decision tree-based models were constructed to analyze the factors influencing approach selection for patients with lumbar spondylolisthesis. Age was the most important factor across the models, with older patients more likely to undergo decompression alone. These findings suggest that elderly patients may receive disproportionately fewer fusions. This highlights an avenue for focused study especially as accumulating evidence points to the benefit of fusion even in elderly patients with grade 1 degenerative lumbar spondylolisthesis.

Figure 1. Comparison of ROC Curves Across Decision Tree-based Models

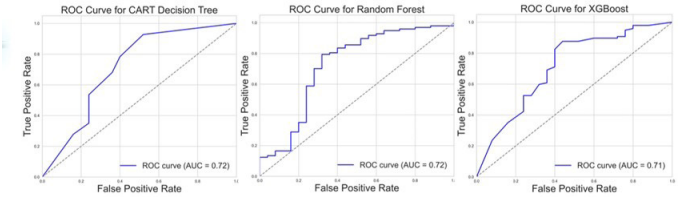


Table 1. Assessment of Model Performance in Classifying Selection of Decompression versus Decompression and Fusion

Model	Subset	Recall	Precision	Accuracy	F1
CART	Train	0.930	0.841	0.813	0.883
	Test	0.928	0.874	0.836	0.900
Random Forest	Train	0.997	0.864	0.879	0.926
	Test	0.948	0.844	0.820	0.893
XGBoost	Train	0.927	0.849	0.819	0.887
	Test	0.907	0.871	0.820	0.889

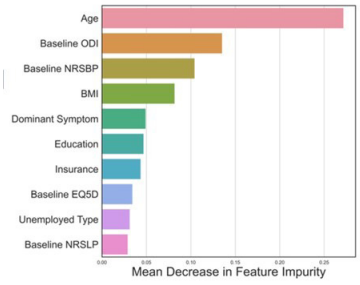


Figure 2. Random Forest Top 10 Feature Importance

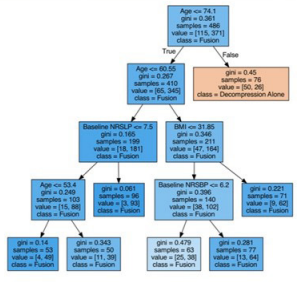


Figure 3. CART Decision Tree depicting Decompression versus Fusion Decision

Tables

133. Predictors of Prolonged Length of Stay Following Lumbar Fusion for High Grade Spondylolisthesis: A Quality Outcomes Database Study

Nikita Lakomkin, MD; Sarah Johnson, MBBS; Kai-Ming G. Fu, MD, PhD; Michael S. Virk, MD, PhD; Dean Chou, MD; Andrew K. Chan, MD; Eric A. Potts, MD; Kevin T. Foley, MD; Paul Park, MD; Michael Y. Wang, MD; Luis M. Tumialán, MD; Jay D. Turner, MD; Juan S. Uribe, MD; Anthony L. Asher, MD; Domagoj Coric, MD; Oren Gottfried, MD; Christopher I. Shaffrey, MD; Steven D. Glassman, MD; Cheerag D. Upadhyaya, MSc; Mark E. Shaffrey, MD; Erica F. Bisson, MD, MPH; *Praveen V. Mummaneni, MD, MBA*; Mohamad Bydon, MD

Hypothesis
Patients with significant socioeconomic barriers to discharge or invasive surgery are at risk for prolonged LOS and would benefit from earlier hospital intervention/discharge-related resource allocation

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Design
Retrospective analysis of prospectively-collected dataset

Introduction
Prolonged hospital length of stay (LOS) is an increasingly important quality metric among regulators and payors and has been associated with decreased patient satisfaction. Patients with high-grade (grades 2-4) lumbar spondylolisthesis are frequently symptomatic and undergo multi-level decompression/fusion. However, predictors of prolonged LOS for this population are currently unknown.

Methods
The multicenter, prospectively collected Quality Outcomes Database was used to identify all patients who underwent single stage lumbar decompression and fusion for Meyerding grade II/III lumbar spondylolisthesis. Prolonged LOS was defined as exceeding the 75th percentile among all patients in the cohort (≥4 days). An array of demographic, comorbidity, and perioperative factors known to impact LOS were collected for each patient. Bivariate tests, including Chi-squared goodness of fit or independent t-test were used to identify variables associated with prolonged LOS. Multivariable logistic regression analysis was employed to determine independent predictors of prolonged LOS.

Results
A total of 359 patients underwent lumbar fusion for grade 2-4 spondylolisthesis, with 74 experiencing a prolonged LOS. Bivariate testing demonstrated that patients in the prolonged LOS group were significantly older, predominantly female, less likely to be privately insured, and reported greater rates of ambulation dependence as well as depression at baseline. Patients with prolonged LOS had significantly longer operative times, estimated blood loss, and greater number of levels fused. Logistic regression analysis revealed lack of insurance (OR 2.30, 95% CI 1.07-4.95, p=0.04), Medicare coverage (OR 1.12, 95% CI 1.01-1.25, p=0.03), and ≥4 level fusion (OR 1.25, 95% CI 1.07-1.46, p<0.01) to be independently associated with prolonged LOS.

Conclusion
Non-commercial insurance and multi-level fusion were significantly associated with prolonged LOS following surgery for grade 2-4 lumbar spondylolisthesis. These findings may be valuable for patient informed consent, as well as identifying higher-risk patients who could benefit from earlier inpatient resource allocation (social work, counseling) to facilitate discharge disposition.

134. Resection of Intradural Tumors at The Thoracolumbar Junction: Laminectomy with or without Instrumented Fusion?

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Hypothesis
Laminectomy alone and laminectomy with fusion will have similar outcomes and complication profiles.

Design
Retrospective cohort study.

Introduction
When resecting thoracolumbar intradural tumors, surgeons must weigh the risk of increased instability with laminectomy alone with hardware complications and MRI metal artifact, which may interfere with monitoring for tumor recurrence/progression. We aim to compare revision/reoperation rates following laminectomy with and without fusion for thoracolumbar junctional intradural tumors.

Methods
A retrospective review identified patients treated at a single quaternary care institution (2012-2023) for resection of intradural tumors at T10-L1. Reoperation rate following laminectomy with or without instrumented fusion was the primary outcome.

Results
In total, 76 patients (43 females) underwent resection for thoracolumbar junctional intradural tumors (58 extramedullary, 18 intramedullary). Mean follow-up was 1.8 years. Sixty-two (80.0%) underwent laminectomy alone, while 24 (20.0%) underwent laminectomy with instrumented fusion. No fusion cohort was younger (51.2 vs 62.3 years, p=0.02). There were no significant differences between the laminectomy alone and laminectomy with fusion cohorts in gender and BMI. The laminectomy without and with fusion cohorts had similar distribution of intramedullary/extramedullary tumors (intramedullary: 28.0% vs 6.7%, p=0.08) and tumor types: schwannoma, ependymoma, and meningioma (p>0.05). Surgically, patients without and with fusion had similar operative time, number of laminectomies (2.5±1.1 vs. 2.9±1.0), and gross total resection rate (72.1%. vs 86.7%)(p>0.05). In the fusion cohort, mean levels fused was 2.6. Importantly, the fusion cohort had higher mean blood loss (426.7±446.0 vs 144.5±985 ml, p<0.001). Laminectomy with and without fusion had similar rates of reoperation (13.3% vs 6.6%, p=0.383). Indications for reoperation included postoperative hematoma (2), pseudomeningocele (1), pseudarthrosis (1-fusion cohort), tumor recurrence (1), and CSF leak (1).

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Conclusion
Laminectomy and fusion resulted in increased intraoperative blood loss. However, the incidence of revision/reoperation was similarly low in patients undergoing laminectomy with or without fusion for resection of thoracolumbar junction intradural tumors. Importantly, laminectomy alone did not result in increased rates of symptomatic instability.

135. Single Level Bilateral Fenestrated Transpedicular Screw Fixation Combined with Vertebroplasty for the Management of Osteoporotic Vertebral Fractures with Pedicle Fractures: A Technical Note

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Hypothesis
Osteoporotic vertebral fractures(OVF) co-existing with pedicle fractures(PFs) may cause unstable fracture patterns associated with separation and displacement risk. Fenestrated transpedicular screw fixation(FTSF) of PFs at the same level combined with vertebroplasty prevents the development of separation and displacement in these unstable OVFs in elderly pts

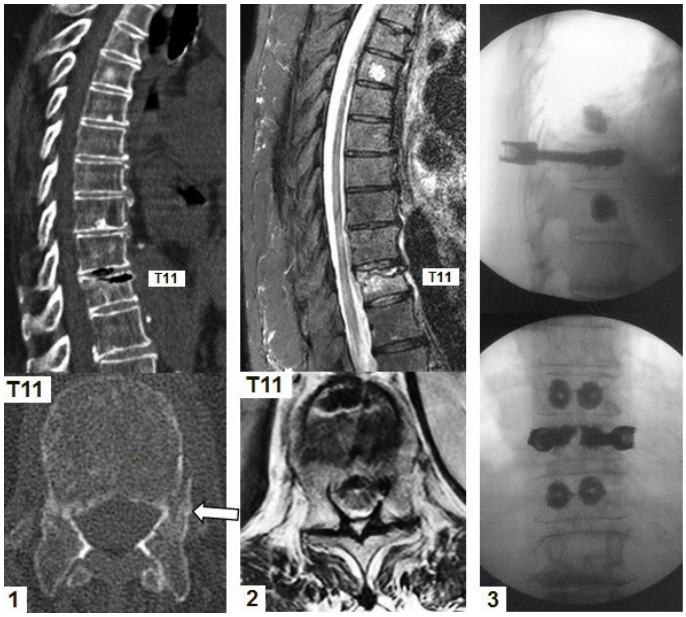
Design
Restrospective

Introduction
OVF co-existing with PFs may cause unstable fracture patterns associated with separation and displacement risk. Vertebroplasty is considered one of the surgical treatment options for OVF. The existence of PFs in OVF may cause a separation between the anterior column & posterior column which mainly leads to instability. This fracture pattern may have a risk of developing separation and displacement even after traditional vertebroplasty. We aim to introduce FTSF technique of PFs at the same level co-existing with unstable OVF

Methods
Analysis of unstable OVF co-existing with PFs who were surgically treated with vertebroplasty combined with a percutaneous FTSF of pedicle at same level of the OVF was performed. Prophylactic vertebroplasty was performed one level above & below. All pts underwent MRI & CT scans during preoperative screening. Radiological and clinical evaluations were analyzed during the preop, postop& f/up

Results
20 pts (5M, 15F) mean age 76 (61-91)yrs of OVF with a mean f/up of 2.5 (2-5)yrs. QCT analysis including BMD & T-score mean values was 61mg/cm3 & -4.23±1 respectively. Vertebroplasty was performed at 87 levels. Mean vertebral body angle, cobb angle, anterior vertebral height, and posterior vertebral height improved by 38%, 62%, 25% & 14% respectively. None of pts developed osteoporotic vertebral fractures separation and displacement, nor did pedicle screw pull-out was observed

Conclusion
Vertebroplasty combined with a percutaneous fenestrated transpedicular screw fixation of pedicle fracture at the same level of osteoporotic vertebral fractures has managed to achieve a stable fixation to the unstable vertebral level. This surgical option may be used to prevent vertebral fracture separation and displacement in elderly pts with these unstable osteoporotic vertebral fractures. Preoperative evaluations to determine this osteoporotic vertebral fracture pattern should include CT scans in addition to MRI scans



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137. Surgical Excision of Intradural Metastases from Systemic Cancers: A 10 Year Institutional Experience

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Hypothesis
For patients with systemic cancers that metastasize to the intradural compartment, surgery improves neurological outcomes and survival.

Design
Retrospective case series

Introduction
Spinal intradural metastases are rare and are usually managed non-operatively given poor prognosis of widespread metastatic disease. Surgical resection is considered in cases of rapid, progressive neurological decline. We describe our single-center, 10-year

experience of surgical resection of spinal intradural metastases.

Methods
Adults who underwent surgical resection of spinal intradural metastatic (excluding neurogenic) tumors at a single quaternary care institution over 10 years were reviewed. Clinical, surgical, and postoperative outcomes were summarized.

Results
Twelve patients (5 female) with mean age 58.3 years (range 32.5 to 77.6) underwent resection of spinal intradural metastases (5 intramedullary, 7 extramedullary). Cases included metastatic adenocarcinoma (2 breast, 1 parotid, 1 uterine), melanoma (3), renal cell carcinoma (2), follicular thyroid carcinoma (1), adenoid cystic carcinoma (1), and prostate cancer (1). Tumors were located at thoracolumbar junction (6), cervicothoracic junction (3), lumbar (2), and cervical spine (1). Patients presented with mean 9.4 weeks (range 1-day to 1-year) of symptoms. At presentation, 9 were found to have leptomeningeal disease, and 6 had brain metastases. All patients underwent laminectomy (median 3; range 2-5 levels). Gross total resection of symptom-causing tumors was achieved in 5 of the 12 patients. Following surgery, 11 patients demonstrated stable/improving neurological exams from preoperative baseline. Ninety-day readmission rate was 50%, and two patients required reoperation for pseudomeningocele. Eleven patients were treated with neoadjuvant/adjuvant therapy (TKIs, hormonal, or immunotherapy), and 6 underwent radiation therapy. Mean follow-up time was 1.2 years, at which point 3 patients died (mean survival 2-years, range 1month-4.9years). Mean cohort Karnofsky Performance Scale improved from 44% preoperatively (range 30-70%) to 53% (64% excluding deceased patients) (range 0% [deceased] to 90%).

Conclusion
This is one of the largest series of surgically treated intradural nonneurogenic metastases. Even in patients with widespread metastatic burden, resection of intradural tumors in patients with neurological decline may improve postoperative function and survival.

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139. Does Preoperative Radiation Therapy Performed for Metastatic Spine Cancer at Cervical Spine Increase Perioperative Complications of Anterior Cervical Surgery?

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Hypothesis
Preoperative radiation therapy performed for metastatic spine cancer at cervical spine may increase preoperative complication rates.

Design
Retrospective cohort study.

Introduction
Radiation therapy (RT) and surgical treatment are two main modalities to manage metastatic spine cancer (MSC) of cervical spine. Occasionally, surgery is indicated due to later onset of significant instability or neurologic deficit despite previously performed RT. Since RT performed for MSC at cervical spine often accompanies radiation to neck, soft tissue fibrosis occurs at fascial plane. Therefore, RT performed prior to anterior cervical surgery (ACS) might lead to difficulty in surgical approach, and increased infection or dural tear. The present study was performed to evaluate whether preoperative RT performed for MSC at cervical spine increases perioperative morbidity for ACS.

Methods
A total of 49 patients who underwent ACS for treatment of MSC at cervical spine were retrospectively reviewed. All patients underwent anterior cervical corpectomy via anterior approach. Patient demographics, surgical factors, operative factors, and complications were recorded. Results of patients who were initially treated with RT before ACS (Preoperative RT group) were compared with patients who did not receive RT before ACS (Non-RT group).

Results
Eighteen patients (36.7%) were included in the preoperative RT group, while remaining 31 (63.3%) patients were included in the non-RT group. Operation time, estimated blood loss, or amount of postoperative drainage did not demonstrate significant intergroup differences. One dural tear (5.6%) occurred in the preoperative RT group which was managed successfully using sealing agents and lumbar drainage. Furthermore, no esophagus injury, major vessel injury, or postoperative infection occurred in the preoperative RT group. Rate of postoperative dysphagia and hoarseness in preoperative RT group was not significantly different with that of non-RT group (p=0.539, and 0.701, respectively).

Conclusion
Preoperative RT does not increase complication rates of ACS for MSC of cervical spine, and ACS could still be performed safely despite previous RT when anterior decompression and stabilization is indicated. The present study suggests that there is no need to avoid ACS and perform posterior surgery due to history of previous RT.

