SRS
Scoliosis Research Society

Final Program

29TH IMAST

INTERNATIONAL MEETING ON ADVANCED SPINE TECHNIQUES

Powered by the Scoliosis Research Society

April 6-9, 2022 | Miami, Florida, USA

2022 Corporate Supporters

We are pleased to acknowledge and thank those companies that provided financial support to SRS in 2022. 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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29th IMAST VENUE

InterContinental Miami
100 Chopin Plaza
Miami, Florida, USA 33131

FUTURE EDUCATIONAL EVENTS

Annual Meeting

57th Annual Meeting
September 14-17, 2022 | Stockholm, Sweden

58th Annual Meeting
September 6-9, 2023 | Seattle, WA, USA

59th Annual Meeting
September 11-14, 2024 | Barcelona, Spain

60th Annual Meeting
September 17-20, 2025 | Charlotte, NC, USA

61st Annual Meeting
October 7-10, 2026 | Sydney, Australia

International Meeting on Advanced Spine Techniques

30th IMAST
March 22-25, 2023 | Dublin, Ireland

31st IMAST
April 10-13, 2024 | San Diego, CA, USA

Welcome to the 29th IMAST

Dear Colleagues and Attendees,

I would like to personally welcome you to the 29th International Meeting for Advanced Spine Techniques, powered by the Scoliosis Research Society, in support of our continued advancements in spine surgery innovation. After two years apart, we are excited to assemble back together!

Of the 500+ abstracts submitted, we have selected 75 podium presentations to be showcased at IMAST. A not-to-be missed highlight is the much-anticipated, prestigious Whitecloud award-nominated scientific session, where the top 15 abstracts for best clinical and basic science/translational research will be presented on Thursday, April 7. There will also be 90+ E-Posters available online for viewing.

We also are pleased to offer the popular "Cases & Cocktails" session again this year. These sessions take place Wednesday evening, April 6, and will continue to be a great opportunity for attendees to discuss important cases in small groups with an IMAST faculty member present at each table. This year's innovative topics are VBT Disasters & Revisions, Cervical and Adult Trauma, Worst Neuromonitoring Disasters and Lessons Learned, and Adjacent Segment Failure/Breakdown.

As part of the interactive and innovative program we have planned, three sessions are also offered through the SRS-AANS Joint Task Force. Be sure to stay through Saturday, as we will conclude with the attendee favorite, "Lunch with the Experts."

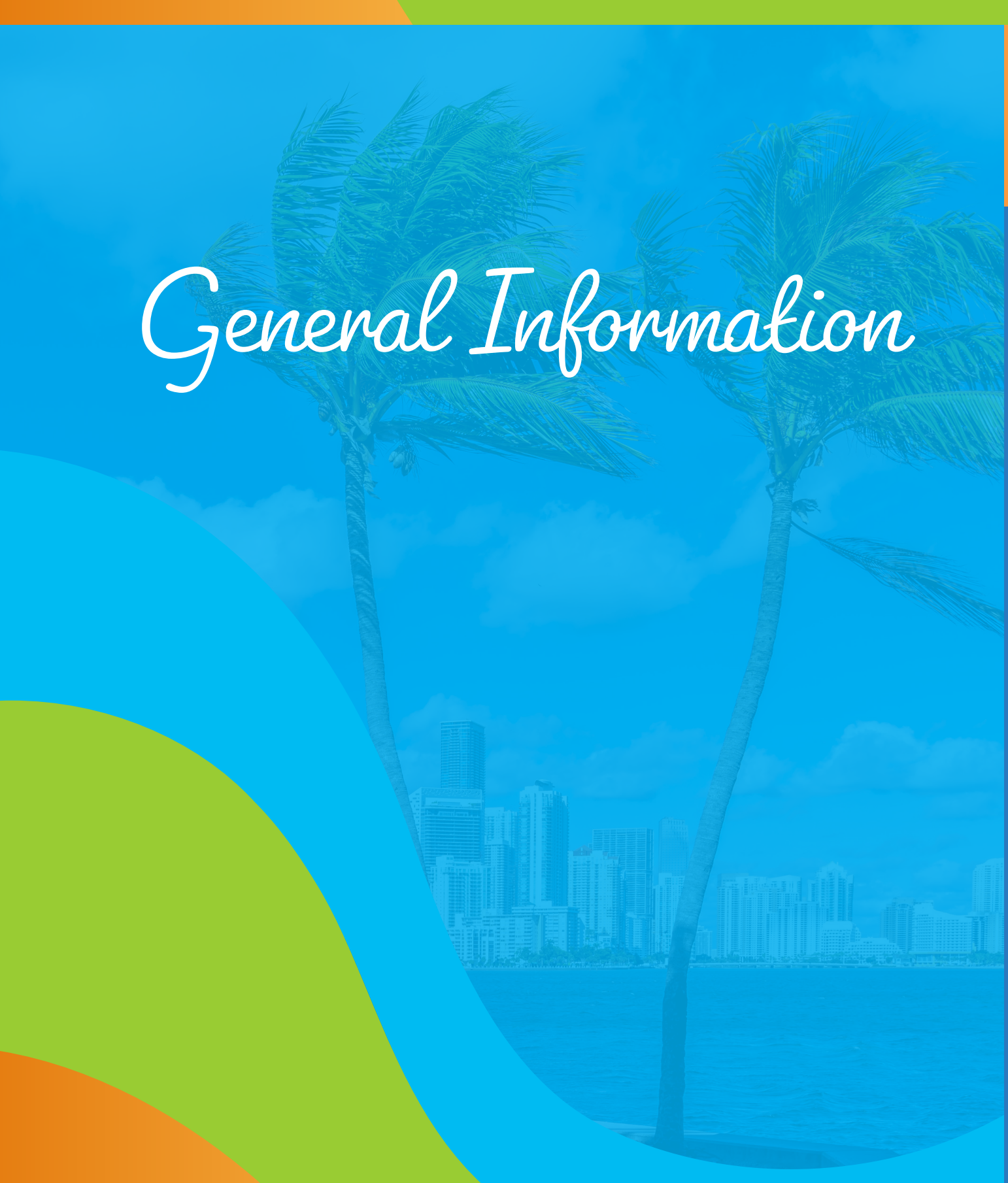
A special thank you to our industry partners, who are excited to be back in person with us. Make sure to plan your schedule accordingly so that you can see all of the latest innovations in the exhibit hall and during the Hands-on Workshops. More information on these can be found beginning on page 185.

The planning committee has invested significant time and thought to ensure that every participant has an educational, enjoyable, and safe experience. It is a pleasure to welcome you to Miami!

With Warm Regards,

Ahmet Alanay, MD
IMAST Committee Chair

General Information



The Scoliosis Research Society gratefully acknowledges Globus Medical, Medtronic and ZimVie for their grant support of the IMAST Early Career Surgeon Session.

IMAST Mobile App

A mobile app will be available to all delegates during the 29th 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 smartphone or tablet with an internet connection.

TO DOWNLOAD THE 29th IMAST MOBILE APP:

1. Search for "SRS 29th IMAST" 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, log in 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 log in with an email address).
- Exhibitor information including exhibit floor plan, company descriptions and the Hands-On Workshop schedule.
- Map of meeting space
- An alert system for real-time updates from SRS and breaking news as it happens.
- Session and overall meeting evaluations
- Live polls and the "Ask a Question" feature allowing you to submit questions during specific sessions
- Final Program and Abstracts
- Participate in gamification! This is a unique way to interact with your peers and engage with the presenters by collecting codes to earn points. Delegates with the most points will collect prizes.