Table. Comparison between preoperative RT group and non-RT group

	Non-RT (n = 31)	Preoperative RT (n = 18)	P value
Age	59.7 ± 18.1	59.7 ± 7.0	0.993
Sex			
HTN	9 (29.0%)	6 (33.3%)	0.780
DM	6 (19.4%)	10 (55.6%)	0.010*
Smoking	7 (22.6%)	5 (27.8%)	0.730
Bilsky grade	1.8 ± 1.0	1.8 ± 0.9	0.937
Pathologic fracture	27 (87.1%)	10 (55.6%)	0.125
Number of levels operated	1.3 ± 0.6	1.1 ± 0.3	0.207
Combined posterior fusion	22 (71.0%)	10 (55.6%)	0.768
Preoperative AIS motor grade	4.7 ± 0.4	4.2 ± 0.7	0.004*
Postoperative AIS motor grade	4.9 ± 0.4	4.7 ± 0.5	0.109
Postoperative RT	18 (58.1%)	14 (77.8%)	0.081
Primary pathology			
HCC	6 (19.4%)	8 (44.4%)	
Breast	6 (19.4%)	0 (0.0%)	
Prostate	1 (3.2%)	2 (11.1%)	0.057
Other gastric origin	1 (3.2%)	1 (5.6%)	
Hematologic	4 (12.9%)	0 (0.0%)	
Others	13 (41.9%)	7 (38.9%)	
Operative factors			
Op time (m)	291.2 ± 165.7	225.6 ± 58.4	0.109
EBL (ml)	250.0 ± 198.7	183.3 ±141.4	0.246
Postoperative drainage (ml)	76.7 ± 48.6	66.33 ± 45.7	0.604
Complications			
Esophageal injury	0 (0.0%)	0 (0.0%)	n/a
Dural tear	0 (0.0%)	1 (5.6%)	0.340
Major vessel injury	0 (0.0%)	0 (0.0%)	n/a
Dysphagia	11 (35.5%)	4 (22.2%)	0.539
Hoarseness	7 (22.6%)	2 (11.1%)	0.701
Infection	2 (6.4%)	0 (0.0%)	0.329
Early mortality	1 (3.2%)	0 (0.0%)	1.000

RT, radiation therapy; HTN, hypertension; DM, diabetes mellitus; AIS, ASIA impairment scale ; HCC, hepatocellular carcinoma; EBL, estimated blood loss; m, minutes; ml, milliliters;
Continuous variables were analyzed using a Student's t-test
Categorical variables were analyzed using a chi-square test
* P<0.05

140. A Radiological Parametric Comparison of Low-Grade Lytic Spondylolisthesis to Degenerative Spondylolisthesis: A Retrospective Approach to Establish Its Dysplastic Origin

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Hypothesis

We propose that the vertebral morphometry of low-grade lytic spondylolisthesis is different from that of low-grade degenerative spondylolisthesis, and certain radiological features are similar to dysplastic spondylolisthesis.

Design

Retrospective Comparative Study

Introduction

Although a significant proportion of patients with lytic and degenerative spondylolisthesis are treated conservatively, patients with failed conservative management or neurological deficit need surgical intervention. Fusion with pedicle screw fixation is a commonly performed procedure, and this requires a proper insight into vertebral anatomy. Therefore, understanding the difference in the morphology of lumbar vertebrae and pedicles in these two situations is of utmost significance as an element of preoperative workup. The aim of this study was to compare low-grade lytic and degenerative spondylolisthesis radiologically and additionally to identify the underlying similarities between lytic and dysplastic spondylolisthesis.

Methods

We retrospectively included patients with low-grade single-level spondylolisthesis at L4-L5 or L5-S1 surgically treated at our institution between April 2021 and July 2023. They were categorized into lytic and degenerative spondylolisthesis. Radiological features, including pedicle height, width, transverse and sagittal pedicle angle, as well as anterior and posterior vertebral heights, were measured on T1-weighted MRI.

Results

The study included a total of 88 patients: 46 in the degenerative spondylolisthesis (DS) group and 42 in the lytic spondylolisthesis (LS) group. In the LS group, the anterior vertebral height (AVH) was significantly higher than the posterior vertebral height (PVH) at L4 and L5 [L4 PVH/AVH ratio 0.93 in LS vs 0.96 in DS; L5 PVH/AVH ratio 0.84 in LS vs 0.92 in DS] and the pedicles were more medially oriented [L4: 19.62° in LS vs 17.7° in DS; L5: 28.92° in LS vs 26.47° in DS]. Additionally, at L5, the pedicle height [10.67mm in LS vs 11.48mm in DS] and width [13.56mm in LS vs 14.37mm in DS] were smaller compared to the DS group.

Conclusion

Low-grade lytic spondylolisthesis shows distinct radiological vertebral and pedicle anatomy compared to degenerative spondylolisthesis. Short and thin pedicles and wedge-shaped vertebrae in lytic spondylolisthesis resemble dysplastic spondylolisthesis, indicating its dysplastic origin.

141. Decompression Across or Between the End Vertebrae is a Poor Prognostic Factor for Achieving MCID in Patients with Cobb Angle over 20 Degrees

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Hypothesis

Decompression surgery associated with severe Cobb angle may have an impact on clinical outcomes in patients with Severe degenerative scoliosis (DS).

Design

Retrospective review of a prospectively collected multi-surgeon registry.

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Introduction
Degenerative spondylolisthesis (DS) is often found in conjunction with lumbar canal stenosis. In cases of short-segment canal stenosis, lumbar laminectomy is commonly recommended. However, it is still unclear whether the relationship between the coronal curvature and the level of decompression can have an impact on clinical outcomes.

Methods
The study included patients with a Cobb angle > 20° who underwent minimally invasive lumbar decompression. The location of decompression was defined as "Cobb-related" when decompression across or between the end vertebrae, and others were labeled as "outside". The primary outcome was the achievement of the minimal clinically important difference (MCID) in the Oswestry Disability Index (ODI) at ≥1 year postoperative. Patients were divided into two groups. Multivariable regression analysis was conducted to identify factors associated with MCID non-achievement in ODI, using variables with P-value < 0.20 from univariate analysis.

Results
A total of 41 patients were included in the study. MCID achievement rate was 46.3% in ODI, with 19 out of 41 patients grouped into the Achieve group, while the remaining patients were categorized as the Non-achieve group. A comparison of preoperative data showed the location of laminectomy (Cobb-related, Achieve: 21.1% vs. Non-achieve: 50.0%, P = 0.111), sacral slope (P = 0.160), pelvic incidence (P = 0.149), and preoperative ODI (P = 0.003) showed P-value < 0.20. Logistic regression analysis revealed that Cobb-related decompression (Odds ratio 11.1, P = 0.023) and preop ODI (Odds ratio 0.93, P=0.014) were independent factors associated with the non-achievement of MCID in ODI.

Conclusion
Among patients with a Cobb >20°, decompression performed across or between the end vertebrae is independently associated with a lower likelihood of achieving the MCID in ODI.

142. Do Obese Patients Undergoing Surgery for Grade 1 Spondylolisthesis Have Worse Outcomes at 5 Years Followup? A QOD Study.

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Hypothesis
The long-term effects of obesity on surgical outcomes are not well documented for low-grade spondylolisthesis. We aim to study the patients related outcomes at 5-year mark postoperatively.

Design
This is an analysis of prospectively collected data from Quality Outcomes Database (QOD). We compared the patients-related outcomes (PROs) of patients with Class 2 or higher obesity (BMI≥35) versus BMI<35 who underwent surgery for low-grade spondylolisthesis.

Introduction
The long-term effects of increased BMI on surgical outcomes are unknown for patients who undergo surgery for low-grade (grade 1) lumbar spondylolisthesis.

Methods
The Quality Outcomes Database (QOD) was used to compare patients with BMI≥35 versus those with BMI<35 who underwent surgery for low-grade spondylolisthesis.

Results
A total of 608 patients (57.6% female) were included and the follow up rate was 80% at five years. Patient with BMI≥35 (130 patients, 21.4%) were compared to patients with BMI<35 (478 patients, 78.6%). The BMI≥35 patients were more likely to have surgery at younger ages (58.5±11.4 vs 63.2±12.0,p<0.001), present with dominant symptom of both back and leg pain (53.8% vs 37.0%,p=0.002), and require assistance for ambulation (20.8% vs 9.2%, p<0.001) at baseline. Further, patients with BMI≥35 had worse PROs at baseline including VAS leg (7.1±2.6 vs 6.4±2.9,p<0.001) and VAS back (7.6±2.3 vs 6.5±2.8,p<0.001), and disability (ODI: 53.7±15.7 vs 44.8±17.0,p<0.001). Patients with BMI≥35 were more likely to require fusion (85.4% vs 74.7%,p=0.01). They also experienced higher blood loss (262.9±259.6 vs 165.5±175.8 ml,p<0.001), longer hospitalization (3.2±1.5 vs 2.6±1.8 days, p<0.001), and were more likely to have non-routine discharge (17.1% vs 7.4%,p<0.001). At 5 years postoperatively, the BMI≥35 cohort reported significantly worse PROs including VAS leg (3.7±3.4 vs 2.3±2.9,p<0.001) and VAS back (4.3±3.3 vs 3.3±3.0,p<0.001), and disability (ODI: 33.1±21.1 vs 21.6±19.0,p<0.001). However, both cohorts expressed similar rates of satisfaction on NASS questionnaire regarding their surgery (p>0.05). While the BMI ≥35 cohort had equivalent MCID for VAS back pain and ODI at five years postop, the BMI ≥35 cohort had a 15% lower odds of achieving MCID for VAS leg pain (p=0.007) compared to the BMI<35 cohort.

Conclusion
At the five-year time point, patients with a BMI≥35 do achieve similar rates of satisfaction and MCID for back pain and ODI (but not leg pain) as patients with BMI<35.

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144. What is the Safe Starting Point and Burr Depth for Robot-Assisted Pedicle Screw Placement? An Anatomic CT-Based Study on 1,000 Pedicles

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Hypothesis
A lateral starting point allows for a longer burr depth than the ideal starting point in the setting of potential frameshift and angulation error.

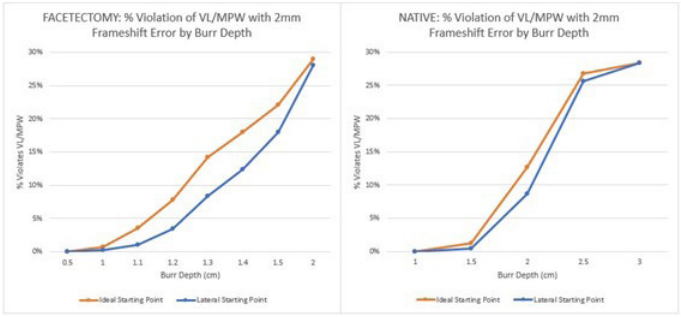
Design
Retrospective study

Introduction
Navigated robot-assisted spine surgery is known to achieve high pedicle screw accuracy with comparable outcomes to freehand techniques. However, screw-related complications still occur and may be underreported given differences in how "screw accuracy" is defined in literature. Screw-related complications can occur before pedicle screws are placed, specifically during the use of a navigated burr. Incremental changes in frameshift and angulation with a high-speed burr can potentially disrupt the ventral lamina and medial pedicle wall. No prior studies have investigated the safe starting point and burr depth limit with robot-assisted cases.

Methods
A total of 100 pts with lumbar degen pathology were consecutively collected (2022-2023). Preop CT measurements were performed from L1-L5 (1000 pedicles) based on 2 starting points: 1)Ideal:identified on the axial CT at the intersection of the mid-pedicle on Sagittal cut and the mid-transverse process on Coronal cut. 2)Lateral:2mm lateral to the Ideal. Measurements accounted for facetectomy, pedicle isthmus, distances to ventral lamina/medial pedicle wall/mid-pedicle, trajectory angulation error, 2mm frameshift error, burr depth distances from 0 to 3cm, and a 3mm burr width.

Results
For native facets, the risk for violation of ventral lamina/medial pedicle wall with 2mm frameshift is 0% with a 1cm burr depth along both the Ideal and Lateral trajectories. At 1.5cm, the risk increases to 1.2% (12/1000) and 0.4% (4/1000), respectively. At 2cm, the risk substantially increases to 12.7% (127/1000) and 8.7% (87/1000). For those with facetectomy, the risk for violation of ventral lamina and medial pedicle wall is 0% with a 0.5cm burr depth along both the Ideal and Lateral trajectories. At 1.0cm, the risk increases to 0.7% (7/1000) and 0.3% (3/1000), respectively. At 1.2cm, the risk substantially increases to 7.8% (78/1000) and 3.5% (35/1000).

Conclusion
For robot-assisted spine surgery, a 2mm lateral starting point may have a lower risk for a medial breach than with the ideal starting point, especially for small, cortical, or dysplastic lumbar pedicles. For those with and without facetectomy, the burr depth should not exceed 1cm and 1.5cm, respectively.



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146. Segmental Compensation: A Novel Understanding of Segmental Compensation and Reciprocal Change Following Lumbar Reconstruction

Amber Price, MD; Gregory M. Mundis Jr., MD; Hani Malone, MD; Tina L. Iannacone, BSN; Robert K. Eastlack, MD; Guillermo C. Kahl, MD; Andrew Chung, DO; Elizabeth P. Norheim, MD; Eric Schaum, PT, DPT; Michele Sewart, PMP; Ignacio Pasqualini, MD; Antonio Scarale, MD; Kyung-Chung Kang, MD, PhD

Hypothesis
Loss of segmental lordosis leads to compensation in the lumbar spine. We hypothesize that normalizing segmental lordosis will lead to a reduction in compensatory mechanisms.

Design
Retrospective, Single Institution

Introduction
The concept of compensatory change within spinal deformity is well-described. Inadequate restoration of alignment during reconstruction has shown to result in a 10-fold increased risk of adjacent segment disease requiring reoperation. To our knowledge, an examination of segmental alignment compensation following focal fusion has not been performed.

Methods
Retrospective analysis of radiographic outcomes for patients that underwent one-level lumbar interbody fusion at L4-5 or L5-S1. Inclusion criteria included > 5° increase in segmental lordosis at the index level from preop to postop, and baseline 'normal' lumbar lordosis, defined by PI-LL mismatch within 10°. Exclusion criteria included multilevel fusions. Radiographic parameters included segmental lordosis via motion

segment angle (MSA)(degrees) and intradiscal angle (IDA)(degrees), as well as lumbar lordosis, PI, and SVA.

Results
79 patients met inclusion criteria, including 43 male and 34 female patients with a mean age of 68 years. Mean surgical level ΔIDA at 1 and 12 months was 10.4 and 10 at L4-5 ($p<0.001$) and 15.7 and 15.4 ($p<0.19$) at L5/S1. Reciprocal changes seen after L4-5 fusion included L3-4 IDA decrease at 1 and 12 months (-3.5 and -4.3, $p<.0001$) and L5-S1 IDA decrease at 1 and 12 months(-3.3 and -4.3, $p<.001$). Reciprocal decrease in IDA was more dramatic at L4-5 after L5-S1 fusion at 1 and 12months (-14.2 and -14.6 respectively; $p<0.001$).

Conclusion
Loss of segmental lordosis leads to adjacent segment compensation in the lumbar spine. These compensatory mechanisms have been shown to lead to mechanical stress and may be related to adjacent segment failure. Normalizing segmental lordosis leads to a reduction in compensatory mechanisms, as demonstrated by the reciprocation shown in our study. Normalization of adjacent levels may lead to a reduction in adjacent segment stresses and risks of adjacent segment disease.

147. Is There a Learning Curve for the Bedrock Pelvic Fixation Technique?

Christopher T. Martin, MD; Jason J. Haselhuhn, DO; Paul Soriano, MD; Jonathan N. Sembrano, MD; Kristen E. Jones, MD, FAANS; *David W. Polly Jr., MD*

Hypothesis
The objective of this study was to determine the rate of intraoperative TTR repositioning at our institution since our experience has grown.

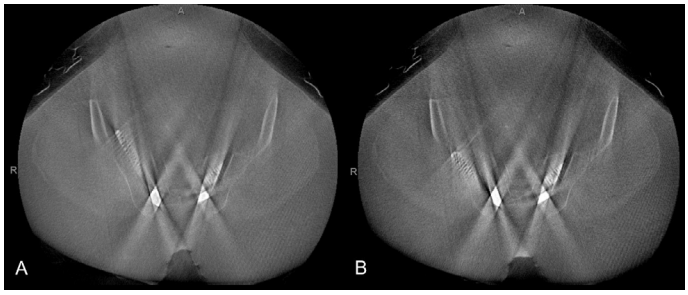
Design
Retrospective

Introduction
Spinal fusion to the sacrum increases the stress on the sacroiliac (SI) joint, and literature has shown an increased rate of new SI joint symptoms with increased length of fusion. Computed tomography (CT) navigated open SI joint fusion using porous triangular titanium rods (TTR) cephalad to S2AI screws has been employed to prevent hardware failure and promote SI joint fusion to decrease the risk of new SI joint pain postoperatively. In our initial 21 cases we found a 7.1% rate of implant malposition requiring intraoperative repositioning.

Methods
Surgeries in which pelvic fixation was performed via CT navigated open SI joint fusion with TTR cephalad to S2AI screws between 5/1/2019 and 5/27/2021 were reviewed. Operative reports were analyzed and any TTR or S2AI screw repositions that occurred were recorded. Demographic and surgical information and TTR and S2AI specifications were obtained. Height was used as a surrogate for pelvic size. Radiographs were analyzed to determine if a dysmorphic sacrum was present and to measure the length of engagement of the ilium and sacrum. Computed tomography (CT) scans were analyzed to determine the rate of non-union at one year postoperative. Patient reported outcomes (PROs) were analyzed.

Results
A total of 43 patients (14M:29F) with a mean age of 62.3 + 11.0 years were included. Average BMI and height were 31.5 + 7.1 kg/m2 and 1.7 + 0.1 m, respectively. Cephalad extent of fusion ranged from T4 to L5, with a mean of 4.8 (range 1-14) levels fused. Surgeries were performed by a co-surgeon team in 28 cases and by a single surgeon in 15 cases. 86 TTR were implanted, ranging 7.0-7.5 mm in diameter and 65-90 mm in length. Four (4.3%) TTR were repositioned intraoperatively and one (1.1%) was subsequently removed and replaced with crushed cancellous allograft. All malpositions were medial and/or cephalad. 86 S2AI screws were implanted, ranging 9.5-10.5 mm in diameter and 80-110 mm in length. No (0%) S2AI screws required intraoperative repositioning. In the initial 21 cases, 3/42 (7.1%) TTR required intraoperative repositioning; this decreased in the subsequent 22 cases to 2/44 (4.5%).

Conclusion
Stacked pelvic fixation with TTR is technically demanding. Overall, our reposition rate was 5.8%. The initial cohort was 7.1% and the subsequent cohort was 4.5%. This indicates there is a learning curve even with the use of navigation.



Intraoperative CT scans from a case demonstrating: (A) a medial breach of the right iliac wing by a TTR, (B) after TTR repositioning

148. Postoperative Change in Lordosis After Decompression and Stabilization with Dynamic Sagittal Tether or Transforaminal Lumbar Interbody Fusion for Degenerative Spondylolisthesis

Todd Alamin, MD; Louis C. Fielding, MD; William F. Lavelle, MD; *Javier Castro, MD*

Hypothesis
Both Dinamic Sagittal Tether and Transforaminal Lumbar Interbody Fusion are comparable in segmental lordosis improvement and maintenance

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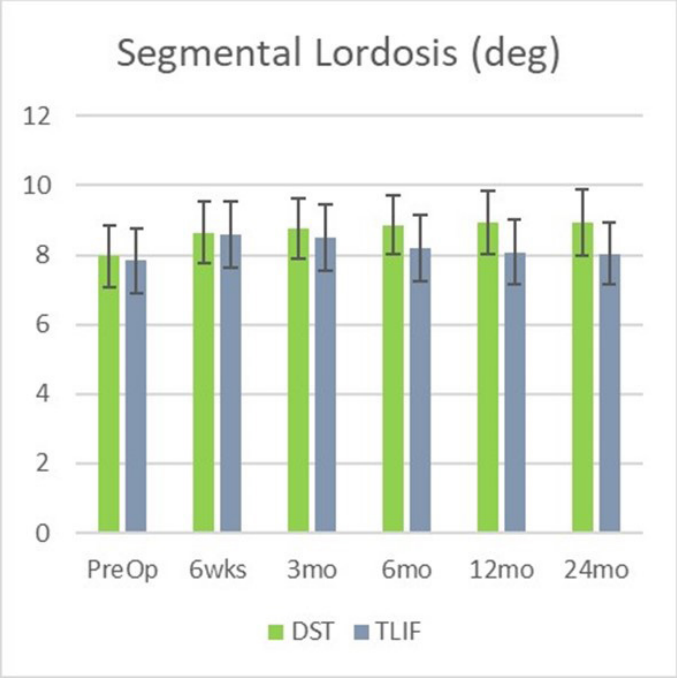
Design
Prospective cohort. Analysis from ongoing FDA IDE study (NCT03115983)

Introduction
Maintenance or restoration of lumbar lordosis after surgical intervention is important to achieve optimal clinical outcomes. Dynamic sagittal tether (DST) stabilization is an investigational alternative to instrumented fusion after decompression for degenerative spondylolisthesis (DS). An FDA IDE study (NCT03115983) comparing decompression with DST to decompression with transforaminal lumbar interbody fusion (TLIF) allowed comparison of radiographic outcomes.

Methods
Patients with Grade I DS and symptomatic stenosis, ODI≥35, VAS leg/hip≥50, and age 25-80 (eligibility criteria at clinicaltrials.gov) were eligible. Segmental lordosis (SL) was measured preoperatively, 6wks, 3mo, 6mo, 12mo and 24mo postoperatively, as well as a composite clinical success (CCS) assessment with propensity score (PS) matching between groups.

Results
Preoperative SL in the DST/TLIF groups was 8.0°±4.6°/7.8°±5.0° and increased to 8.9°±4.7°/8.0°±4.0° at 24mo in both groups, with no statistically significant difference. At 24mo, the DST group had a 10.4% higher PS-adjusted clinical success rate compared to TLIF (95%CI: 0.5%, 20.2%).

Conclusion
Similar increases in SL can be achieved with DST stabilization compared with TLIF at 24 months follow up. DST group had a significantly higher clinical success rate compared to the TLIF group.



DST V/S TLIF SEGMENTAL LORDOSIS AT FOLLOW UP

149. Utility of Preoperative Whole-Body Imaging in Candidates for Lumbar Spine Surgery

Omri Maayan, BS; Bo Zhang, BS; Anthony Pajak, BS; Pratyush Shahi, MBBS, MS; Tejas Subramanian, BS; Troy B. Amen, MD; Tomoyuki Asada, MD; Sheeraz Qureshi, MD; *Francis C. Lovecchio, MD*

Hypothesis
Osteoarthritis (OA) of the hip (HOA) and knee (KOA) may hinder postoperative outcomes in patients with degenerative spine conditions.

Design
Retrospective cohort study.

Introduction
HOA and KOA often introduce diagnostic uncertainty in patients with degenerative spine conditions. This study aimed to assess the utility of preoperative whole-body imaging in diagnosing lower extremity osteoarthritis (LEOA) and determine its impact on postoperative recovery.

Methods
Patients with preoperative whole-body imaging undergoing lumbar spine surgery for degenerative conditions were included. The Kellgren and Lawrence score was implemented to grade joint OA as mild (score≤2) or severe (score≥3). Length of stay (LOS) and side of radiculopathy were assessed. The Oswestry Disability Index (ODI), Patient-Reported Outcomes Measurement Information System (PROMIS), Visual Analog Scale (VAS) Back/Leg, and Short Form-12 Physical Component Scale/Mental Component Scale (SF-12 PCS/MCS) were recorded at preoperative, early postoperative (2-,6-,12-week), and late postoperative (6-,12-,24-month) timepoints. Multivariate analysis was used to evaluate the association of OA with patient-reported outcomes (PROMs) and minimum clinically important difference (MCID) achievement.

Results
207 patients were included (HOA: 67.7% mild, 32.3% severe; KOA: 72.7% mild, 27.3% severe). 28 hips (6.7%) and 22 knees (5.3%) were post-arthroplasty and excluded from the analysis. Patients with severe LEOA were older compared to patients with mild LEOA ($p<0.05$). LEOA laterality was not associated with the side of radiculopathy. After controlling for age, LOS was approximately 50% greater for patients with severe HOA ($p=0.031$) and KOA ($p=0.013$) compared to mild HOA and KOA (Fig. 1). Patients with severe KOA exhibited worse PROMIS at the early ($p=0.013$) and late ($p=0.049$) postoperative timepoint, as well as worse VAS Back ($p=0.009$) and SF-12 PCS ($p=0.025$) at the late postoperative timepoint. Severe HOA and KOA decreased achievement of MCID for SF-12 PCS (OR 0.44; $p=0.049$) and PROMIS (OR 0.37; $p=0.027$), respectively.

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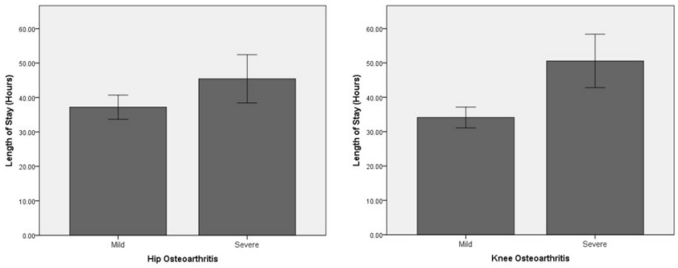
Conclusion
Severe LEOA was associated with decreased achievement of MCID for certain PROMs and increased LOS. Thus, obtaining preoperative whole-body imaging may uncover underlying LEOA and prompt patient-specific counseling.



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152. Magnetically Controlled Growing Rods Increase 3D True Spine Length in Idiopathic Early Onset Scoliosis Patients: Results from a Multicenter Study

Jennifer K. Hurry, MASc; John-David Brown; Ankita Bansal, MBBS, MS; Abdullah Al Amer, MD; Oheneba Boachie-Adjei, MD; Michael G. Vitale, MD, MPH; Joshua M. Pahys, MD; Scott J. Luhmann, MD; Pediatric Spine Study Group; *Ron El-Hawary, MD*

Hypothesis
Three-dimensional spine measurements will give more clinically useful data than traditional coronal height in early-onset scoliosis patients with growing instrumentation.

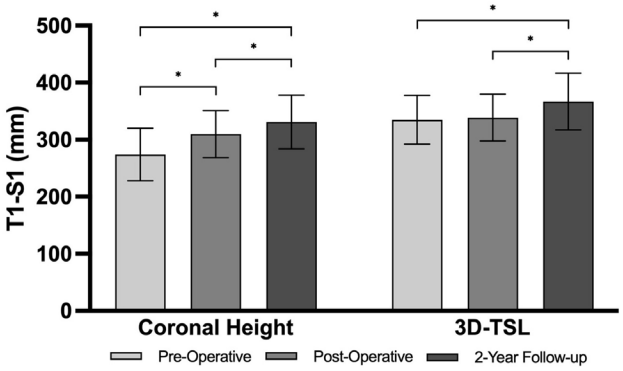
Design
Retrospective analysis of prospectively collected data.

Introduction
Traditional assessment of spine growth uses one-dimensional vertical T1-S1 spine height. As this measurement is influenced by spinal deformity, it is not a reliable indicator of true spine growth. Here a 3D true spine length (3D-TSL) measurement technique assesses actual spine growth in early-onset scoliosis (EOS) patients treated with magnetically controlled growing rods (MCGR).

Methods
EOS patients had scoliosis, kyphosis, traditional coronal height, and 3D-TSL measured pre-index surgery, post-index, and 2-year follow-up.

Results
135 (82 female) with a mean age of 8.1 years (2.7-15.6) were included. Scoliosis improved from 71° pre-index to 41° post-index (p<0.001) and remained constant at 2 years (43°, p=0.58). Kyphosis improved from 49° to 36° (p<0.001); this correction diminished by 2 years to 42° (p=0.002). Traditional T1-S1 height increased from pre-index to post-index (274 mm vs 310 mm; p<0.001), and again at 2 years (332 mm, p<0.001), which partly reflects spine growth but also changes in deformity. 3D-TSL did not change perioperatively (335 mm vs 339 mm, p=0.83), but significantly changed by 2 years (367 mm; p<0.001). Participants <5 yo at surgery increased 22 mm (8.2%), 5-10 yo increased 26 mm (7.8%), and >10 increased 41 mm (11.0%). For instrumented levels only, mean vertebral growth was 1.2 mm/level for <5 yo, 1.3 mm/level for 5-10 yo, and 2.0 mm/level for >10 yo.

Conclusion
Out of plane changes in spine geometry justify the use of the 3D-TSL for this cohort of patients. For idiopathic EOS patients treated with MCGR, 3D spine length increased by 28 mm from immediately post-operatively to 2 years post-surgery.



Coronal height and 3D-TSL T1-S1 mean and standard deviation of the mean for all patients at pre-index, post-index, and 2-year follow up (* denotes p<0.05)

153. Early Onset Scoliosis Questionnaire (EOSQ-24) Variation Amongst Parents/Caregivers

Tishya Wren, PhD; Tiffany N. Phan; Michael J. Heffernan, MD; Tyler Tetreault, MD; Brandon A. Ramo, MD; Pediatric Spine Study Group; *Lindsay M. Andras, MD*

Hypothesis
Significant variability will be encountered in answers provided by different parents/caregivers on the EOSQ-24 completed at the same timepoint.

Design
Multicenter, Prospective

Introduction
The EOSQ-24 is a validated questionnaire to measure health-related quality of life (HRQoL) for patients with EOS (Early Onset Scoliosis) and has been used to evaluate the impact of treatment of this condition on the patient and their family.

Methods
Inclusion criteria were EOS patients with two parents/caregivers, each of whom was administered a copy of the questionnaire and asked to respond to questions

independently. If one of the caregivers was unavailable at the time of the patient's visit, it was requested electronically. If the caregivers completed the study more than 4 weeks apart it was excluded. Differences between caregiver responses were examined.

Results
Two caregivers of 38 patients both completed the EOSQ-24 at the same timepoint. 27 respondents identified as mom, 25 as dad, and 24 as other/undisclosed (stepparent, grandparent, etc.). The mean difference between caregivers for standardized total EOSQ-24 scores was 8.45 points (range: 0 – 37.0) on a 100-point scale. 31.6% (12/38) of caregivers had a difference of >10 points. Fathers gave slightly higher scores than mothers, but the difference was not significant (mean 67.3 vs. 63.4, p=0.09). The subdomain with the highest mean difference was Daily Living with a difference of 16.2. The subdomain with the lowest mean difference was Emotion with a difference of 8.4. At the time of the survey the patients were being treated as follows: 7 patients (18.9%) with magnetically lengthening growing rods (MCGR), 6 patients (16.2%) with elongation derotation flexion (EDF) casting, 12 patients (32.4%) with bracing and 12 patients (32.4%) with monitoring/observation alone. Those treated with growing rods had mean EOSQ-24 scores 10 points higher than those who had not had instrumentation (74.1 vs. 65.6, p=0.13).

Conclusion
While EOSQ-24 provides important insight into the impact of this condition and its treatment on quality of life, there is often variability between parent/caregiver respondents. Nearly a third of patients had a greater difference in caregiver response than was found between treatment types. The difference between caregivers completing surveys is a factor that warrants consideration when interpreting EOSQ-24 results.

Sub-Domain	Mean Raw Score (SD)	Mean Difference [range]
General health	68.6 (16.8)	9.9 [0, 50]
Pain/ Discomfort	69.7 (22.1)	9.2 [0, 37.5]
Pulmonary Function	80.3 (22.6)	9.2 [0, 50]
Transfer	73.5 (28.6)	12.1 [0, 50]
Physical Function	63.6 (31.7)	15.0 [0, 75]
Daily Living	52.1 (35.5)	16.3 [0, 75]
Fatigue/ Energy Level	67.6 (24.9)	12.5 [0, 37.5]
Emotion	71.4 (23.2)	7.95 [0, 62.5]
Parental Impact	67.6 (20.4)	12.7 [0, 70]
Financial Impact	71.3 (26.7)	14.2 [0, 50]
Satisfaction	65.8 (21.1)	14.5 [0, 50]

Analysis of EOSQ-24 subdomain between each caregiver

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155. Can the Choice of Osteotomies Spare Motion Segments in Scheuermann's Kyphosis?

Konstantinos Martikos, MD; Francesco Vommaro, MD; Antonio Scarale, MD; Luca Boriani, MD; Giovanni Ciani, MD; Lucrezia Leggi, MD; Alessandro Gasbarrini, MD, PhD

Hypothesis
Can pedicle subtraction osteotomy provide superior results in terms of correction, mechanical complications and fusion length compared to Ponte osteotomies in Scheuermann's kyphosis?

Design
Retrospective study

Introduction
Scheuermann's kyphosis is typically treated with posterior column osteotomies (PO) that distribute correction equally among spinal segments, with potential risk of junctional failure. Pedicle subtraction osteotomy (PSO) at the apex of the deformity may concentrate correction locally and reduce tension at the extremities of the instrumentation. The amount of correction achieved with each technique may correlate to instrumentation extension.

Methods
We evaluated 18 adolescent patients affected by Scheuermann's kyphosis that were surgically treated with posterior thoracolumbar fusion and PSO at the apex, and compared them to a similar group of 20 consecutive patients treated with PO. Inclusion criteria were adolescent age (12-18 years), kyphosis from 80° to 110°, minimum FU 2 years. Radiographic evaluation includes pre and post-operatory kyphosis, apical correction (+/-2 levels adjacent to PSO), choice of lowest instrumented vertebra (LIV) related to sagittal stable lumbar vertebra (SSLV) as well as complications at FU.