**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 specific 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. Click "Q&A" tab at the top of the page.
3. Type your question in the text box at the bottom and click "Submit." Your question will appear within the question list.
4. If someone has asked a question you would like answered, you can "upvote" the question by clicking the 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 increases.

PARTICIPATE IN LIVE SESSION POLLS

To participate in a session poll, click the "Polls" tab at the top of the page. 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.

#SRSIMAST22

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General Meeting Overview

MEETING DESCRIPTION

The 29th IMAST will offer an in-person and virtual 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. The program includes live sessions streamed directly from Miami and E-Posters. IMAST focuses on innovative and new methods/techniques for spinal pathology. Educational content includes instructional course lectures, four-minute paper presentations, case discussions, E-Posters, and industry workshops, all lead by a multidisciplinary and international faculty.

LEARNING OBJECTIVES

Upon completion of IMAST, participants should be able to:

- Analyze current research on new and future spine deformity treatments
- Identify appropriate candidates for minimally invasive surgery
- Evaluate popular approaches for continued relevance and improvement
- Utilize alignment goals for prevention of proximal junctional kyphosis
- Integrate robotics and navigation technology to assist surgery for pediatric and adult patients

TARGET AUDIENCE

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

General Meeting Information

ADMISSION TO SESSIONS

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

ATTIRE

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

CELL PHONE PROTOCOL

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

CME INFORMATION

ACCME Accreditation Statement

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

Credit Designation

The Scoliosis Research Society designates this Live and Other (Hybrid) activity, 29th IMAST, for a maximum of 29.75 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

CME Certificates

CME certificates will be available to pre-registered delegates upon the opening of the meeting at www.srs.org/imast2022/cme. Delegates who registered onsite may access their certificates after May 1, 2022. Certificates are NOT available to delegates registering onsite until May 1.

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, 2022.

EVALUATIONS

Evaluations for each session are available to all attendees in the IMAST22 mobile app.

General Meeting Information

DISCLOSURE OF CONFLICT OF INTEREST

It is the policy of SRS to insure balance, independence, objectivity, and scientific rigor in all educational activities. In accordance with this policy, SRS identifies conflicts of interest with instructors, content managers, and other individuals who are in a position to control the content of an activity. Conflicts are mitigated by SRS to ensure that all scientific research referred to, reported, or used in a Continuing Medical Education (CME) activity conforms to the generally accepted standards of experimental design, data collection, and analysis.

EMERGENCY & FIRST AID

The InterContinental Miami 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-POSTER KIOSK

There are over 90+ E-Posters available to view on the E-Poster kiosks on Level 2 - Mezzanine.
The E-Poster Kiosks are supported, in part, by ZimVie.

EXHIBITS & HANDS-ON WORKSHOPS (HOWS)

SRS encourages IMAST delegates to visit the 2022 IMAST Exhibitors during exhibit viewing times and between sessions. See page 185 for the full listing of exhibitors.

IMAST delegates are encouraged to attend the Hands-On Workshops (HOW) on Thursday, April 7 and Friday, April 8. Morning, lunch and afternoon sessions will be offered.

Each workshop is programmed by a single-supporting company and will feature presentations on topics and technologies selected by the company. Please note: CME credits are not available for Hands-On Workshops. See page 190 for the schedule of Hands-On Workshop sessions.

FDA STATEMENT (UNITED STATES)

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

INSURANCE/LIABILITIES AND DISCLAIMERS

The materials presented during this meeting are made available for educational purposes only. The material is not intended to represent the only, nor necessarily best, methods or procedures appropriate for the medical situations discussed, but rather is intended to present an approach, view, statement or opinion of the faculty that may be helpful to others who face similar situations. SRS disclaims any and all liability for injury or other damages resulting to any individual attending a scientific meeting and for all claims that may arise out of the use of techniques demonstrated therein by such individuals, whether these claims shall be asserted by a physician or any other person.

INTERNET ACCESS

Wireless Internet access is available throughout the meeting space.
To log on select:
Network: SRS Meeting
Password: IMAST2022

LANGUAGE

Presentations and course materials will be provided in English.

LIVE WEBCAST

On Saturday, April 9 from 09:00 - 10:15, EDT, *Education Session 9. Bandwagon vs. Pendulum Swing*, will be webcast live. More information about the webcast is available on the IMAST website: www.srs.org/imast2022
The webcast is supported, in part, by DuPuy Synthes.

LOST & FOUND

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

NO SMOKING POLICY

Smoking is not permitted during any IMAST activity or event.

PRINTING STATION

Delegates are welcome to use the complimentary printing station, located next to the Exhibitors, to print their certificate of attendance and CME certificate (pre-registered delegates only; onsite registrants will have access to their certificates beginning May 1, 2022).
The Printing Station is supported, in part, by ZimVie.

REGISTRATION DESK

Location: Level 2-Mezzanine, InterContinental Miami

Hours:
Wednesday, April 6 14:00 - 20:00
Thursday, April 7 06:30 - 18:00
Friday, April 8 07:00 - 17:00
Saturday, April 9 08:00 - 13:00

SPEAKER READY ROOM

Location: Level 2-Mezzanine, InterContinental Miami

Presenters may upload their presentations onsite in the Speaker Ready Room. Please upload presentations no later than 24 hours before the session is scheduled to begin.

Hours:
Wednesday, April 6 14:00 - 20:00
Thursday, April 7 07:30 - 18:00
Friday, April 8 07:30 - 17:00
Saturday, April 9 08:00 - 12:30

SELF-PACED PROGRAM

The self-paced program will be available April 5 through June 30, 2022 on the virtual IMAST platform for all in-person and virtual

General Meeting Information

registered attendees. E-Posters, industry modules, and recordings of the live sessions are included in the self-paced program.

In addition, discussion boards, daily announcements, evaluations, CME certificates, and a virtual wellness lounge are available in the online meeting platform.

SRS COMMUNICATIONS HUB

New this year! Engage with the SRS Communications Team at their booth. Learn more about the SRS podcast, social media, and meeting app. It makes the perfect spot to get an IMAST selfie.

SRS MEMBERSHIP INFORMATION

Involvement in the virtual 29th IMAST counts towards SRS membership meeting requirements. Stop by the SRS Membership Information Table on Level 2 - Mezzanine for information about becoming a SRS member, upcoming meetings, and more, or visit www.srs.org/professionals/membership to apply.

TECHNOLOGY

IMAST can be accessed via any electronic device with an internet connection, speakers/headphones, and screen to view and listen to presentations (e.g., computer, tablet, smartphone).

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.

VIRTUAL LIVE PROGRAM

The virtual live IMAST program will run April 7-9 and includes the presidential address, presentation of the Whitecloud award-nominated papers, instructional course lectures, abstract presentations, case discussions, an Early Career Surgeons session, and industry sessions.

The IMAST online platform will be available to in-person and virtual-only meeting delegates beginning April 5, 2022 through June 30, 2022.

To access the virtual content, go to https://srs.brightspace.com, login with your SRS username and password, and select the 29th IMAST Meeting listed under "My Courses." All sessions presented live will be recorded and available on-demand for self-paced viewing through June 30, 2022.

VIRTUAL MEETING ACCESS

Starting April 5, the IMAST virtual platform can be accessed by:

1. Going to the SRS Brightspace E-Learning webpage: https://srs.brightspace.com
2. Signing in with your SRS username and password
3. Selecting the 29th IMAST virtual offering listed under "My Courses"

If you still need to register for the virtual meeting, please click here to register.