Results
Kyphosis was corrected from 92° to 43° with PSO, that proved superior to PO ranging from 87° to 62°, the result was stastically significant. Mean apical kyphosis correction went from 67° to 29° in the PSO group vs 65° to 52° in the PO group. In the PSO group, almost 78% of overall correction took place at the two levels adjacent to PSO, with the remaining 22% of correction being distributed towards the extremities of instrumentation. Considering fusion levels, in the PSO group 12 patients (66%) had SSLV -1 as LIV, while in the PO group all patients had SSLV as LIV. No cases of junctional failure or mechanical complications were observed in the PSO group, correction was maintained at 2 years FU. In the PO group there was 1 case of PJK and 1 case of PJF that needed revision surgery. No significant neurological complications were observed overall.

Conclusion
In Scheuermann's kyphosis, apical PSO allows to concentrate correction mainly at the apex of deformity, reducing stress at the extremities and potentially preventing junctional failure. With apical PSO, distal fusion may be limited 1 level above sagittal stable vertebra allowing for better motion preservation.

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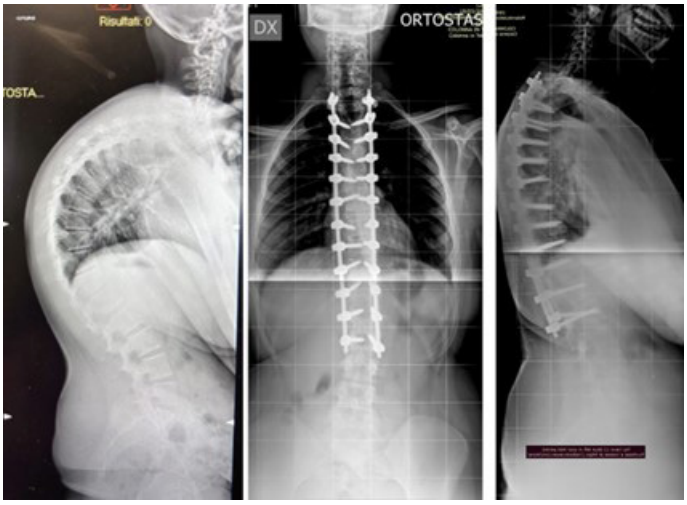


130° SK treated with PSO

156. Modified Pedicle Subtraction Osteotomy for Osteoporotic Vertebral Compression Fractures: A Retrospective Study of 104 Patients

Junyu Li, MD; Jiahao Zhang, MD; Siming Xian, MD; Wenbin Bai, MD; Yihao Liu, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; Yan Zeng, MD

Hypothesis
Modified Pedicle Subtraction Osteotomy can be an effective solution for the treatment of OVCF.

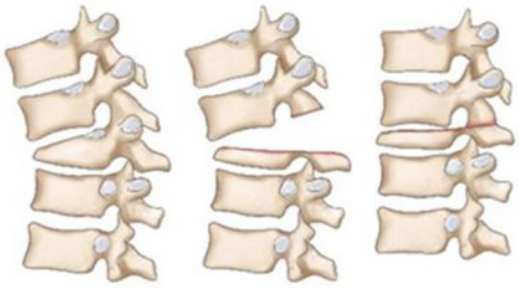
Design
Retrospective Study

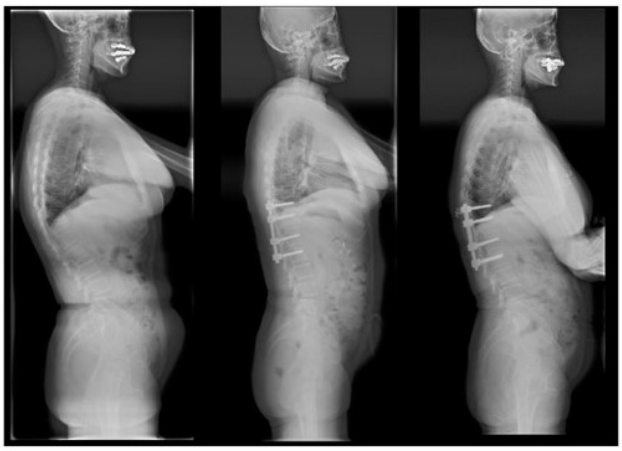
Introduction
Osteoporotic vertebral compression fractures caused by osteoporosis is a common clinical fracture type. There are many surgical treatment options for OVCF, but there is a lack of comparison among different options. Therefore, we counted a total of 104 cases of OVCF operations with different surgical plans, followed up the patients, and compared the surgical outcome indications before, after and during the follow-up.

Methods
104 patients who underwent posterior osteotomy and kyphosis correction surgery at our hospital with a minimum follow-up period of 24 months were included. All cases were injuries induced by a fall incurred while standing or lifting heavy objects without high-energy trauma. The mean CT value was 71 HU,indicating severe osteoporosis. The indications for surgery included gait disturbance due to severe pain with pseudarthrosis, increased kyphotic angle, and progressive neurological symptoms. Pre- and post-operative CL, TLK, TK, PrTK, TKmax, GK, LL, PI, SS, PT, SVA,TPA,were investigated radiologically. Additionally, We evaluated estimated blood loss, surgical time and perioperative symptom.

Results
The results show, after operation, TLK (39.42 ± 14.26° vs 9.02 ± 8.30°, P < 0.001), TK (34.05 ± 17.71° vs 21.83 ± 11.90°, P = 0.003), TK max (51.78 ± 11.96° vs 18.35 ± 9.93°, P < 0.001), PT (26.31 ± 13.60° vs 14.4 ± 17.84°, P = 0.009), SVA (38.44 ± 27.52 vs 21.44 ± 13.02, P = 0.010), CL (16.12 ± 15.92° vs 8.15 ± 7.58°, P = 0.038) and TPA (24.9 ± 13.18° vs 16.18 ± 10.28°, P = 0.045) were improved significantly in modified Pedicle subtraction osteotomy (mPSO). During follow-up, TLK (39.42 ± 14.26° vs 11.68 ± 8.48°, P < 0.001) and TK max (51.78 ± 11.96° vs 23.53 ± 9.8°, P < 0.001) were improved significantly in Modified PSO group. In additon, estimated blood loss (790ml vs 1198ml, P=0.035), surgical time (244min vs 301min, P=0.010) were favorable in Modified PSO group.

Conclusion
To conclude, mPSO could acquire a favorable degree of kyphosis correction as well as early and high bone union. Compared with other surgical methods, it also has the advantages of less surgical trauma and shorter operation time. It can be an effective solution for the treatment of OVCF.





a **b** **c**

A 58-year-old woman with OVCF was treated with modified PSO surgery.
a. before the operation,TK 53.8°,TKmax 44.3°,SVA 29.00mm and TPA 36.4°;
b. after the operation,TK 18.9°,TKmax 16.4°,SVA 7.92mm and TPA 4.0°;
c. TK 37.1°,TKmax 14.1°,SVA 13.26mm and TPA 28.7°

Modified PSO osteotomy diagram & typical cases

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157. Biomechanical Evaluation of Pedicle Subtraction Osteotomy (PSO), Modified PSO and Vertebral Column Resection (VCR): A Finite Element Analysis

Junyu Li, MD; Lizhi Xu, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; Yan Zeng, MD

Hypothesis

1) mPSO have similar spinal stability to PSO. 2) mPSO have less risks of adjacent segments degradation compared to PSO and VCR.

Design

A total of 18 operating conditions will be examined. Biomechanical performance of the FE model will be measured by finite element analysis.

Introduction

Osteoporotic Vertebral Compression Fracture (OVCF) is a concerning disease in the aging population. Surgery is an effective way to correct kyphosis and relieve neurological symptoms, yet the effect of surgery on spinal anterior column biomechanics is unknown. The aim of this study was to compare changes in the biomechanics of the vertebral bodies, intervertebral discs and internal fixations after pedicle subtraction osteotomy (PSO), vertebral column resection (VCR) and modified PSO (mPSO) using a finite element (FE) model for OVCF. We expected a better biomechanical results for mPSO compared to PSO and VCR.

Methods

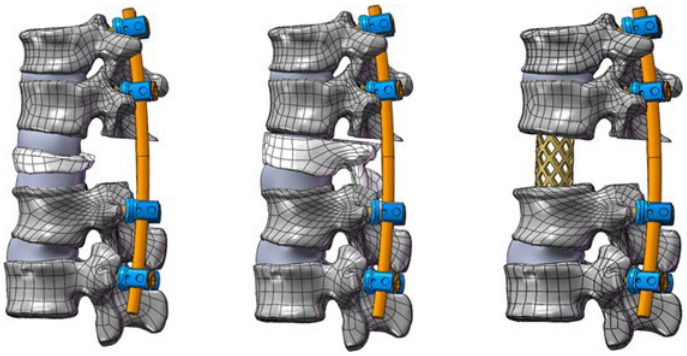
An FE model of the thoracolumbar T10-L2 segments was created using CT scanning from a 71-year-old female volunteer with OVCF but no other severe spinal deformities. PSO, VCR and mPSO for OVCF were simulated using FE model. Stress distribution characteristics, load sharing, strain displacement and strain angle change of the FE model were measured.

Results

6 oeprating conditions (flexion, extension, left/right bending, left/right torsion) for each post-operative FE model have been examined. In most actions, the displacement of mPSO is smaller or similar to that of PSO, with both larger than that of VCR. The maximum equivalent stress on the vertebral body of the three surgical methods is within the safe range. The stress is mainly distributed on the T10 vertebral body and the fixed vertebral body L2, while the stress of VCR is greater than that of mPSO and PSO. We have also found that the intervertebral disc pressure is highest in VCR, followed by PSO, and lowest in mPSO under all six operating conditions. And the maximum pressure on the intervertebral discs is located between T10 and T11.

Conclusion

The FE analysis showed that mPSO has a similar spine stability to PSO, and possibly creates a better environment for bone-to-bone fusion and prevents adjacent segments degeneration. Combined with its smaller surgical risks, we believe that the modified pedicle subtraction osteotomy may be an appropriate surgical intervention for indicated cases of OVCF.



3 post-operative FE models

158. Who Got Hip Pain After Spinopelvic Fixation, when and How? Result of Sacral Alar Iliac (SAI) Screws in Pediatric Neuromuscular Scoliosis

Pochih Shen, MD, PhD; Nancy Hadley Miller, MD, PhD; Mark A. Erickson, MD

Hypothesis

The spinopelvic fixation with sacral-alar-iliac (SAI) screws improves and stabilizes spine and pelvis obliquity, which may decrease the risk of subsequent hip subluxation or related symptoms.

Design

Retrospective cohort study

Introduction

Patients with neuromuscular conditions often experience thoracolumbar scoliosis, pelvic obliquity, and hip subluxation or dislocation. Spinopelvic fixation can reduce scoliosis deformity and maintain the sitting balance for those populations. SAI screws are generally accepted for better construct stability and lower surgical complication in scoliosis and pelvic obliquity correction. But little was known regarding the influence of spinopelvic fixation with SAI screws on hip status.

Methods

From 2013 to 2021, pediatric neuromuscular patients who underwent spinopelvic fixation with SAI screws with more than 1.5 years of follow-up were retrospectively reviewed. Radiography results and electrical medical records were assessed. The predictive models for postoperative hip symptoms were analyzed using logistic regression and receiver operating characteristic analysis.

Results

Eighty-two patients underwent spine surgery at an average age of 12.6±2.2 years. Of them, forty-one had hip bony surgery before the spinal surgery. Twenty-four (29.2%) of them reported hip pain af-

ter surgery. Thirteen patients had pain in both hips, while eleven experienced pre-existing hip pain that worsened after the spinal surgery. Eleven patients developed new hip pain within a year, and three experienced hip pain four years after the surgery. Three patients received femoral head surgery to alleviate hip pain, one underwent acetabulum osteotomy, and three received intra-articular steroid injections. The postoperative pelvic obliquity (PO) could predict postoperative hip pain (odds ratio 1.157, 95% CI 1.043-1.284, p=0.006). With a postoperative PO≥4.5°, the AUC was 0.723 (95% CI 0.603-0.844), and the sensitivity and specificity were 62.5% and 79.3%, respectively.

Conclusion
Due to communication challenges, medical complexity, and retrospective study design, hip pain may be underestimated in this population. The cause could be multifactorial and may require additional hip surgery. Awareness of the possibility of further hip surgery and preserving the space for acetabulum osteotomy through modifying the SAI screw trajectory and length may optimize the functional outcome.

Table 1 Demography and Radiography Result

		Total Cohort (N=82)		Hip pain **Positive** (N=24)		Hip pain **Negative** (N=58)		*P value*
Age at Surgery (y)		12.5 ± 2.4		11.9 ± 2.7		12.7 ± 2.0		0.184
Gender (Male : Female)		33:49		9:15		24:34		0.744
Follow-up duration (y)		3.6 ± 2.0		4.1 ± 2.0		3.4 ± 2.0		0.166
Hip surgery before spine fusion (Y:N)		41:41		13:11		28:30		0.627
BMI		18.8 ± 8.6		22.3 ± 14.5		17.4 ± 3.6		0.112
Major Cobb angle(°)	Preop	77.1 ± 21.5		78.2 ± 22.4		76.7 ± 21.3		0.777
	Postop	25.0 ± 16.0	*P<0.0001*	26.3 ± 15.1	*P<0.0001*	24.4 ± 16.5	*P<0.0001*	0.632
Pelvic obliquity(°)	Preop	16.9 ± 11.4		19.5 ± 13.6		15.8 ± 10.2		0.188
	Postop	5.1 ± 4.6	*P<0.0001*	7.3 ± 4.8	*P<0.0001*	4.1 ± 4.3	*P<0.0001*	0.003
Lumbar lordosis(°)	Preop	34.0 ± 27.1		38.1 ± 30.9		32.3 ± 25.6		0.398
	Postop	48.1 ± 17.7	*P<0.0001*	53.3 ± 15.4	*P=0.0113*	46.2 ± 18.0	*P=0.0001*	0.095
Upper hip FHMP(%)	Preop	30.1 ± 21.4		33.0 ± 17.0		28.9 ± 23.0		0.488
	Postop	22.1 ± 19.5	*P<0.0001*	25.3 ± 17.2	*P=0.0485*	20.8 ± 20.3	*P=0.0004*	0.335
Lower hip FHMP(%)	Preop	12.6 ± 17.5		11.8 ± 14.6		13.0 ± 18.6		0.786
	Postop	16.3 ± 19.2	*P<0.0001*	13.9 ± 18.8	*P=0.514*	17.3 ± 19.4	*P=0.0111*	0.470

Preop: preoperative; Postop: postoperative; FHMP: femoral head coverage percentage

159. Modified Bipolar Technique in Patients with Neuromuscular Scoliosis

Guillermo C. Kahl, MD

Hypothesis
Patients with neuromuscular scoliosis often require prolonged fusion from the upper thoracic spine to the sacrum or pelvis to achieve and maintain curve and OP correction. Miladi's bipolar treatment technique does not perform arthrodesis and uses hooks for thoracic instrumentation and screws in the lumbopelvic region. Consider that arthrodesis is not necessary in patients with neuromuscular scoliosis who do not walk, and spontaneous ankylosis has been described performing fixation without arthrodesis. The modified bipolar technique allowed satisfactory correction of pelvic obliquity and trunk alignment through less invasive surgery, without inclusion of the pelvis and with less morbidity.

Design
Prospective observational study.

Introduction
Scoliosis is a common spinal deformity in patients with neuromuscular and syndromic disorders. Objective: to evaluate the results of the modified Miladi technique in the treatment of patients with chair-dependent neuromuscular spinal deformities.

Methods
Prospective observational study carried out at El Cruce Hospital. Surgical technique: Modified Miladi Inclusion Criteria: Neuromuscular scoliosis Pelvic obliquity > 10º. Bipolar technique. Chair-dependent. Exclusion Criteria: Previous spinal surgeries. Inclusion of the pelvis in the instrumentation. Follow-up of less than 12 months. The Cobb was assessed in a seated front and profile x-ray. Pelvic obliquity. The Lonstein and Akbarnia classification was used. Surgery time, use and type of intraoperative traction and complications.

Results
9 patients Mean age between 13 +11 years). Etiology: 7 chronic non-evolutionary encephalopathy and 2 Rett syndromes. Preoperative Cobb average 83.11º. Average pelvic obliquity 20.14º. 6 type 2 of Lonstein and Akbarnia and 3 type 1. Average preoperative traction radiograph 65.7º. Average preoperative Cobb 29.6º. Average pelvic obliquity 6.4º 3 patients preoperative traction. All intraoperative asymmetric traction. Average surgery time 199 minutes Complications: 2 superficial infections and one implant disengagement.

Conclusion
The short-term clinical and radiographic results with the modified bipolar technique without including the pelvis in the treatment of spinal deformities in chair-dependent neuromuscular patients have been satisfactory, with 64% correction in the coronal curve and 66% in the pelvic obliquity.

160. Reoperation in Patients with Cerebral Palsy After Spinal Fusion: Incidence, Reasons, and Impact on Health-Related Quality of Life

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Hypothesis
Patients with cerebral palsy undergoing spinal fusion procedures experience a significant rate of reoperation.

Design
Retrospective review of a prospectively collected multicenter database

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Introduction
Patients with cerebral palsy (CP) undergoing spinal fusion experience a high rate of reoperation, although this has not been previously quantified. This report seeks to establish a rate, major reasons, and effect of reoperation on health-related quality of life (HRQoL), as well as explore potential risk factors.

Methods
A prospectively collected multicenter database was retrospectively reviewed to identify consecutive patients with CP who had undergone spinal fusion with a minimum 2-year follow-up. We compared patients who underwent reoperation (Yes, Y) vs. those who did not (No, N) with respect to preoperative, intraoperative, and postoperative factors.

Results
251 patients were identified with an average of 28 ± 6.7 months' follow-up. Thirty-five patients (13.9%) underwent a total of 37 reoperations. Of the 35 patients reoperated, 18 (7.2%) were for infection and 17 (6.8%) were instrumentation related. The majority of infections were deep (17/18, 85%). Of the 17 instrumentation related reoperations, the majority were for instrumentation loosening (5) or prominence (5), followed by junctional kyphosis (3), broken instrumentation (2), and pseudarthrosis (2). The patients with lower percent correction of the major curve were at highest risk for a reoperation (Y=54.3% correction vs. N=63.6% correction, p=0.02). Patients who underwent an unplanned return to the OR had longer hospitalizations (Y=19.5 days vs. N=10.7 days, $p \leq 0.01$). These patients had lower comfort and emotions domain scores on the CPCHILD outcomes instrument at 2 years after surgery (p=0.04), with a trend toward lower personal care scores at 2 years (p=0.08).

Conclusion
At an average of 28 ± 6.7 months post-op, spinal fusion for patients with CP carries a significant rate of reoperation (13.9%), which affects HRQoL and hospital length of stay. Infection, proximal junctional kyphosis, and instrumentation prominence/loosening are the most common reasons for reoperation.

161. Plastic Multilayered Wound Closure in Pediatric Non-Idiopathic Scoliosis Patients is Associated with Less Long Term Complications

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Hypothesis
Plastic multilayered wound closure (PMC) will lead to significantly less complications and better outcomes in non-idiopathic scoliosis patients.

Design
Retrospective Cohort Study

Introduction
PMC in adult spinal deformity and pediatric idiopathic patients has been found to be beneficial in decreasing complications, but less data exists in the pediatric non-idiopathic patient population. There has been little data to date regarding perioperative outcomes regarding type of wound closure in this subset of patients.

Methods
Non-idiopathic scoliosis patients undergoing primary instrumentation and fusion by three senior attendings between 2015 – 2022 were included in our study. Clinical charts and operative reports were reviewed. Cases were stratified by plastic closure status. Outcomes include estimated blood loss (EBL), surgery time, pain and ambulation outcomes, length of stay (LOS), drain output and time to removal, transfusions, and morphine consumption. Additionally, total complications were compared between the two groups, including respiratory infections and infections at 90 days, one year and two-year follow up. Continuous variables were analyzed on Kruskal-Wallis tests, while categorical variables were analyzed using Chi-Square Tests.

Results
96 patients were identified, 62 undergoing PMC. There was no significant difference in age, sex, BMI or comorbidities ($p > 0.05$). Of these patients, 26 in the PMC group and 25 in the standard group were non-ambulatory. Surgery and anesthesia time (in minutes) were 223.0 and 332.5 respectively in PMC, compared with 288.0 ($p < 0.001$) and 441.5 ($p = 0.006$) in the standard group. No differences in overall complications (27.9% vs 32.4%, $p = 0.65$),transfusions (65.0% vs. 73.5%, p=0.39) or surgical site infections at 90 days (14.8% vs 18.2%, $p = 0.77$) and two year (0% vs 3.6%, $p = 0.36$) were observed. However, the PMC group had significantly less infections at one year follow up than the standard closure group (3.2% vs 21.4%, $p = 0.01$). This difference was not observed when we isolated non-ambulatory patients.

Conclusion
Those in the PMC group had less long-term complications than those in the standard closure group, either due to technique or surgery time. However, no differences were observed in other outcomes. Therefore, it is recommended that surgeons opt for a closure approach based on preference and experience.

162. Fusionless Minimally Invasive Surgery is a Viable Alternative for Preteen Pediatric Neuromuscular and Syndromic Scoliosis Patients

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Hypothesis
Fusionless minimally invasive surgical techniques offer superior intraoperative and postoperative outcomes to traditional spinal fusion procedures in preteen pediatric neuromuscular or syndromic scoliosis patients.

Design
Retrospective Cohort Study

Introduction
Fusionless minimally invasive surgery (MIS) has emerged as a groundbreaking approach for scoliosis. In contrast to traditional fusion-based intervention, fusionless MIS promises the preservation of spinal growth, maintenance of natural biomechanics, and a reduction in perioperative complications. When considering preteens with neuromuscular or syndromic challenges, these benefits can have profound implications for functional outcomes and overall quality of life. Our study aims to shed light on the efficacy and advantages of fusionless over traditional methods for this unique patient population.

Methods
22 patients with neuromuscular or syndromic scoliosis were included in the study. 7 patients had undergone fusionless MIS during the years 2018-2019 and 15 had undergone a posterior spinal fusion (PSF) in the years 2018-2023. Clinical, surgical, and radiographic outcomes were measured. Kruskal-Wallis tests were used for continuous variables and chi-squared test was used for categorical variables.

Results
15 patients were in our fusion group as they had undergone a PSF and 7 patients were in our fusionless MIS group. The fusionless MIS group had lower EBL (p=0.02), higher preop Cobb (p=0.03), less complications (0 vs 26.7%, p=0.4), and decreased operative time (p<0.001) when compared to our fusion group.

Conclusion
At the 4-year follow up, none of the fusionless MIS patients needed revision, experienced implant failure, or had loss of correction. It is likely that the vertebra of these patients underwent spontaneous fusion, which we deem an acceptable outcome for this age group. Based on our limited experience, fusionless MIS can be utilized in the younger non-idiopathic scoliosis population using a smaller diameter rod, which at best may require 2 surgeries with better control and correction of the curve. For a complex age group and diagnoses, a fusionless MIS approach seems promising and may be a better alternative to present techniques.

163. Abstract withdrawn

164. Titanium VS Cobalt Chrome: What is the Impact on MRI Metal Artifact?

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Hypothesis
Cobalt chrome rods will not significantly affect the amount of artifact when compared to titanium rods.

Design
Retrospective, Single-Center

Introduction
Cobalt Chrome (CoCr) offers advantageous biomechanical properties for correction of spinal deformity when compared to Titanium (Ti). However, its impact on postoperative imaging is unclear, as current literature is contradictory and consists of small series that are in vitro or animal studies. This is particularly relevant to treating early onset scoliosis, as these patients have greater incidence of intraspinal pathology and often require additional MRI imaging.

Methods
Retrospective review of MRIs obtained on patients following posterior spinal fusion at a tertiary children's hospital from 2005-2018. One orthopaedic surgeon and 2 radiologists measured MRIs for area of maximal artifact, stratified by type of metal, rod diameter, and type of MRI. Each image was graded for clarity using a 1-3 scale, with 1 representing excellent clarity, 2 acceptable clarity, and 3 poor clarity.

Results
44 MRIs met the inclusion criteria, 21 CoCr and 23 Ti. The mean artifact for the CoCr rods was 33.7mm ± 8.5 compared to 30.6mm ± 8.7 for Ti, which was not significant (p=0.24). The intraclass correlation coefficient for artifact size was 0.62 [95% CI: 0.43-0.77], which was consistent with good reliability. Image clarity of CoCr was rated as 15.9% excellent, 42.9% good, and 41.3% poor compared with 23.2% excellent, 56.5% good, and 20.3% poor for Ti (p=0.03). There were 38 MRIs done with 1.5 Tesla (T), 5 done with 3T and 1 not recorded. The mean artifact on the 1.5 T was 31.3mm ± 8.0 and the mean artifact on the 3T was 38.2mm ± 12.6. Image clarity was rated as excellent in 21.9% for 1.5T vs 6.7% for 3T, good in 51.8% for 1.5T vs 40.0% for 3T, and poor in 26.3% for 1.5T vs 53.3% for 3T (p=0.11). Two patients had a metal artifact reduction sequence, one with Ti and the other with CoCr. The patient with Ti had a mean artifact of 39.8mm and poor image clarity. The patient with CoCr had a mean artifact of 24.1mm and excellent image clarity.

Conclusion
In the largest series of postoperative MRIs to date, there was a non-significant increase in artifact with CoCr implants. Metal implants and type of metal

impacted the image clarity of MRIs following pediatric spine surgery. 3T MRIs trended towards larger artifact. Further study regarding optimal scanners and sequences for postoperative patients is warranted.

165. The Effect of Body Mass Index (BMI) on Radiation Exposure and Pedicle Screw Accuracy in Intra-Operative Navigation-Guided Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS-TLIF)

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Hypothesis
Higher BMI will result in increased radiation exposure but will not affect pedicle screw accuracy

Design
Retrospective cohort

Introduction
Robotic navigation is increasingly being utilized in spine surgery. However, the effect of body habitus on the use of robotic navigation is not known. Thus, the purpose of this study was to assess the effect of BMI on perioperative outcomes, radiation exposure and screw accuracy in minimally invasive TLIF (MI-TLIF) using robotic navigation.

Methods
Consecutive patients undergoing robot-assisted 1-level MI-TLIF at a single institution (2019-2023) were selected and divided into non-obese (BMI<30) and obese (BMI>30) groups. Demographics (age, sex, BMI, ASA score, Charlson Comorbidity Index, tobacco use) and surgical parameters (operative time, blood loss, fluoroscopy time, radiation dose, pedicle screw accuracy) were compared. Pedicle screw accuracy assessed on postoperative CT was defined as good (no breach), acceptable (<4 mm superior/lateral pedicle breach, <2 mm inferior/medial pedicle breach, or tip breach), and poor (facet violation affecting superior unfused level, pedicle breach outside acceptable zone, or endplate breach)

Results
243 patients (170 non-obese, 73 obese group) were included. There were no significant differences in demographics except obese patients had higher ASA class (p=0.044) and BMI (34.3 vs 25.2 for non-obese, p<0.001). There were no significant differences in operative time, blood loss or fluoroscopy time. However, the obese group had a higher radiation dose (72.2mGy versus 47.3 for non-obese; p=0.002). After adjusting for age and sex, multivariate regression shiweded that higher BMI was associated with higher radiation dose (Standardized beta=0.26, p<0.001) and greater odds of poor screw placement (OR: 1.67, p=0.018).

Conclusion
Obese patients undergoing robot-assisted minimally invasive lumbar fusion spine surgery received higher doses of intraoperative radiation exposure and had lower accuracy of pedicle screw placement compared to non-obese patients.

166. Can We Screen for Limb Length Discrepancy on Spinal Radiographs of Patients with Scoliosis?

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Hypothesis
Femoral head height difference (FHHD) and/or iliac crest height difference (ICHD) can be used as indirect measurements of leg lengths and hence used to screen for limb length discrepancy (LLD) on PA erect scoliosis radiographs.

Design
Retrospective cohort study.

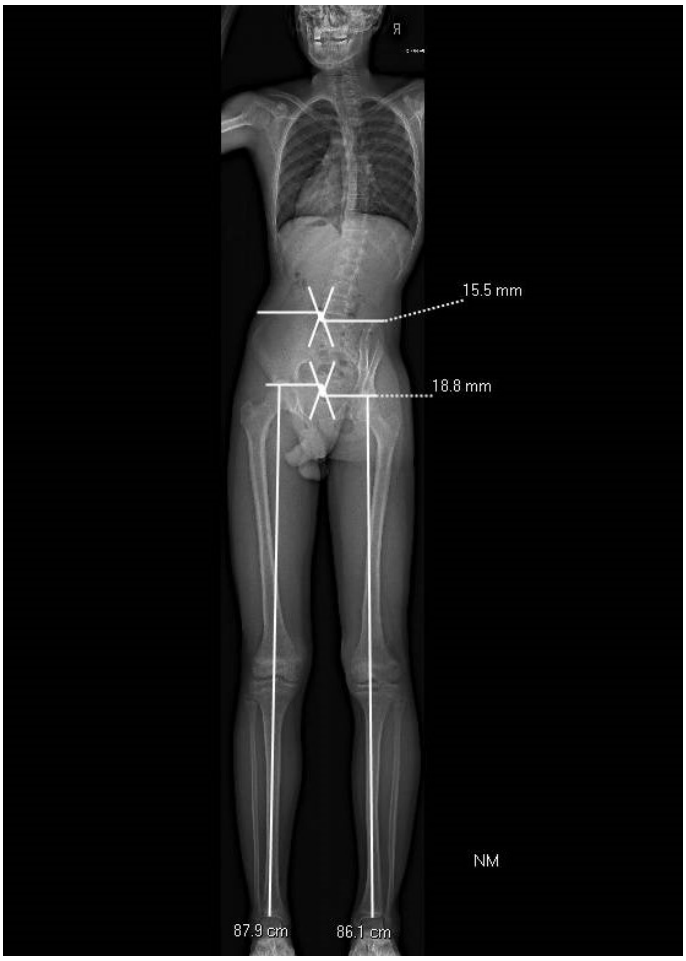
Introduction
In evaluating patients with scoliosis, it is important to exclude an associated LLD since this may contribute a functional component to the structural scoliosis. In many centers today, LLD can only be established or excluded by direct measurements of limb lengths on lower limb radiographs. The aim of this study was to determine whether height differences in the level of the iliac crests or femoral heads on erect spinal radiographs can be used as a proxy for screening and surveillance of limb LLD in patients with scoliosis.

Methods
Whole body (spine and lower limbs) PA and lateral standing radiographs of scoliosis patients acquired using slot scanning digital radiography were retrospectively reviewed. Direct measurement of each limb was taken from the top (highest point) of the femoral head to the middle of the tibial plafond; any difference between the sides was recorded as the LLD. In addition, the PACS Software tool to measure height difference was used to determine femoral head height difference (FHHD) and iliac crest height difference (ICHD). The relationships between LLD & FHHD, and LLD & ICHD were analyzed using Pearson's correlation coefficient. Bland-Altman plots were used to measure agreement between LLD & FHHD, and LLF & ICHD respectively.

Results
Over a 6-month period (Nov 2019 - Apr 2020), radiographs of 141 patients (92 females, 49 males) with an average age of 12.0 ± 2.65 years were analyzed. Patients with lower limb contractures or who did not stand with knees fully extended were excluded.

A strong correlation (r=0.730, p<0.001) was found between LLD and FFHD; the correlation between LLD and ICHD was weaker (r=0.585, p<0.001). Bland-Altman analysis showed good agreements of LLD with FHHD and ICHD.

Conclusion
FHHD and ICHD can be used to screen for LLD on spinal PA radiographs. FHHD has the better correlation with LLD and is the preferred indirect measurement



Femoral head height difference, Iliac crest height difference, & direct limb length measurement.

167. Is There Utility for Preoperative Carotid Dopplers in The Adult Spinal Deformity Population?

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Hypothesis
To assess the utility of performing preoperative bilateral carotid doppler studies to prevent postoperative cerebrovascular accident(CVA).

Design
Retrospective study

Introduction
Carotid stenosis is a comorbidity that may be exacerbated during adult spinal deformity(ASD) surgery leading to postoperative complications such as a transient ischemic attack(TIA) or cerebrovascular accident(CVA). Preoperative doppler ultrasound studies may be of utility to identify carotid stenosis and assess the extent of stenosis to optimize preoperative planning. However, given the low rate of CVA complications postoperatively in the spine pt population, the utility of these studies as a screening tool is not known.

Methods
265 pts undergoing ASD surgery by 2 surgeons at a single institution between 2017-2022 were reviewed. The official read and assessment of the extent of the carotid stenosis in the radiology report was utilized. Results of the carotid duplex ultrasound were classified as mild or no stenosis(0-49%), moderate carotid stenosis(50-69%), severe carotid stenosis(70-99%), and occluded carotids(100%). For pts w/ >50% stenosis, further chart review was done to note any preoperative intervention and 2yr FU to assess for any postoperative complications. Postoperative complications included mortality, TIA, and CVA. A CVA was defined as any new neurological deficit caused by impaired blood supply to the brain with a duration of >24hrs. Otherwise, the neurological deficit was noted as a TIA.