WELCOME RECEPTION

All registered delegates are invited to pick up their registration materials and to attend the IMAST Welcome Reception on Wednesday, April 6 from 17:30-19:00. The reception will be hosted in the Exhibit area on Level 2 - Mezzanine of the InterContinental Miami, where beverages and light hors d' oeuvres will be served. There is no charge for registered delegates. Registered guests may purchase a Welcome Reception ticket for $20 USD at the registration desk. Dress for the Welcome Reception is business casual.

The Welcome Reception is supported, in part, by DePuy Synthes, Globus Medical and OrthoPediatrics.

We encourage delegates to take part in the Cases & Cocktails Sessions immediately following the Welcome Reception on Wednesday, April 6 from 19:15-20:45.

Cases will be presented by faculty in four concurrent sessions. 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 & Cocktails Session Topics:

- Worst Neuromonitoring Disasters and Lessons Learned
- VBT Disasters & Revisions
- Cervical and Adult Trauma
- Adjacent Segment Failure/Breakdown

EVALUATIONS

We Need Your Feedback!

Complete the session and overall meeting evaluations on the app or online.

If you have questions, contact SRS at cme@srs.org

On the App: *Session Evaluations:*

1. Select "Agenda" from the home screen
2. Select the Session you want to evaluate
3. Scroll to the bottom of the session page and select "Session Evaluation" to complete

Overall Meeting Evaluation:

1. Select "Polls & Surveys" from the home screen
2. Select the "IMAST Overall Evaluation" to complete

Online: https://www.srs.org/imast2022/cme

Meeting Overview

All times are listed in the **Eastern** time zone (ET). To assist with how to convert times to your specific time zone; use the online time converter.

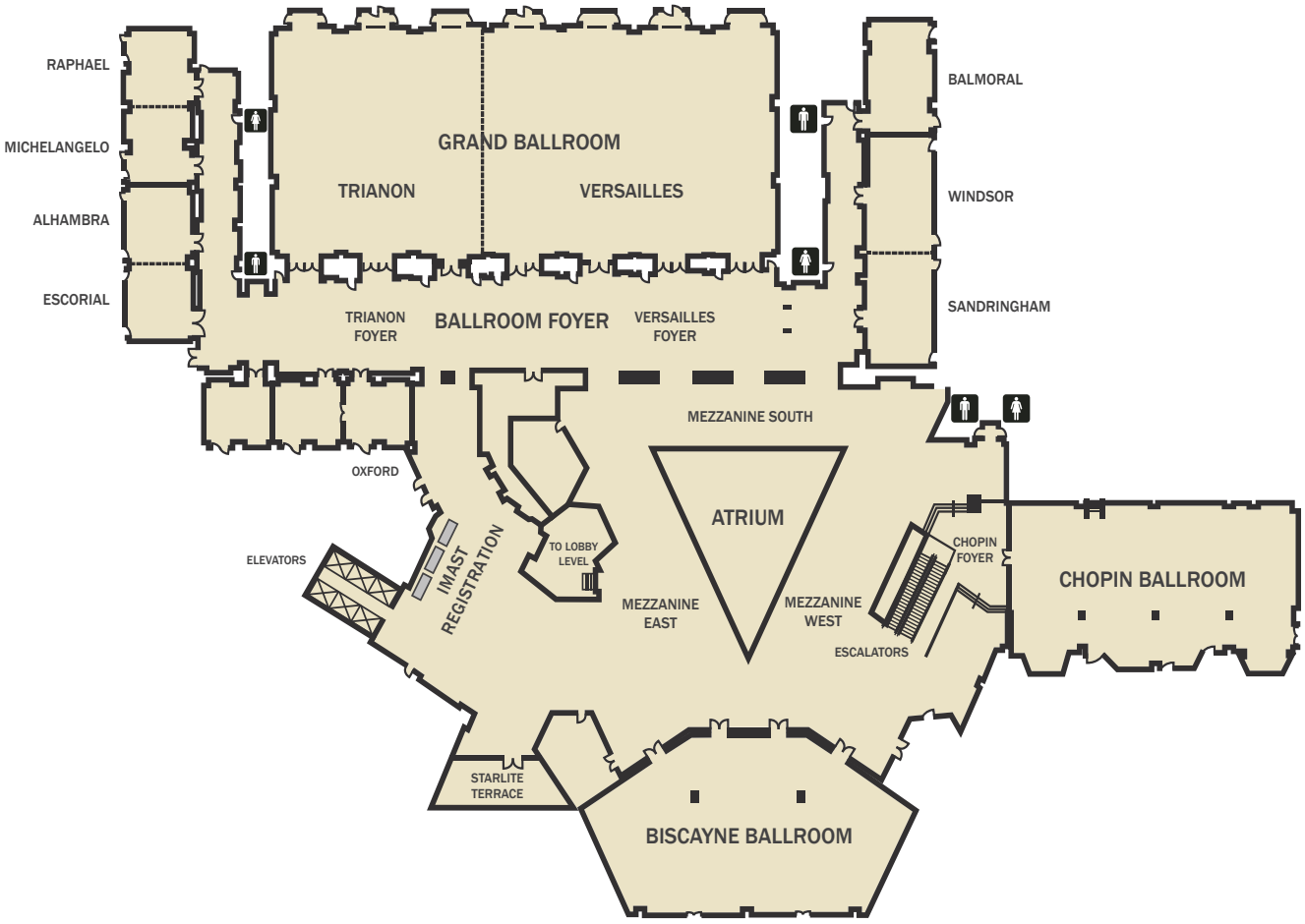
	Wednesday, April 6	Thursday, April 7	Friday, April 8	Saturday, April 9
Morning		06:30 – 18:00 Registration Open 07:30 – 08:30 Hands-On Workshops* *with breakfast* 08:30 – 09:00 Exhibit Viewing & Refreshment Break 09:00-11:15 Abstract Session 1: Whitecloud Clinical Award Nominees & Presidential Address 11:15 – 11:55 Exhibit Viewing & Refreshment Break 11:55 – 13:00 Concurrent Sessions (Abstract sessions 2A & 2B)	07:00 – 17:00 Registration Open 07:30 – 08:30 Hands-On Workshops* *with breakfast* 08:30 – 09:00 Exhibit Viewing & Refreshment Break 09:00 – 10:10 Concurrent Sessions (Abstract sessions 5A & 5B) 10:10 – 10:50 Exhibit Viewing & Refreshment Break 10:50 – 12:15 Concurrent Sessions (Abstract sessions 6A & 6B)	08:00 – 13:00 Registration Open 09:00 – 10:15 Education Session 9 10:30 – 11:30 Education Session 10 11:30 – 11:45 Lunch Pick-up 11:45 – 13:15 Education Session 11
Afternoon	14:00 – 20:00 Registration Open	13:00 – 14:15 Exhibit Viewing 13:15 – 14:15 Hands-On Workshops* *Lunch Pick-up (13:00-13:15)* 14:45 – 16:15 Concurrent Sessions (Education sessions 3A - 3C) 16:15 – 16:45 Exhibit Viewing & Refreshment Break 16:45 – 17:45 Concurrent Sessions (Education sessions 4A - 4C)	12:15 – 13:30 Exhibit Viewing 12:30 – 13:30 Hands-On Workshops* *Lunch Pick-up (12:15-12:30)* 14:00 – 15:30 Concurrent Sessions (Education sessions 7A - 7C) 15:30 – 16:00 Exhibit Viewing & Refreshment Break 16:00 – 17:00 Concurrent Sessions (Education sessions 8A -8C)	13:15 – IMAST Concludes
Evening	17:30 – 19:00 Exhibit Viewing Welcome Reception* 19:15 – 20:45 Cases & Cocktails Discussion Sessions	18:00 – 19:00 Hands-On Workshops* *with snacks & refreshments*	17:30 – 19:00 Faculty Reception *– Invitation Only*	