Results
102 pts(38.5%) had preoperative carotid duplex ultrasound studies. These pts were older(p<0.001) and had a higher rate of smoking history (p=0.029). 93 pts(91.2%) were found to have <50% stenosis bilaterally. Overall, 6 pts(5.9%) had 50-69% carotid stenosis on either internal carotid artery (ICA), 2(2.0%) had stenosis bilaterally. None of the pts had >70% stenosis, unilaterally or bilaterally. 3 pts (2.9%) had an indeterminate radiology read without a repeat study. None of the pts underwent any intervention for stenosis prior to surgery. 50 pts(49.02%) had 2yr FU data, none of which had a postoperative complication related to carotid stenosis at 2yr FU.

Conclusion
The preoperative incidence of carotid stenosis was 8.8%, with no postoperative medical complications related to the stenosis. Therefore, preoperative carotid doppler studies are of limited utility in asymptomatic pts

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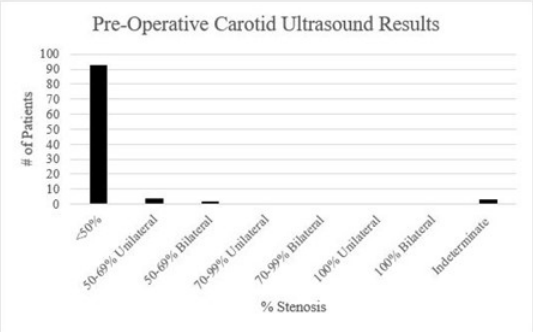
Figure 1: Pre-op Carotid Doppler Result Frequency Histogram



168. Preoperative ASA Grade Predicts Odds of 90-Day Readmission and Outcomes at 24 Months Following Anterior or Posterior CSM Surgery: A Report from The Quality Outcomes Database

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Hypothesis
QOD can be used to identify clinical risk factors for readmission and poor outcomes following CSM surgery.

Design
QOD analysis

Introduction
Cervical spinal myelopathy (CSM) is a prevalent cause of spinal cord dysfunction and is a leading cervical spine surgery indication.

Methods
Prospectively collected data from the Quality Outcomes Database registry CSM cohort were used. The primary outcome measures were 90-day readmission rates and 24-month patient reported outcomes. Statistically significant variables in univariate analysis were included in multivariate logistic regression.

Results
Of 1128 CSM patients, 62 (5.5%) were readmitted within 90 days. Readmission indications (not mutually exclusive) included 6 (0.53%) hematomas, 6 (0.53%) cases of wound dehiscence, 6 (0.53%) new spinal cord deficits, 5 (0.44%) surgical site infections, 2 (0.18%) new nerve root injuries/deficits, 2 (0.18%) cases of pain, 1 (0.09%) hardware revision, and 1 (0.09%) dysphagia case; the remaining were medical complications. Univariate analysis found increased age (OR per 1-year increase: 1.03, p=0.005), coronary artery disease (CAD) (OR: 2.5, p=0.007), and increased ASA grade (OR per 1-point increase: 2.9, p<0.001) to be significantly associated with increased 90-day readmissions. Study cohort had median ASA grade 3. Multivariate logistic regression controlling for age, BMI, ambulation status, CAD, and baseline mJOA and NDI scores found increased ASA grade (aOR per 1-point increase: 2.5, adjusted-p=0.002) to be the only studied variable significantly associated with increased 90-day readmission rates. Further, increased ASA grade was an independent predictor of decreased mJOA (Lin. Reg. Coeff=-0.67, adjusted-p<0.001), reduced quality-adjusted life year (QALY) (Lin. Reg. Coeff=-0.04, adjusted-p=0.007), and increased NDI (Lin. Reg. Coeff=3.5, adjusted-p=0.005) scores at 24 months.

Conclusion
Patients undergoing anterior or posterior CSM surgery have relatively low (5.5%) 90-day readmission rates. For CSM patients, increased ASA grade significantly predicts 90-day readmissions and poor 24-month outcomes, including mJOA, quality of life, and NDI. Careful discharge planning and thorough patient education may be indicated to reduce this risk.

169. Price Transparency for Cervical and Lumbar Spine Fusion: An Overview of the Top 50 US News & World Report Orthopaedic Hospitals

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Hypothesis
Price transparency for cervical and lumbar spine fusion procedures is currently not easily accessible or readily understandable at the majority of the top 50 US News & World Report Orthopaedic Hospitals.

Design
The top 50 orthopaedic hospitals were categorized by region and public/private status. Two investigators evaluated available cost information for cervical and lumbar spinal fusion between June and July 2023. This study analyzed the type of documents, lines of data, and the presence of a cost estimator tool.

Introduction
In an effort to improve price transparency, the Centers for Medicare and Medicaid Services (CMS) has mandated all hospitals in the US to publish charges for procedures and services. The goals of this mandate are to allow consumers to more effectively shop and compare prices across hospitals. The aims of our study are to evaluate the top 50 orthopaedic hospitals to determine compliance with this mandate and to assess the ease of finding cost information for cervical and lumbar spinal fusion.

Methods
Websites of the top 50 USNWR orthopaedic institutions were accessed to find public cost information. The document type, number of lines of data, and cost data were recorded. Cost data was queried based on associated DRG codes (459, 460, 471-473), CPT codes (22633, 22612, 22551), and standardized keyword searches.

Results
Ninety percent of hospitals provided standardized charges and shoppable services files. Machine readable file format accounted for 75% of files but often are not user friendly. DRG charges were most commonly found, present in 27-30 institutions, while CPT charges were found in 11-13 institutions. Keyword search results were rarely useful. There was an average of 742,549 rows of data per institution. Reported charges varied widely depending on use of DRG or CPT ($3,645-759,256). Charges did not differ based on public or private status. Cost estimator tools were available on 100% of the evaluated institutional websites.

Conclusion
The majority of institutions are compliant with the mandate but provide large data files with obscure charges that lack direct benefit to most patients. Cost estimator tools are increasingly being used and provide a more user friendly option but have limitations. These findings underscore a need to improve price transparency in order for patients to truly be able to use the information.

170: Abstract withdrawn

171. Interdisciplinary Preoperative Optimization Conference Mitigates the Risk of Post-Operative Complications in Adult Spinal Deformity Surgery

Josephine R. Coury, MD; Gerard F. Marciano, MD; Matan Malka, BA; Prerana Katiyar, BS; Eric Schaum, PT, DPT; Lawrence G. Lenke, MD; Ronald A. Lehman Jr., MD; Joseph M. Lombardi, MD; *Zeeshan M. Sardar, MD*; Mark Weidenbaum, MD

Hypothesis
Preoperative, interdisciplinary discussion of adult spinal deformity(ASD) pts will identify modifiable risk factors to optimize pts for surgery.

Design
Retrospective review

Introduction
ASD surgery is associated with high rates of medical and surgical complications. We developed a scoring system to stratify preoperative risk and to generate a score used to select cases for presentation to a preoperative optimization conference(POC) whose members included medical specialists, anesthesiologists, surgeons, and associated personnel. The "POC score" was used to assess planned procedures and to direct medical optimization in an effort to decrease risks of postop complications.

Methods
POC scores ranging from 0-40(Figure 1) were determined based on chart review. All pts w/ scores >10 from June 2021 to June 2022 were included. Pts w/ scores <10 were assessed as low risk and excluded from the study/discussed at POC. Demographics, medical, and surgical complications were collected and analyzed.

Results
Of the 273 pts identified w/ scores >10, 85 were presented at POC. The average score for pts included but not presented at POC was 11.1 compared to a score of 14.7 for presented pts($p<0.001$). Surgery was cancelled for 13%(11 high risk cases) of pts presented and additional medical optimization was suggested in 51%(43) of pts. Overall, previously unplanned suggestions were recommended for 91% of presented pts (ex: stress dose steroids, preoperative respiratory therapy, and measures to prevent ocular injury in a Sjogren's pt). The complication rate for pts w/ scores of 10-11 was 2-4.5% while the complication rate for pts w/ scores >12 was 40%-100%($p<0.001$). For pts w/ scores >12 the complication rate was 43%(POC 13.7, n=75) for those who had been presented as compared to 67% for those who had had not been presented(POC 13.6 n=60)($p<0.005$).

Conclusion
This study confirms that the described scoring system and interdisciplinary POC can stratify preoperative risk for pts undergoing ASD surgery. The data validated a score of 12 to be a threshold above which complication rates rose significantly. The value of presentation at POC was confirmed as post-operative complications were significantly lower for pts who had been presented. Calculating POC scores and engaging in discussion at interdisciplinary conference mitigates the risks of complications after ASD surgery.

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Figure 1. POC Scoring System.

	0	1	2	3	Score
Age	<60	>60-70	>70-80	>80	
BMI	18-29.9	<18 or 30-35(2)	>35-40 (4)	>40(6)	
Revision	No		Yes (2)		
Tobacco/Vape	No (none last 3 months)		Yes (4)		
DM			Well Controlled(2)	Uncontrolled(4) HgA1C>7.0	
Levels	<2	3-5	>6-10	>10	
Surgical Time		1-2 hrs	>3-6 hrs	>6hrs	
Neurological	None	Single limb weakness	CSM or >l limb weakness	Paralysis or Non-ambulatory	
Renal	Normal	Mild eGFR ≥60 Stage 1-2	Mod-Sev eGFR 60 Stage 3-4	HD dependent Stage V	
Pulmonary	Normal FEV1 >90	Mild COPD/Asthma FEV1 50-89%	Mod COPD FEV1 30-49%	Sev COPD FEV1 <30% or previously intubated	
Narcotic Use	None	Q 1-4 days	Q5-12 days	Daily	
Psych list all Dx					

	Yes (2)	No (0)
Have you ever had a heart attack or cardiac bypass operation?		
Do you have stents in your heart? If yes, ask your surgeon to complete the *Stent Letter*		
Do you have high blood pressure?		
Have you been diagnosed with congestive heart failure?		
Do you have atrial fibrillation or atrial flutter?		
Have you ever had a stroke or surgery on your carotid arteries?		
Have you ever been told you had a Pulmonary Embolism, Deep Vein Thrombosis or Blood Clot?		
Cardiopulmonary Score:		

COMPLEXITY SCORE:

Page 1 Subtotal _____ **+ Cardiopulmonary Score** _____ **=**

172. Predictors of Returning to Work by 5 Years After Surgery for Grade 1 Lumbar Spondylolisthesis: A QOD Study

Timothy J. Yee, MD; Vardhaan Ambati, MD; Arati Patel, MD; Samer Zammar, MD, MBA; Anthony M. DiGiorgio, DO; Domagoj Coric, MD; Eric A. Potts, MD; Erica F. Bisson, MD, MPH; Jack Knightly, MD; Kai-Ming G. Fu, MD, PhD; Kevin T. Foley, MD; Mark E. Shaffrey, MD; Mohamad Bydon, MD; Dean Chnoneou, MD; Andrew K. Chan, MD; Scott Meyer, MD; Anthony L. Asher, MD; Christopher I. Shaffrey, MD; Jonathan R. Slotkin, MD; Michael Y. Wang, MD; Regis W. Haid Jr., MD; Steven D. Glassman, MD; Paul Park, MD; Michael S. Virk, MD, PhD; Vivian Le, MPH; Praveen V. Mummaneni, MD, MBA

Hypothesis
Surgery for grade 1 spondylolisthesis allows patients to stay in the workforce at five years followup. Furthermore, a large proportion of patients who are not working before surgery are able to rejoin the workforce 5 years after surgery.

Design
Retrospective analysis of prospectively collected data

Introduction
Unemployment following surgery incurs significant societal costs. We aim to identify predictors of return to work following surgery for grade 1 lumbar spondylolisthesis.

Methods
Patients in the prospective Quality Outcomes Database Grade 1 Lumbar Spondylolisthesis module were divided into two groups: employed preoperatively and unemployed preoperatively. Univariate and multivariate instruments were used to identify predictors of return to work/employment within 5 years postoperatively.

Results
Across the 12 highest enrolling QOD sites, 604 patients had baseline employment status recorded. 275 were employed preoperatively, of which 249 had return-to-work follow-up data. Of the 329 patients unemployed preoperatively, 218 had return-to-work follow-up data. By 5 years postoperatively, 87.1% (n=217) of those employed preoperatively and 22.0% (n=48) of those unemployed preoperatively returned to work. In each cohort, there were no differences in age, gender, BMI, ASA grade, or ethnicity between those who did versus did not return to work. On multivariate analysis for preoperatively employed cohort, college degree (OR: 5.1, CI: 1.6-20.3) and active employment (OR: 6.4, CI: 1.8-23.7) remained independent predictors of returning to work. For those preoperatively unemployed, college degree (OR: 2.6, CI: 1.2-5.9) independently predicted return to work.

Conclusion
Nearly 90% of patients employed preoperatively return to work, and 22% of patients unemployed preoperatively are able to return to the workforce within 60 months after surgery for grade 1 spondylolisthesis.

53. Performance Comparison Between Hounsfield Units and Dexa in Predicting Lumbar Interbody Cage Subsidence After Circumferential Lumbar Fusion*

Kirsten A. Schuler, BS; *Lindsay D. Orosz, MS, PA-C*; Tarek Yamout, MD; Brandon J. Allen; Wondwossen T. Lerebo, PhD; Rita T. Roy, MD; Thomas C. Schuler, MD; Christopher R. Good, MD; Colin M. Haines, MD; Ehsan Jazini, MD

Hypothesis
Cutoff value CTHU<135 is associated with lumbar interbody cage subsidence and outperforms DEXA in subsidence prediction.

Design
Single-center, multi-surgeon, retrospective cohort study

Introduction
Bone mineral density assessment is essential for spinal fusion surgical planning, but gold standard dual energy x-ray absorptiometry (DEXA) is affected by degeneration often resulting in falsely elevated scores.

E-Point Presentation Abstracts

Studies on opportunistic measurement of computed tomography Hounsfield units (CTHU) suggest lower values predict interbody cage subsidence, yet cutoff values vary and lack standardization.

Methods
Circumferential lumbar fusions were retrospectively enrolled if DEXA, CT, and x-rays were available. Subsidence ≥ 2mm was assessed by validated motion detection software. Lowest DEXAany and DEXAspine T-scores were categorized (normal ≥ -1.0, -1.0 > osteopenia > -2.5, osteoporosis ≤ -2.5) and L1 CTHUs were measured. Factors associated with subsidence were determined. Logistic regression compared the predictive performance of subsidence between CTHU and DEXA.

Results
The 127-patient cohort had 96.9% degenerative pathologies, 54.3% females, median age 60 years, 2.4% osteoporosis, 44.1% CTHU<135, and 13.4% subsidence. CTHU<135 (p=0.004) and age (p=0.016) were significantly associated with subsidence; DEXA lowest T-score (p=0.550) was not. The odds of subsidence were statistically significant if CTHU<135 for crude and adjusted (OR=4.0, 95% CI 1.2-13.9, p=0.029) comparisons. The odds of subsidence were not significant if lowest T-score<-1.0 for DEXAany and DEXAspine (OR=1.8, 95% CI 0.6-4.9, p=0.284 and OR=1.1, 95% CI 0.3-4.1, p=0.920, respectively).

Conclusion
CTHU<135 was associated with subsidence while DEXA lowest T-score was not in this cohort. The odds of subsidence were 4.0 times higher for CTHU<135 after controlling for known risks, supporting this cutoff value. This study suggests that CTHU is a more reliable predictor of subsidence than DEXA and is a useful tool for assessing bone quality when planning lumbar surgery.

**Abstract moved from a podium to E-Point presentation*

Exhibit Hall Floor Plan

We encourage you to visit the exhibits throughout the meeting to learn more about the technological advances.

The IMAST Exhibitors are located in the Marriott Grand Ballroom Foyer, North Tower. For full exhibitor information, refer to the Mobile App or the digital final program.

Visit the SRS Membership Desk

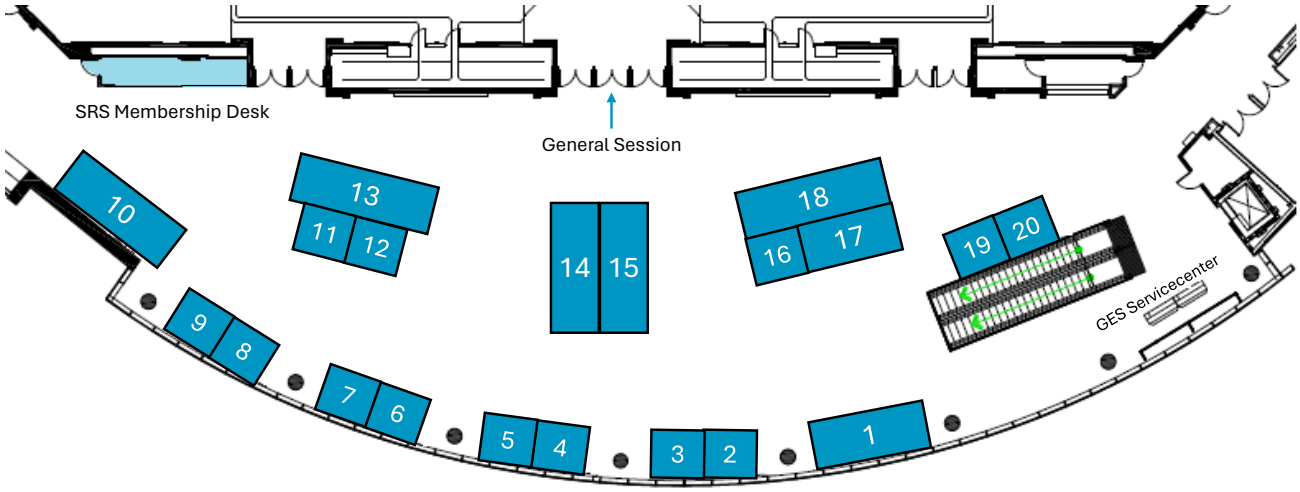
Stop by the SRS Membership Desk for information about becoming an SRS member, upcoming meetings, and more. The SRS Desk is located in the Exhibit area (Marriott Grand Ballroom Foyer).

Hours:

Wednesday, April 10 18:00 - 20:00 *(Welcome Reception 18:00 - 20:00)*

Thursday, April 11 09:00 - 17:30

Friday, April 12 08:30 - 16:00



BOOTH #	COMPANY
1	Orthofix / SeaSpine
2	IMAST Photo Booth
3	OcuTrx Technologies, Inc.
4	Expanding Innovations, Inc.
5	Momentum Health, Inc.
6	Spinal Elements
7	Carlsmed
8	SI-BONE
9	Pacira BioSciences, Inc.
10	DePuy Synthes
11	MiRus
12	Silony Spine Corp.
13	Globus Medical
14	ATEC Spine
15	Highridge Medical
16	SpineGuard, Inc.
17	Stryker
18	Medtronic
19	Mainstay Medical
20	Shanghai REACH Medical Instrument Co., Ltd

Exhibitor Descriptions

ATEC Spine | Booth #14

1950 Camino Vida Roble
Carlsbad, CA 92008 USA
www.atecspine.com

ATEC is more than a medical technology company. We are an Organic Innovation Machine™ Revolutionizing the Approach to Spine Surgery. We are committed to creating clinical distinction by developing new approaches that integrate seamlessly with EOS and the Alpha InformatiX™ System to achieve the goals of spine surgery.

Carlsmed | Booth #7

1800 Aston Ave. Suite 100
Carlsbad, CA 92008 USA
www.carlsmed.com

Carlsmed's mission is to improve outcomes and decrease the total cost of healthcare for complex spine surgery and beyond. We deliver personalized medicine at scale and are dedicated to creating transformational change in the spine industry by leveraging data-driven surgical planning and enabling the production of personalized interbody devices.

DePuy Synthes | Booth #10

325 Paramount Drive
Raynham, MA 2767 USA
www.depuysynthes.com

DePuy Synthes, part of the Johnson & Johnson Medical Devices Companies, provides one of the most comprehensive orthopaedics portfolios in the world. DePuy Synthes solutions, in specialties including joint reconstruction, trauma, craniomaxillofacial, spinal surgery and sports medicine, are designed to advance patient care while delivering clinical and economic value to health care systems worldwide. For more information, visit www.depuysynthes.com.

Expanding Innovations, Inc. | Booth #4

110 Pioneer Way, Suite I
Mountain View, CA 92107 USA
www.expandinginnovations.com

Expanding Innovations, Inc. (EI) re-imagined the conventional intra cage lifting screw and developed a revolutionary, **NON-SCREW** based expandable technology that surgeons and patients can count on. The design of *X-PAC*™ replaces the traditional intra cage screw, with a powerful, continuous lifting mechanism, supported by unidirectional locking teeth for controlled expansion. The EI portfolio includes *X-PAC* TLIF & *X-PAC* LLIF Cage Systems, as well as active development of *X-PAC* ALIF, ATP and Endo platforms.

Globus Medical | Booth #13

2560 General Armistead
Audubon, PA 19403 USA
www.globusmedical.com

Globus Medical is committed to providing innovative technologies and industry-leading clinical support to help surgeons and healthcare providers deliver better care around the globe. The Company provides one of the most comprehensive offerings of musculoskeletal solutions and enabling technologies to impact the care continuum, now including the procedurally integrated portfolio of NuVasive. The Company's employees are relentlessly focused on advancing patient care. For more information, please visit www.globusmedical.com/uniting.

Highridge Medical | Booth #15

10225 Westmoor Drive
Westminster, CO 80021 USA
www.highridgemedical.com

ZimVie Spine is dedicated to restoring daily life for patients through comprehensive spinal solutions with a focus on education, training, and clinical support for surgeons. Along with cervical disc replacement, vertebral body tethering, comprehensive spinal fixation, and fusion implants, ZimVie Spine offers minimally invasive procedural solutions and a complete suite of biologic solutions.

IMAST Photo Booth | Booth #2

Stop by the IMAST photo booth to capture a picture of yourself & colleagues to remember IMAST 2024 and get ready for IMAST 2025!

Mainstay Medical | Booth #19

2159 India St. Suite 200
San Diego, CA 92101
www.mainstaymedical.com

Mainstay Medical is a medical device company offering a new therapeutic solution for adults suffering from mechanical chronic low back pain (CLBP). ReActiv8 Restorative Neurostimulation is a rehabilitative therapy designed to address impaired neuromuscular control and degeneration of the multifidus muscle linked to mechanical CLBP.

Exhibitor Descriptions

Medtronic | Booth #18

710 Medtronic Parkway
Minneapolis, MN 55432 USA
www.medtronic.com

We lead global healthcare technology, boldly attacking the most challenging problems. Our Mission — to alleviate pain, restore health, and extend life — unites a global team of 90,000+ people, and our technologies transform the lives of two people every second, every hour, every day. Expect more from us. Medtronic. Engineering the extraordinary.

MiRus | Booth #11

1755 W. Oak Parkway Suite 100
Marietta, GA 30062 USA
www.mirusmed.com

MiRus is a life sciences company headquartered in Marietta, Georgia that has developed and is commercializing proprietary novel biomaterials, implants and procedural solutions for the treatment of spine, orthopaedic and structural heart disease. Inspired by the pioneering material science of NASA for rocket engines, MiRus has created Rhenium based medical alloys that are transforming medicine by making surgeries less invasive and implants safer and more durable. Find out more information about MiRus at www.mirusmed.com.

Momentum Health | Booth #5

109-2727 Rue Saint-Patrick
Montral/ Quebec, Canada H3A 0K8
www.momentum.health

Momentum Health is a digital health company leveraging remote 3D imagery and artificial intelligence to revolutionize musculoskeletal medicine, led by Chief Medical Officer and Orthopedic Surgeon, Dr. Jean Ouellet.

Momentum Spine is designed to connect spinal deformity patients to their physician securely and remotely. The mobile application employs smartphone cameras to recreate a true-to-scale three-dimensional model of the body from a simple 15-second video. Momentum Spine's proprietary algorithms analyze the 3D topography to predict the internal anatomy of the spine. In other words, Momentum Spine quantifies the extra-spinal deformities (what we can see from the outside with the naked eye) and correlates them to the Cobb Angle (what we can only see on X-rays) to predict the severity progression of the deformity. Automatic feature extraction, such as shoulder imbalance and trunk asymmetry, are also calculated via computer vision to provide both the clinician and the patient with a global picture of the deformity. Overall, instead of offering the same treatment algorithm to everyone, patients benefit form an augmented, individualized standard of care. Momentum Spine's imagery-guided AI predictions allow physicians to stratify patients by severity, intervene timely and follow progress closely to ensure an optimized and personalized standard of care. Momentum Spine is FDA Cleared and approved by Health Canada as a software as a medical device.

Momentum Health's mission is to empower patient's and clinicians to remotely manage care by digitizing the human body and transforming smartphones into the next-generation, patient-centered imaging platform.

Ocutrx Technologies Inc. | Booth #3

31642 Coast Highway, Ste 200
Laguna Beach, CA 92651 USA
www.ocutrxtech.com

Ocutrx Technologies, Inc. is developing the DigiLoupe™ AR/XR headset, a revolutionary solution designed to transform the landscape of spinal surgery and orthopedic procedures. Unlike traditional loupes, which often impose ergonomic challenges on surgeons, the DigiLoupe headset offers unparalleled comfort and flexibility. By incorporating cutting-edge technology, DigiLoupe offers higher resolution, greater magnification (up to 10x), and 3D holographic imaging of the surgery site. This AR/XR headset is not merely an enhancement, it represents a paradigm shift in surgical precision and ergonomics. Surgeons using the DigiLoupe headset can maintain optimal positioning throughout procedures, minimizing strain and discomfort, while maximizing accuracy and efficiency. Under the guidance of esteemed experts like Dr. Leonel Hunt, M.D., who brings invaluable experience to Ocutrx's Medical Advisory Board, the company continues to expand on it's AR/XR solutions and further push the boundaries of innovation. See the shaping future of surgery for yourself – visit us at booth #3 during IMAST.

Orthofix / SeaSpine | Booth #1

3451 Plano Parkway
Lewisville, TX 75056 USA
www.orthofix.com

The newly merged Orthofix-SeaSpine organization is a leading global spine and orthopedics company with a comprehensive portfolio of biologics, innovative spinal hardware, bone growth therapies, specialized orthopedic solutions and a leading surgical navigation system. Its products are distributed in approximately 68 countries worldwide. The company is headquartered

Exhibitor Descriptions

in Lewisville, Texas and has primary offices in Carlsbad, CA, with a focus on spine and biologics product innovation and surgeon education, and Verona, Italy, with an emphasis on product innovation, production, and medical education for orthopedics. The combined company's global R&D, commercial and manufacturing footprint also includes facilities and offices in Irvine, CA, Toronto, Canada, Sunnyvale, CA, Wayne, PA, Olive Branch, MS, Maidenhead, UK, Munich, Germany, Paris, France and São Paulo, Brazil. To learn more, visit Orthofix.com.

Pacira BioSciences, Inc. | Booth #9

5 Sylvan Way, Suite 300
Parsippany, NJ 07054 USA
www.pacira.com

Pacira BioSciences, Inc. (Nasdaq: PCRX) is committed to providing a non-opioid option to as many patients as possible to redefine the role of opioids as rescue therapy only. The company is also developing innovative interventions to address debilitating conditions involving the sympathetic nervous system, such as cardiac electrical storm, chronic pain, and spasticity. Pacira has three commercial-stage non-opioid treatments: EXPAREL® (bupivacaine liposome injectable suspension), a long-acting, local analgesia currently approved for postsurgical pain management; ZILRETTA® (triamcinolone acetonide extended-release injectable suspension), an extended-release, intra-articular, injection indicated for the management of osteoarthritis knee pain; and iovera°®, a novel, handheld device for delivering immediate, long-acting, drug-free pain control using precise, controlled doses of cold temperature to a targeted nerve. To learn more about Pacira, including the corporate mission to reduce overreliance on opioids, visit www.pacira.com.

Shanghai REACH Medical Instrument Co., Ltd. | Booth #20

13th Building, No.999 Jiangyue Road, Minhang District, 201114
Shanghai, China,
www.reach-med.com

REACH is founded in 2006, has been a pioneer in the innovative design of various spine implants for nearly 20 years. Accredited by CE, FDA, TGA and ISO13485, REACH products have been successfully sold to many countries and been highly regarded for their superior quality and excellent services.

SI-BONE | Booth #8

471 El Camino Real, Suite 101
Santa Clara, CA 95050 USA
www.si-bone.com/providers

SI-BONE, Inc. is a global leading medical device company specializing in *Sacropelvic Solutions*™. SI-BONE utilizes its *iFuse Technology*® to develop products to treat degenerative conditions, adult spinal deformity, and pelvic trauma. The *iFuse Implant System*®, a proprietary minimally invasive surgical implant system to fuse the sacroiliac joint, was launched in 2009 to treat sacroiliac joint dysfunction. The iFuse Implant System portfolio has expanded to include *iFuse Bedrock Granite*® to provide a solid foundation in spinal deformity surgery, and *iFuse TORQ*® for treatment of pelvic trauma including sacral fragility and insufficiency fractures. With more than 85,000 procedures worldwide performed by 3,000+ surgeons, and 120+ publications, iFuse is the leading choice in the surgical treatment of sacropelvic disorders.

Silony Spine Corp | Booth #12

8200 NW 27th St, STE# 104
Doral, FL 33122 USA
www.silonyspine.com

Established in 2013 by the internationally renowned Schoen Clinic hospital group, Silony Spine is a market disrupter aiming to change the status quo of how product manufacturers partner with hospital systems. Silony Spine curates and designs spinal hardware and tools that provide surgeons and hospitals with high-value product solutions that are highly compatible with enabling technologies.

Spinal Elements | Booth #6

3115 S Melrose Dr. STE 200
Carlsbad, CA 92010 USA
www.spinalelements.com

Spinal Elements is a medical device company focused on the design, development, and commercialization of a comprehensive portfolio of systems, products, and technologies for spine surgery procedures. A leading designer, developer, manufacturer, and marketer

Exhibitor Descriptions

of innovative medical devices used in spinal surgical procedures, Spinal Elements combines leading medical device technologies, biologics, and instrumentation to create positive surgical outcomes that exceed surgeon and patient expectations. Spinal Elements has built a reputation delivering innovative and differentiated technologies that enable fundamental shifts in solutions for spine surgery. The company markets a complete portfolio of advanced spinal implant technologies.

Learn more at spinalelements.com.

SpineGuard Inc. | Booth #16

1434 Spruce Streer Suite 100
Boulder, CO 80302 USA
www.spineguard.com

SpineGuard is an innovative company deploying its proprietary radiation-free real time sensing technology DSG® (Dynamic Surgical Guidance) to secure and streamline the placement of implants in the skeleton. SpineGuard designs, develops, and markets medical devices embedding its technology. Over 100,000 surgical procedures have been secured worldwide thanks to DSG® and 32 studies published in peer-reviewed scientific journals have demonstrated the multiple benefits DSG® offers to patients, surgeons, surgical staff and hospitals. Building on these strong fundamentals and several strategic partnerships, SpineGuard is expanding the scope of its DSG® technology to the treatment of scoliosis via anterior approach, sacroiliac joint fusion, dental implantology and innovations such as the "smart" pedicle screw and power drill or surgical robotics.

Stryker | Booth #17

600 Hope Parkway
Leesburg, VA 20175 USA
www.strykerspine.com

Stryker is a global leader in medical technologies and, together with its customers, is driven to make healthcare better. The company offers innovative products and services in MedSurg, Neurotechnology, Orthopaedics and Spine that help improve patient and healthcare outcomes. Alongside its customers around the world, Stryker impacts more than 130 million patients annually. More information is available at www.stryker.com.

Hands-On Workshops

IMAST delegates are encouraged to attend the Hands-On Workshops (HOWs). Each workshop is programmed by a single- supporting company and will feature presentations on topics and technologies selected by the company. Catering will be served at each Workshop.

**Please note: CME credits are not available for Hands-On Workshops.*

Thursday, April 11, 2024	Friday, April 12, 2024
08:00 - 09:00 *(includes breakfast)*	**11:30 - 12:30** *(includes lunch)*
1. Augmedics	1. Amgen
2. Orthofix / SeaSpine	2. ATEC Spine
3. SI-BONE	3. DePuy Synthes
4. Stryker	4. Pacira BioSciences, Inc.
12:00 - 13:00 *(includes lunch)*	
1. DePuy Synthes	
2. Globus Medical	
3. Medtronic	
4. Highridge Medical	

THURSDAY, APRIL 11 | 08:00 - 09:00

AUGMEDICS

Marriott Grand Ballroom Salon 12

Augmented Reality (AR) in Minimally Invasive and Complex Spine: Early Experience & Technique Pearls

This hands-on technology workshop will focus on the innovative application of augmented reality (AR) navigation in minimally invasive and complex spine procedures. Led by Dr. Raj Sethi and Dr. Venu Nemani, this one-hour session will focus on:

- Case-based application of AR navigation in spine procedures
- Early experience with AR adoption and learning curve
- Technique pearls for safety, accuracy, and efficiency

In addition to the didactic session, participants will receive hands-on training with the Augmedics xvision Spine System. Upon completion, attendees should be able to assess and evaluate the advantages and disadvantages of AR navigation for the treatment of spinal conditions.