**Denotes non-CME session*

Meeting Space Floor Plan

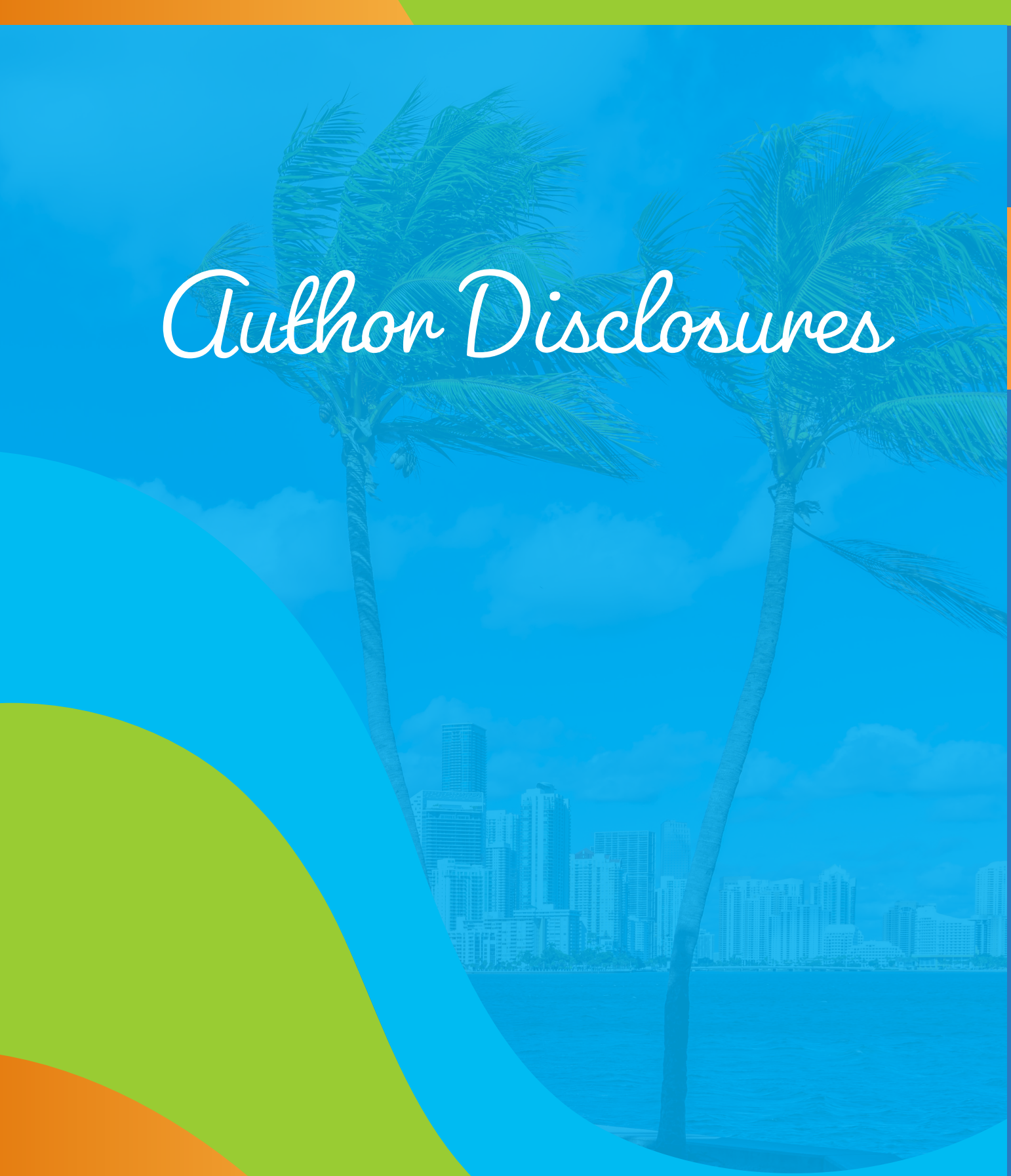
INTERCONTINENTAL MIAMI

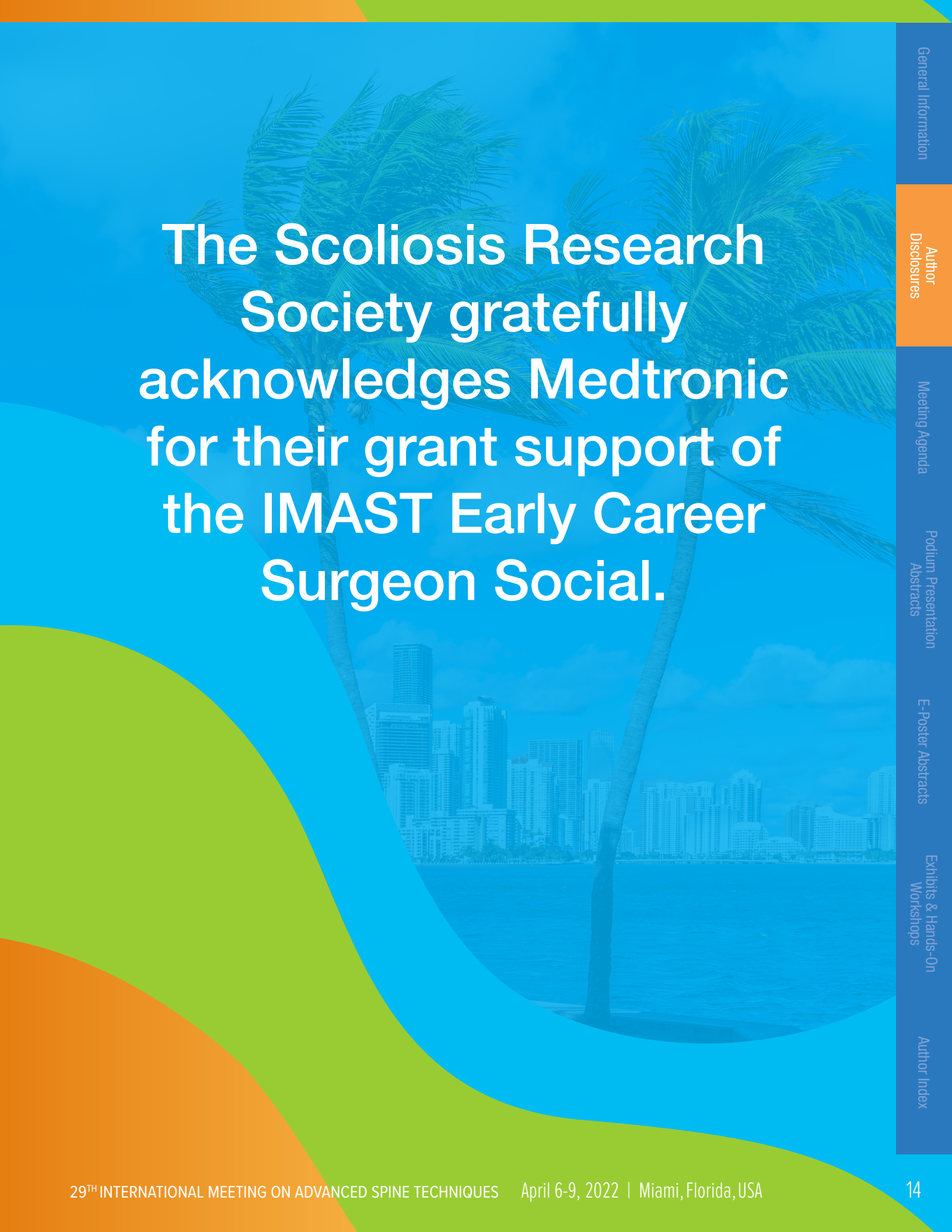
Level 2 - Mezzanine



Function / Event	Location
Registration	Mezzanine
Exhibitors	Mezzanine
Speaker Ready Room	Oxford
General Session	Versailles Ballroom
Concurrent Sessions	Trianon Ballroom, Biscayne Ballroom and Chopin Ballroom
Cases & Cocktails Sessions	1) Escorial / Alhambra, 2) Michelangelo / Raphael, 3) Sandringham / Windsor, 4) Balmoral
Hands-On Workshops	1) Escorial / Alhambra, 2) Michelangelo / Raphael, 3) Sandringham, 4) Windsor

Author Disclosures





The Scoliosis Research Society gratefully acknowledges Medtronic for their grant support of the IMAST Early Career Surgeon Social.

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Meeting Agenda

The Scoliosis Research Society gratefully acknowledges ZimVie for their grant support of the IMAST Lunch with the Experts Session.

Meeting Agenda

**Faculty and speakers are subject to change*

All times are listed in the **Eastern** Time Zone (ET) and subject to change. To assist with how to convert times to your specific time zone; use the online time converter.

WEDNESDAY, APRIL 6, 2022

14:00-20:00

Registration Open
Level 2 - Mezzanine

17:30-19:00

Welcome Reception & Exhibitor Viewing
Level 2 - Mezzanine

19:15- 20:45

Concurrent Sessions Cases & Cocktails 1-4
1) Escorial / Alhambra, 2) Michelangelo / Raphael, 3) Sandringham / Windsor, 4) Balmoral

Cases & Cocktails 1. Worst Neuromonitoring Disasters and Lessons Learned
Moderators: Kai-Ming Gregory Fu, MD & Serena S. Hu, MD
Table Moderators: *Shay Bess, MD; Asdrubal Falavigna, MD, PhD; David W. Polly Jr., MD; Justin S. Smith, MD, PhD; Michael Y. Wang, MD*

Cases & Cocktails 2. VBT Disasters & Revisions
Moderator: Ahmet Alanay, MD
Table Moderators: *Laurel C. Blakemore, MD; A. Noelle Larson, MD; Stefan Parent, MD, PhD; Amer F. Samdani, MD; Suken A. Shah, MD; Per Trobisch, MD*

Cases & Cocktails 3. Cervical and Adult Trauma
Moderator: Brian Hsu, MBBS, FRCSA
Table Moderators: *Jens Chapman, MD; Munish C. Gupta, MD; Brian Hsu, MBBS, FRCSA; Eric O. Klineberg, MD; Steven C. Ludwig, MD*

Cases & Cocktails 4. Adjacent Segment Failure/Breakdown
Moderator: David O. Okonkwo, MD, PhD
Table Moderators: *John R. Dimar II, MD; Meric Enercan, MD; D. Kojo Hilton, MD; Themistocles S. Protopsaltis, MD; Juan S. Uribe, MD*

Meeting Agenda

THURSDAY, APRIL 7, 2022

06:30-18:00

Registration Open
Level 2 - Mezzanine

07:30-08:30

Industry Workshops
Escorial / Alhambra, Sandringham and Windsor
For the full schedule, please refer to page 190.

08:30-16:45

Exhibit Hall Open
Level 2 - Mezzanine

09:00-11:15

Session 1. Whitecloud Award Nominees
Versailles Ballroom
Moderators: Ahmet Alanay, MD & David L. Skaggs, MD, MMM

09:05-09:09 **Paper #1: Outcomes of Single-Sided vs. Bilateral Thoracic and Lumbar Anterior Vertebral Body Tethering in Lenke 1 and 2 Curves with Lumbar C Modifier†**
Joshua M. Pahys, MD; Amer F. Samdani, MD; Alejandro Quinonez, BS; Steven W. Hwang, MD

09:09-09:13 **Paper #2: Anterior Vertebral Body Tethering (aVBT) for Immature Idiopathic Scoliosis: Results on Patients Reaching Skeletal Maturity†**
Amer F. Samdani, MD; *Stephen Plachta, MD*; Joshua M. Pahys, MD; Solomon Samuel, D. Eng.; Alejandro Quinonez, BS; Steven W. Hwang, MD

09:13-09:17 **Paper #3: Low Radius of Curvature Growth Friendly Implants Increase the Risk of Developing Clinically Significant Proximal Junctional Kyphosis†**
Ellen Parker, PhD; Mohmed Al Anazi, MD; *Ron El-Hawary, MD*

09:17-09:26 **Discussion**

09:26-09:30 **Paper #4: Topical Tranexic Acid Does Not Result in Reduced Blood Loss in Adult Spinal Deformity Surgery: Preliminary Results from a Double-Blinded RCT***
Kyle W. Morse, MD; Jordan, A Gruskay, MD; Renaud Lafage, MS; Hna Muzmil, BS; Evangelia Zgonis, BS; Rachel Knopp, MPH; Virginie Lafage, PhD; Matthew E. Cunningh, MD, PhD; Frank J. Schwab, MD; Han Jo Kim, MD

09:30-09:34 **Paper #5: Are We Getting Better at 3-Column Osteotomy in Terms of Achieving Optimal Realignment, Minimizing Complications, and Clinical Outcomes in Adult Spinal Deformity?†**
Peter G. Passias, MD; Oscar Krol, BS; Lara Passfall, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Breton G. Line, BS; Shaleen Vira, MD; Alan H. Daniels, MD; Bassel G. Diebo, MD; Jeffrey L. Gum, MD; Andrew J. Schoenfeld, MD, MS; Khoi D. Than, MD; Han Jo Kim, MD; Richard Hostin, MD; Munish C. Gupta, MD; Robert K. Eastlack, MD; Douglas C. Burton, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Eric O. Klineberg, MD; Shay Bess, MD; International Spine Study Group

09:34-09:38 **Paper #6: The Impact of Nusinersen Treatment on Scoliosis Progression in Patients with Spinal Muscular Atrophy***
Hayley Ip, MS; Sophelia Chan, MD; *Kenny Y. Kwan, MD*

09:38-09:47 **Discussion**

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*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!