Faculty: Rajiv K. Sethi, MD, Venu M. Nemani, MD, PhD

ORTHOFIX / SEASPINE

Marriott Grand Ballroom Salon 1

As Fast as Freehand: How 7D Flash Navigation Elevates My Deformity Practice

Join us for a case discussion and hands-on workshop surrounding the 7D FLASH Navigation System, a radiation-free navigation solution for complex spinal procedures. Listen to our esteemed surgeon panel share their own personal experience of how this technology has enhanced their practice without adding time or disruption of workflow in the OR. Truly navigation on demand!

Surgeon Presenters: Khaled M. Kebaish, MD, Tyler R. Koski, MD, Gregory M. Mundis. Jr, MD

SI-BONE

Marriott Grand Ballroom Salon 10

Sacropelvic Fixation - Why, When & How?

Please join us in this case-based presentation, reviewing the common complications in spinal deformity and how to implement the latest surgical strategies to reduce the 24% sacropelvic fixation failure rate. We will uncover your high-risk patients and review the emerging considerations for sacropelvic fixation in both short and long constructs.

Speakers: Sigurd Berven, MD and Isador Lieberman, MD

Hands-On Workshops

STRYKER
Marriott Grand Ballroom Salon 3
Intra-Operative CT Imaging and Surgical Navigation in Pediatric Neuromuscular Scoliosis

Join Dr. Upasani and Stryker as we breakdown the surgical benefits of utilizing Airo TruCT and the Q Guidance System with Spine Guidance Software for treating pediatric neuromuscular scoliosis using the Everest Deformity Spinal System.

Faculty: Dr. Vidyadhar Upasani

THURSDAY, APRIL 11 | 12:00 - 13:00

DEPUY SYNTHES
Marriott Grand Ballroom Salon 10
Surgical Techniques in Complex Reconstruction for Adults

Dive deep into real-world cases with seasoned thought leaders covering topics on cervicothoracic deformity, coronal deformity, VCR, PSO, and more. Engage in lively discussions and exchange insights on surgical techniques for complex reconstruction in adults.

Moderator: Munish C. Gupta, MD
Faculty: Ioannis Avramis, MD; Ali A. Baaj, MD; Alekos A. Theologis, MD

GLOBUS MEDICAL
Marriott Grand Ballroom Salon 12
Emerging Technologies That Will Help Define the Future of Deformity Surgery

Please join this surgeon-led workshop to learn more about the latest evolution of enabling technology for deformity surgery from Globus® Medical. Discover the newest addition to the portfolio that is designed to help surgeons create an intelligent pre-operative plan to restore the patients' global spinal alignment. Then learn how to precisely execute a surgical plan using innovative robotics, imaging, and power tools.

Product Focus: Adult Deformity
Faculty: Themistocles Protopsaltis, MD

HIGHRIDGE MEDICAL
Marriott Grand Ballroom Salon 3
Innovative Solutions for Idiopathic Scoliosis: Non-fusion and Fusion

Discussion on the benefits of VBT and PSF options and how to avoid pitfalls through optimized techniques.

Faculty: Firoz Miyanji, MD, Josh Pahys, MD, Michael Vitale, MD

MEDTRONIC
Marriott Grand Ballroom Salon 1
The Evolving Role of Robotics, Data, and AI in Deformity Spine Surgery

As the demand for customized care increases, Medtronic is delivering a connected ecosystem of technology, people, and solutions through AiBLE - a customizable healthcare solution that integrates connected care and predictive technology to advance surgery in the pursuit of better patient outcomes. This workshop will provide a unique opportunity to discover how spine surgeons are leveraging artificial intelligence-driven surgical planning, patient-specific spinal implants for complex constructs, and robotic-assisted surgical delivery into their practice. Join us to learn how Medtronic is partnering with surgeons to advance surgery in pursuit of better patient outcomes.

Moderator: Dr. Christopher Shaffrey
Faculty: Dr. Ronald Lehman and Dr. Joseph Osorio

Hands-On Workshops

FRIDAY APRIL 12 | 11:30 - 12:30

AMGEN

Marriott Grand Ballroom Salon 3

Postmenopausal Osteoporosis - Relevant Information for the Spine Care Provider

Osteoporosis is common in patients undergoing spine deformity surgery. The workshop is intended to provide update on the diagnosis and management of osteoporosis for spine care provider. The workshop consists of an instructor-led lecture and interactive Q&A IMAST 2024 attendees who are interested in bone health, osteoporosis and bone quality are welcome to attend.

Moderator: Dr. Robert Eastlack, Scripps Health

Presenter: Dr. Peter Passias, Duke University

ATEC SPINE

Marriott Grand Ballroom Salon 12

Defining the Future of Deformity Surgery: Patient-Specific Care through Data-Driven Solutions

You are invited to join our esteemed surgeon panel for a case-based discussion highlighting the crucial role of information, technology, and AI in addressing the most critical challenges and complications in complex deformity surgery. Share your insights and collaborate with peers in defining strategies aimed at improving outcome predictability through standardized, well-informed end-to-end care.

Faculty: Tyler Koski, MD, Rajiv Sethi, MD, Virginie LaFage, PhD

DEPUY SYNTHES

Marriott Grand Ballroom Salon 1

Next-Gen Spine Surgery: Redefining Enabling Technology | Fireside Chat

Join us for a captivating Fireside Chat where cutting-edge enabling technology meets real-world impact. From groundbreaking advancements to practical adoption. This session will inspire, educate, and spark meaningful conversations that is shaping the future of MedTech.

Faculty: Eric O. Klineberg, MD (Moderator); Christopher P. Ames, MD; Jennifer M. Bauer, MD; Isador H. Lieberman, MD

PACIRA BIOSCIENCES, INC.

Marriott Grand Ballroom Salon 10

Innovative Post-Operative Pain Management Techniques for Adult and Pediatric Spine Surgery

Join this interactive session which will discuss new and evolving pain management strategies to manage post-surgical pain in both pediatric and adult spine surgery. Live erector spinae plane (ESP) and transversus abdominus plane (TAP) blocks will be demonstrated on a live model for both ultrasound and fluoroscopy guided approaches in addition to technique and dosing options for the use of liposomal bupivacaine.

Faculty: Daniel M. Sciubba, MD, MBA; Robert H. Cho, MD

Author Disclosures

Name	Country	Disclosure(s)
Board of Directors		
Lindsay M. Andras, MD	United States	OrthoPediatrics (g); Eli Lilly (c); Journal of Pediatric Orthopaedics (e); NuVasive (b, d); Orthobullets (b, d, g); Pediatric Orthopaedic Society of North America (e); Scoliosis Research Society (e); Medtronic (d)
Laurel C. Blakemore, MD	United States	Stryker Spine (g); Medtronic (b)
Douglas C. Burton, MD	United States	DePuy Synthes (a, b, g); Globus (b, g); Blue Ocean (b, g); Progenerative Medical (c)
Marinus de Kleuver, MD, PhD	Netherlands	Medtronic (d, e)
Ron El-Hawary, MD	Canada	DePuy Synthes (a, b); Medtronic (a, b); OrthoPediatrics (b, c, e); Zimmer Biomet (a)
Munish C. Gupta, MD	United States	DePuy Synthes (b, e, g); Medtronic (b, e, g); Globus Medical (b, g); Innomed (g); Broadwater-travel for faculty (g); OMeGA-grant paid to institution for fellowship (g); AO Spine-grant paid to institution for fellowship; honorarium, travel (g); J&J (c); SRS-Board of Directors, travel for faculty (g); Honorarium-LSU (g); AO Spine -travel for faculty (g); National Spine Health Foundation-voluntary, no monies (g); Scoliosis Research Society-Board of Directors, travel for faculty courses (g); Zimmer for training (g)
Eric O. Klineberg, MD	United States	DePuy Synthes (b); Stryker Spine (b, g); Medtronic (a, b); AOSpine (a, d, e); SI Bone (b); Agnovos (b); Seaspine (b); MMI (c); Relatable (c); IMAST (e); SRS (e)
Firoz Miyanji, MD	Canada	DePuy Synthes (b); Zimmer Biomet (b, g); Stryker Spine (b); AO Fracture, Tumour, and Deformity Expert Group (e); OrthoPediatrics (b)
Praveen V. Mummaneni, MD, MBA	United States	Globus Medical (b); Stryker Spine (b); DePuy Synthes (b, g); BK Medical (b); Spinicity/ISD (c); Thieme Publishers (g); Springer Publishers (g); ISSG (a); AO spine (a); NREF (a); NIH (a); NuVasive (b); Brainlab (b); SI Bone (e); PCORI (a); SLIP II (a); Pacira (a); Discgenics (a)
Ferran Pellisé, MD, PhD	Spain	DePuy Synthes (a); Medtronic (a, b)
Christopher I. Shaffrey, MD	United States	NuVasive (a, b, c, g)
Suken A. Shah, MD	United States	DePuy Synthes (a, b, e, g); Stryker Spine (a, g); Globus Medical (a, b); Setting Scoliosis Straight Foundation (a, e); Pacira BioSciences (b)
David L. Skaggs, MD, MMM	United States	Zimmer Biomet (b, d, g); Medtronic (g); Globus Medical (b, g); Wolters Kluwer Health (g); Zipline Medical, Inc. (c); Green Sun Medical (c); Orthobullets (b, c, e); Top Doctors (c); NuVasive (a)
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About SRS

Scoliosis Research Society

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 1,600 health care professionals.

Mission Statement

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

DEI Statement

Diversity Equity & Inclusion

The SRS recognizes the benefit of bringing the knowledge, perspectives, experiences, and insights of a diverse membership to our society. We are committed to including outstanding members from the broad spectrum of human ethnicities, genders, sexual orientations, national origins, geographic backgrounds, abilities, disabilities, religious beliefs, and ages. We will create a culture that is equitable and inclusive, where everyone has a voice and differences are celebrated. By building a membership and leadership who better reflect the diverse communities we study and care for, we foster better and more equitable care for patients with spinal disorders.

Membership

SRS is open to orthopaedic surgeons, neurosurgeons, researchers, and allied health professionals who have a practice that focuses on spinal deformity. Visit www.srs.org/membership for more information on membership types, requirement details, and to apply online.

Programs and Activities

SRS is focused primarily on education and research that include the Annual Meeting, the International Meeting on Advanced Spine Techniques (IMAST), Regional Courses, the Research Education Outreach (REO) Fund, which provides grants for spine deformity research, and development of patient education materials.

Website Information

For the latest information on SRS meetings, programs, activities, and membership please visit www.srs.org. The SRS Website Committee works to ensure that the website information is accurate, accessible, and tailored for target audiences. Site content is varied and frequently uses graphics to stimulate ideas and interest. Content categories include information for medical professionals, patients/ public, and SRS members.

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Social Media

Join the conversation surrounding IMAST by including #SRSIMAST24 in your social media posts.

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Save the Dates

Current Concepts in Spine Deformity

This curriculum-based, interactive regional course is designed for 150-200 delegates by the Scoliosis Research Society and regionally representative SRS members. These courses combine lectures, case presentations, and panel discussions covering a broad range of spinal deformity issues. SRS Regional Courses also include Industry Workshops and an Exhibit Hall.

For orthopaedic and neurosurgeons who have completed specialty training, who practice spine surgery and have an interest in operative and non-operative treatment of patients with spinal deformity.

Spine Deformity Solutions: A Hands-On Course

The SRS hands-on courses provide an opportunity for participants to expand their knowledge and improve their skills through training and discussions with leading spinal deformity surgeons from throughout the world. Registration will be limited to ensure access to faculty, small-group interaction for better learning, and opportunities for hands-on work. A minimum of eight hours of the course will be devoted to lab work, with a strong faculty-to-learner ratio. Topics and lab sessions will cover all areas of the spine and a variety of conditions and techniques. The intimate learning theme will begin on night one with small group “Fireside Chats” with faculty and will proceed to presentations, video demonstrations and lab rotations on day 2 and 3.

Meeting Overview

WEDNESDAY, APRIL 10		
15:00 - 18:00	Registration Open	Marriott Grand Ballroom Entrance
15:00 - 18:00	Speaker Ready Room Open	San Diego Ballroom A
16:00 - 18:00	Cases & Cocktails 1-3 *(concurrent sessions)* **C&C1** **C&C2** **C&C3**	 Marriott Grand Ballroom Salon 1 Marriott Grand Ballroom Salon 10 Marriott Grand Ballroom Salon 12
18:00 - 20:00	Welcome Reception*	Marriott Grand Ballroom Foyer
THURSDAY, APRIL 11		
07:00 - 18:00	Registration Open	Marriott Grand Ballroom Entrance
07:00 - 18:00	Speaker Ready Room Open	San Diego Ballroom A
08:00 - 09:00	Hands-On Workshops* *(concurrent sessions)* **Orthofix / SeaSpine** **Stryker** **SI-BONE** **Augmedics**	 Marriott Grand Ballroom Salon 1 Marriott Grand Ballroom Salon 3 Marriott Grand Ballroom Salon 10 Marriott Grand Ballroom Salon 12
09:00 - 09:30	Refreshment Break & Exhibit Viewing*	Marriott Grand Ballroom Foyer
09:30 - 11:45	**Abstract Session 1**	Marriott Grand Ballroom Salons 5-9
11:45 - 12:00	Lunch Pick-Up	Marriott Grand Ballroom Foyer
12:00 - 13:00	Hands-On Workshops* *(concurrent sessions)* **Medtronic** **Highridge Medical** **DePuy Synthes** **Globus Medical**	 Marriott Grand Ballroom Salon 1 Marriott Grand Ballroom Salon 3 Marriott Grand Ballroom Salon 10 Marriott Grand Ballroom Salon 12
13:00 - 13:30	Break & Exhibit Viewing*	Marriott Grand Ballroom Foyer
13:30 - 15:00	Sessions 2A & 2B *(concurrent sessions)* **Education Session 2A** **Abstract Session 2B**	 Marriott Grand Ballroom Salons 5-9 San Diego Ballroom B&C
15:00 - 15:30	Refreshment Break & Exhibit Viewing*	Marriott Grand Ballroom Foyer
15:30 - 17:00	Sessions 3A & 3B *(concurrent sessions)* **Education Session 3A** **Abstract Session 3B**	 Marriott Grand Ballroom Salons 5-9 San Diego Ballroom B&C
17:00 - 17:30	Break & Exhibit Viewing*	Marriott Grand Ballroom Foyer
17:30 - 18:30	**Education Session 4**	Marriott Grand Ballroom Salons 5-9
FRIDAY, APRIL 12		
07:00 - 18:00	Registration Open	Marriott Grand Ballroom Entrance
07:00 - 18:00	Speaker Ready Room Open	San Diego Ballroom A
07:30 - 08:45	Abstract Sessions 5A-5D *(concurrent sessions)* **Abstract Session 5A** **Abstract Session 5B** **Abstract Session 5C** **Abstract Session 5D**	 Marriott Grand Ballroom Salon 1 Marriott Grand Ballroom Salon 3 Marriott Grand Ballroom Salon 10 Marriott Grand Ballroom Salon 12
08:45 - 09:00	Refreshment Break & Exhibit Viewing*	Marriott Grand Ballroom Foyer
09:00 - 11:00	**Education Session 4 & Keynote Speaker**	Marriott Grand Ballroom Salons 5-9
11:00 - 11:30	Lunch Pick-Up & Exhibit Viewing*	Marriott Grand Ballroom Foyer
11:30 - 12:30	Hands-On Workshops* *(concurrent sessions)* **DePuy Synthes** **Amgen** **Pacira BioSciences, Inc.** **ATEC Spine**	 Marriott Grand Ballroom Salon 1 Marriott Grand Ballroom Salon 3 Marriott Grand Ballroom Salon 10 Marriott Grand Ballroom Salon 12
12:30 - 12:45	Break & Exhibit Viewing*	Marriott Grand Ballroom Foyer
12:45 - 14:15	Education Sessions 7A & 7B *(concurrent sessions)* **Education Session 7A** **Education Session 7B**	 Marriott Grand Ballroom Salons 5-9 San Diego Ballroom B&C
14:15 - 14:30	Refreshment Break & Exhibit Viewing*	Marriott Grand Ballroom Foyer
14:30 - 16:05	**Education Session 8**	Marriott Grand Ballroom Salons 5-9
16:15 - 18:00	**Innovation Celebration***	South Patio Pool

**Denotes non-CME session*