Meeting Agenda

THURSDAY, APRIL 7, 2022

09:47-09:51 **Paper #7: Development and Validation of the Regional Alignment and Proportion (RAP) Score in Operative Cervical Deformity Patients***
Peter G. Passias, MD; Katherine E. Pierce, BS; Waleed Ahmad, BS; Sara Naessig, BS; Oscar Krol, BS; Peter Tretiakov, BS; Bailey Imbo, BA; Tyler K. Williamson, MS, BS; Rachel Joujon-Roche, BS; Shaleen Vira, MD; Andrew J. Schoenfeld, MD, MS; Praveen V. Mummaneni, MD; Dean Chou, MD; *Renaud Lafage, MS*

09:51-09:55 **Paper #8: Lateral Mass Screws vs. Pedicle Screws at C7 - Reoperation Rates for Adjacent Segment Disease (Operative ASD) and Nonunions (Operative Nonunions) in Posterior Cervical Fusions stopping at C7†**
Kern H. Guppy, MD, PhD; Harsimran S. Brara, MD; Kathryn E. Royse; Jacob H. Fennessy, MD; Jessica E. Harris, MS

09:55-09:59 **Paper #9: Novel AI-based Algorithm for Automated Cervical Sagittal Balance Analysis Validated on Pre- and Postoperative X-rays of 129 Patients***
Sophia Vogt, MD; *Carolin Scholl, MS*; Priyanka Grover, MS; Julian Marks, BS; Marcel Dreischarf, PhD; Ulf-Dietrich Braumann, PhD; Patrick Strube, MD; Sabrina Böhle, MD

09:59-10:09 **Discussion**

10:09-10:13 **Paper #10: Randomized Controlled Trial of Instrumented vs. Uninstrumented Posterolateral Fusion for Lumbar Spondylolisthesis†**
Andreas K. Andresen, MD; Leah Y Carreon, MD, MS; Mikkel Østerheden Andersen, MD

10:13-10:17 **Paper #11: Clinical Outcomes Following Direct vs. Indirect Decompression Techniques for Lumbar Spondylolisthesis†**
Lydia McKeithan, MD; Joseph Romano, MD; William H. Waddell, MD; Anthony Steinle, BA; Jacquelyn S. Pennings, PhD; Nian Hui, PhD; Mohad Bydon, MD;ir Abtahi, MD; Scott Zuckerman, MD; Clinton Devin, MD; Byron F. Stephens, MD

10:17-10:21 **Paper #12: Should Corrective Re-Alignment Goals be Tailored to Different Frailty States?†**
Oscar Krol, BS; Lara Passfall, BS; Bailey Imbo, BA; Rachel Joujon-Roche, BS; Peter Tretiakov, BS; Tyler K. Williamson, MS, BS; Stephane Owusu-Sarpong, MD; Waleed Ahmad, BS; Shaleen Vira, MD; Andrew J. Schoenfeld, MD, MS; Jordan Lebovic, MBA; Paul Park, MD; Dean Chou, MD; Renaud Lafage, MS; Virginie Lafage, PhD; *Peter G. Passias, MD*

10:21-10:30 **Discussion**

10:30-10:34 **Paper #13: Mechanical Complications and Revision Surgery in Patients with False Type II Alignment after Adult Spinal Deformity Surgery: Minimum Two Year Follow Up†**
Michael Dinizo, MD; Karnmanee Srisanguan, BS; Thomas J. Errico, MD; *Tina Raman, MD*

10:34-10:38 **Paper #14: The Role of Vitimin D Deficiency in the Onset of Adolescent Idiopathic Scoliosis: A Validation Study on Bipedal Mice Model***
Zhen Liu, MD; Jie Li, MD; Zhikai Qian, MD; Ziyang Tang, MD; Kir Abdukahar, MD; Zongshan Hu, PhD; Zezhang Zhu, MD; Yong Qiu, MD; *Jian Cao, Assistant Professor*

10:38-10:42 **Paper #15: The Correlation Analysis of Pelvic Incidence Minus Lumbar Lordosis with Pelvic Incidence from a Database of 468 Asymptomatic Volunteers***
Jean-Charles Le Huec, MD; Stephane Bourret, PhD; Zeeshan M. Sardar, MD; Meghan Cerpa, MPH; Kazuhiro Hasegawa, MD, PhD; Hwee Weng Dennis Hey, MD; Hend Riahi, MD; Michael P. Kelly, MD; Lawrence G. Lenke, MD

10:42-10:51 **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!

Meeting Agenda

THURSDAY, APRIL 7, 2022

10:51-10:54 **Preview of 57th Annual Meeting - Stockholm, Sweden**
Justin S. Smith, MD, PhD

10:54-10:57 **Preview of 30th IMAST - Dublin, Ireland**
Stefan Parent, MD, PhD

10:57-11:00 **Introduction of the President**
Serena S. Hu, MD

11:00-11:15 **Keynote Address**
Christopher I. Shaffrey, MD

11:15-11:55

Refreshment Break & Exhibit Viewing*
Level 2 - Mezzanine

11:55-13:00

Concurrent Sessions 2A-B. Abstract Presentations
2A) Trianon Ballroom, 2B) Biscayne Ballroom

11:55-13:00

Session 2A. Innovations in Adult Deformity
Trianon Ballroom
Moderators: Munish C. Gupta, MD & Eric O. Klineberg, MD

11:55-11:59 **Paper #16: Determining the Impact of Proximal Junctional Kyphosis on Cost-Utility in Adult Spinal Deformity Patients**
Oscar Krol, BS; Lara Passfall, BS; Stephane Owusu-Sarpong, MD; Waleed Ahmad, BS; Tyler K. Williamson, MS, BS; Bailey Imbo, BA; Rachel Joujon-Roche, BS; Peter Tretiakov, BS; Jordan Lebovic, MBA; *Shaleen Vira, MD*; Peter G. Passias, MD

11:59-12:03 **Paper #17: The Effect of Upper Instrumented Vertebra Level (T9 vs. T10) on Radiologic and Functional Outcomes in the Surgical Treatment of Adult Spinal Deformity in Osteoporotic Patients over 60 years of age**
Hisi M. Mraja, MD; Halil Gok, MD; Ugur Tasci, MD; Tunay Sanli, MA; Ayhan Mutlu, MD; Selhan Karadereler, MD; *Meric Enercan, MD*; Azmi Hzaoglu, MD

12:03-12:07 **Paper #18: The Influence of Frailty on PJF – Is Optimal Realignment Superseded by Physiologic Age?**
Oscar Krol, BS; Lara Passfall, BS; Peter Tretiakov, BS; Tyler K. Williamson, MS, BS; Bailey Imbo, BA; Rachel Joujon-Roche, BS; Shaleen Vira, MD; Andrew J. Schoenfeld, MD, MS; Renaud Lafage, MS; Virginie Lafage, PhD; Stephane Owusu-Sarpong, MD; Paul Park, MD; Dean Chou, MD; Jordan Lebovic, MBA; Peter G. Passias, MD; *Robert K. Eastlack, MD*

12:07-12:16 **Discussion**

12:16-12:20 **Paper #19: Compared to Multi-Rod (≥3) Constructs, Interbody Fusion Does Not Reduce the Rate of Rod Failure at 2-Year Minimum Follow-Up**
Jonathan Elysee, MS; Michael E. Steinhaus, MD; *Francis C. Lovecchio, MD*; Gregory Kazarian, MD; Philip J. York, MD; Bryan Ang, BS; Alex L. Huang, BS; Renaud Lafage, MS; Frank J. Schwab, MD; Virginie Lafage, PhD; Han Jo Kim, MD

12:20-12:24 **Paper #20: Rod Fractures in Thoracolumbar Fusions to the Sacrum/Pelvis for Adult Symptomatic Lumbar Scoliosis: Long-Term Follow-Up of a Prospective Multicenter Cohort of 160 Patients**
Juan Sardi, MD; Bruno Lazaro, MD; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Brian L. Dial, MD; Jeffrey M. Hills, MD; Christine Baldus, RN; Elizabeth L. Yanik, PhD; Chun-Po Yen, MD; Virginie Lafage, PhD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Keith H. Bridwell, MD

12:24-12:28 **Paper #21: Risk Factors for Mechanical Complications Associated with Multi-Rod Constructs in Adult Spinal Deformity: Where and Why do They Occur?**
Paul J. Park, MD; Cole Morrissette, MS; Nathan J. Lee, MD; Meghan Cerpa, MPH; Alex Ha, MD; Scott Zuckerman, MD; Ronald A. Lehman Jr., MD; Lawrence G. Lenke, MD

Meeting Agenda

THURSDAY, APRIL 7, 2022

12:28-12:37 Discussion

12:37-12:41 **Paper #22: Incidence of Postoperative Neurologic Complications after Adult Spinal Deformity Surgery and Rate of Recovery at 5 Year Follow up**
Karnmanee Srisanguan, BS; Michael Dinizo, MD; Thomas J. Errico, MD; *Tina Raman, MD*

12:41-12:45 **Paper #23: Metabolic Syndrome and 30/90 Day Outcomes After Adult Spinal Deformity Surgery**
Gregory Van Perrier, BS; Aonnicha Burapachaisri, BS; Constance Maglaras, PhD; Michael Dinizo, MD; Themistocles S. Protopsaltis, MD; *Tina Raman, MD*

12:45-12:49 **Paper #24: Effect of Osteoporosis and Bisphosphonate on Reoperations in Adult Spinal Deformity**
Peter G. Passias, MD; Waleed Ahmad, BS; Peter Tretiakov, BS; Tyler K. Williamson, MS, BS; Rachel Joujon-Roche, BS; Bailey Imbo, BA; Oscar Krol, BS; Sara Naessig, BS; Frank A. Segreto, BS; *Shaleen Vira, MD*; Renaud Lafage, MS; Virginie Lafage, PhD; Andrew J. Schoenfeld, MD, MS; Bassel G. Diebo, MD; Jordan Lebovic, MBA; Dean Chou, MD; Paul Park, MD; Praveen V. Mummaneni, MD; M. Burhan Janjua, MD

12:49-13:00 Discussion

11:55-13:00

Session 2B. Innovations in Adolescent Idiopathic Scoliosis
Biscayne Ballroom
Moderators: Stefan Parent, MD, PhD & Suken A. Shah, MD

11:55-11:59 **Paper #25: Impact of Navigation on 30-Day Outcomes for Pediatric Deformity Surgery**
Austen Katz, MD; Junho Song, BS; Sayyida Hasan, BS; Jeff Silber, MD; David Essig, MD; Vishal Sarwahi, MD, MBBS

11:59-12:03 **Paper #26: Robotics Coupled with Navigation (RAN) for Pediatric Spine Surgery: Initial Intraoperative Experience with 162 Cases**
Nicole Welch, BA; Frank Mota, MD; Craig Birch, MD; Lauren Hutchinson, MPH; *Daniel J. Hedequist, MD*

12:03-12:07 **Paper #27: Beware of Open Triradiate Cartilage: 1 in 4 Patients will Lose Greater than 10 Degrees of Correction following Posterior-Only Fusion**
Anthony A. Catanzano, MD; Paul D. Sponseller, MD, MBA; Peter O. Newton, MD; Tracey P. Bastrom, MA; Carrie E. Bartley, MA; Suken A. Shah, MD; Patrick J. Cahill, MD; Harms Study Group; Burt Yaszay, MD

12:07-12:16 Discussion

12:16-12:20 **Paper #28: Does a Dedicated "Scoliosis Team" and Surgical Standardization Improve Outcomes in Adolescent Idiopathic Scoliosis Surgery and is it Reproducible?**
Vishal Sarwahi, MD, MBBS; Jesse M Galina, BS; Terry D. Amaral, MD; Sayyida Hasan, BS

12:20-12:24 **Paper #29: Impact of Socioeconomic Status on Brace Wear: Not All Patients are the Same**
Bharadwaj Jilakara, BA; *Todd A. Milbrandt, MD, MS*; Stuart L. Weinstein, MD; Lori A. Dolan, PhD; A. Noelle Larson, MD

12:24-12:28 **Paper #30: Tools for Your Toolbox: Testing a Decision-making Aide for Scoliosis Patients**
Paige Cummings, BS; *A. Noelle Larson, MD*; Todd A. Milbrandt, MD, MS

12:28-12:37 Discussion

12:37-12:41 **Paper #31: Defining Different Distal Adding-On Patterns After Thoracic-only Vertebral Body Tethering**
Altug Yucekul, MD; Ipek Ege Gurel, MD; Umut C. Karaarslan; Tais Zulemyan, MD; Gokhan Ergene, MD; Sahin Senay, MD; Sule Turgut Balci, MD; Pinar Yalinay Dikmen, MD; Yasemin Yavuz, PhD; Caglar Yilgor, MD; Ahmet Alanay, MD

12:41-12:45 **Paper #32: Anterior Vertebral Body Tethering for Idiopathic Scoliosis: How Well Does the Tether Hold Up?**
Dhruv S. Shankar, BS; Lily Q. Eaker, BA; Theodor Di Pauli von Treuheim, B. Eng; Jared C. Tishelman, MD; Zacharia Silk, FRCS; Baron S. Lonner, MD

Meeting Agenda

THURSDAY, APRIL 7, 2022

12:45-12:49 **Paper #33: Segmental Correction Technique Results in Earlier Tether Breakage Compared to Global Correction Technique: A Matched Cohort Analysis**
Ahmet Alanay, MD; Altug Yucekul, MD; Nuri Demirci ; Tais Zulemyan, MD; Aynur Kaval ; Gokhan Ergene, MD; Sahin Senay, MD; Sule Turgut Balci, MD; Pinar Yalinay Dikmen, MD; Yasemin Yavuz, PhD; Caglar Yilgor, MD

12:49-13:00 **Discussion**

13:00-13:15

Walking Break & Lunch Pick-up
Foyers of Escorial / Alhambra, Michelangelo / Raphael, Sandringham and Windsor

13:15-14:15

Industry Workshops
Escorial / Alhambra, Michelangelo / Raphael, Sandringham and Windsor
For the full schedule, please refer to page 190.

14:15-14:45

Walking Break

14:45-16:15

Concurrent Sessions 3A-C. Instructional Course Lectures
3A) Trianon Ballroom, 3B) Biscayne Ballroom, 4C) Chopin Ballroom

14:45-16:15

Session 3A. Advanced MIS Techniques: A Case-Based Video Symposium from the SRS-AANS Task Force
Trianon Ballroom
Moderators: Pierce D. Nunley, MD; Ann R. Stroink, MD, FAANS; Michael Y. Wang, MD

14:45-14:55 **MIISA Selection Algorithm**
Kai-Ming Gregory Fu, MD

Surgical Approaches

14:55-15:00 **Debate Case Presentation**
Mari L. Groves, MD

15:00-15:10 **MIS TLIF**
Asdrubal Falavigna, MD, PhD

15:10-15:20 **Single Position Lateral**
Gregory M. Mundis Jr., MD

15:20-15:30 **Discussion**

15:30-15:35 **Debate Case Presentation: Best Methods for Lordosis**
Pierce D. Nunley, MD

15:35-15:45 **Lateral with ACR**
Michael Y. Wang, MD, FAANS

15:45-15:55 **Prone Lateral**
Juan S. Uribe, MD

15:55-16:05 **Dual Position with MIS Lateral ALIF at L5-S1**
Neel Anand, MD

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

Meeting Agenda

THURSDAY, APRIL 7, 2022

14:45-16:15

Session 3B. Non-Fusion Surgery: The Next Level – Advanced Techniques and Revision Strategies
Biscayne Ballroom
Moderators: Ahmet Alanay, MD & Stefan Parent, MD, PhD

14:45-14:53 Non-Fusion Surgical Management of AIS: Improve Your Reality or Lower Your Expectations
Kenneth M.C. Cheung, MD, MBBS, FRCS

14:53-15:01 Ongoing Post-Approval Studies for VBT and PDD
A. Noelle Larson, MD

15:01-15:09 Two-Cord Technique and Disk Releases: A Hope or an Unrealistic Expectation for Expanding Indications and Preventing Tether Breakage?
Per D. Trobisch, MD

15:09-15:17 Double VBT: When and How?
Baron S. Lonner, MD

15:17-15:27 Debate & Discussion
Ahmet Alanay, MD

15:27-15:35 Hybrid Thoracic Fusion and Lumbar VBT Will Improve Outcome and Still Preserves Motion
Meric Enercan, MD

15:35-15:43 Revision Strategies
Stefan Parent, MD, PhD

15:43-15:51 Is PDD the Solution? Indication and Surgical Technique
Todd A. Milbrandt, MD, MS

15:51-15:59 PDD - How to Prevent, Diagnose, and Handle Failures
Ron El-Hawary, MD

15:59-16:15 Debate & Discussion

14:45-16:15

Session 3C. SI Joint: To Fuse or Not to Fuse?
Chopin Ballroom
Moderators: Jean-Charles Le Huec, MD & David W. Polly Jr., MD

To Fuse or Not to Fuse the Sacro-Iliac Joint - That is the Question

14:45-14:50 Sacro-Iliac Pain and Pseudo Sciatica Pain: History
Jean-Charles Le Huec, MD

14:50-14:55 Do I Need to Test Sacro-Iliac Joint Before My ALIF or L5S1 TLIF or Lumbo Sacral Fusion or is it Useless?
Jeffrey P. Mullin, MD, MBA

14:55-15:00 SI Joint Pain in My Daily Practice: How to Think About It?
Han Jo Kim, MD

15:00-15:05 Discussion

Techniques Today for Sacro-Iliac Fusion

15:05-15:10 Percutaneous
David W. Polly Jr., MD

15:10-15:15 Bedrock Technique
Jean-Charles Le Huec, MD

Meeting Agenda

THURSDAY, APRIL 7, 2022

15:15-15:20 Robotic Techniques: Useful or Business as Usual?
Isador H. Lieberman, MD

15:20-15:25 Discussion

Debate: Should I Fuse the Sacro-Iliac Joint When I Do Long Lumbo-Sacral Fusion?

15:25-15:30 Pro: Female 65+ Y.O. Need SI Fusion During Long Sacro-Iliac Fusion
Jörg Franke, MD

15:30-15:35 Con: I Prefer to Wait for Pain and Do it Percutaneously if Needed
Robert K. Eastlack, MD

15:35-15:40 Discussion

15:40-16:15 Case Discussions and Panel
Jean-Charles Le Huec, MD

16:15-16:45

Refreshment Break & Exhibit Viewing
Level 2 - Mezzanine

16:45-17:45

Concurrent Sessions 4A-C. Instructional Course Lectures
4A) Trianon Ballroom, 4B) Biscayne Ballroom, 4C) Chopin Ballroom

16:45-17:45

Session 4A. Changing Fate: Pre-Operative Optimization Strategies to Improve Post-Operative Outcomes in Adult Spinal Deformity Surgery
Trianon Ballroom
Moderators: Robert K. Eastlack, MD; Byron F. Stephens, MD; Corey T. Walker, MD

16:45-16:48 Introduction
Robert K. Eastlack, MD

16:48-16:58 Brittle Bone Blues: Osteopenia and Osteoporosis, Should I Operate? – A Dialogue
Byron F. Stephens, MD with *S. Bobo Tanner, MD*

16:58-17:03 Discussion

17:03-17:11 Novel Metrics for Determining the Patient's Nutritional Status
Yukihiro Matsuyama, MD, PhD

17:11-17:16 Discussion

17:16-17:26 Assessing Frailty in an Aging Deformity Population – A Dialogue
Corey T. Walker, MD with *Christopher P. Ames, MD*

17:26-17:31 Discussion

17:31-17:40 Gait Analysis and Wearable Sensors Assessment Before Adult Spinal Deformity Surgery
Isador H. Lieberman, MD

17:40-17:45 Discussion

Meeting Agenda

THURSDAY, APRIL 7, 2022

16:45-17:45

Session 4B. Pediatric Cervical Spine: Deformity, Developmental and Dysplastic Challenges
Biscayne Ballroom
Moderators: Suken Shah, MD & Paul D. Sponseller, MD, MBA

16:45-16:55 Skeletal Dysplasias – Common Disorders and Decision Making
W.G. Stuart Mackenzie, MD

16:55-17:03 Trauma – Do This and Don't Do That
Burt Yaszay, MD

17:03-17:11 Congenital Anomalies – Recognition and Associations
Paul D. Sponseller, MD, MBA

17:11-17:19 Kyphosis – Etiology and Management
Jeffrey W. Campbell, MD

17:19-17:24 Summary of the Most Important Points of Management and Staying Out of Trouble
Paul D. Sponseller, MD, MBA

17:24-17:39 Case Presentations
Suken A. Shah, MD

17:39-17:45 Discussion

16:45-17:45

Session 4C. Managing Complex Issues in Patients with Spinal Tumors
Chopin Ballroom
Moderators: Daniel M. Sciubba, MD

16:45-16:53 En Bloc Resection, Today
Daniel M. Sciubba, MD

16:53-17:01 Cutting Edge of Spinal Reconstruction After Tumor Surgery
Laurence D. Rhines, MD

17:01-17:09 Focused Radiation Therapy and Intralesional Excision: Partners in Crime?
Yoshiya (Josh) Yamada, MD

17:09-17:17 Sacral Resection, Today?
Ziya Gokaslan, MD

17:17-17:25 Decision Making for Spinal Metastases, Today
Ilya Laufer, MD

17:25-17:45 Discussion and Case Presentation

17:45-18:00

Walking Break

18:00-19:00

Industry Workshops
Michelangelo / Raphael, Sandringham and Windsor
For the full schedule, please refer to page 190.

Meeting Agenda

FRIDAY, APRIL 8, 2022

07:00-17:00

Registration Open
Level 2 - Mezzanine

07:30-08:30

Industry Workshops
Escorial / Alhambra and Michelangelo / Raphael
For the full schedule, please refer to page 190.

08:30-16:00

Exhibit Hall Open
Level 2 - Mezzanine

09:00-10:10

Concurrent Sessions 5A-B. Abstract Presentations
5A) Trianon Ballroom, 5B) Biscayne Ballroom

09:00-10:10

Session 5A. Idiopathic and Neuromuscular Scoliosis
Trianon Ballroom
Moderators: Ron El-Hawary, MD & Caglar Yilgor, MD

09:00-09:04 **Paper #34: Minimally Invasive Surgery for Neuromuscular Scoliosis**
Vishal Sarwahi, MD, MBBS; Jesse M Galina, BS; Sayyida Hasan, BS; Alexandre Ansorge, MD; Terry D. Amaral, MD

09:04-09:08 **Paper #35: Single Incision Minimally Invasive Surgery (MIS) for AIS Patients: The Best of Both Worlds**
Vishal Sarwahi, MD, MBBS; Sayyida Hasan, BS; Jesse M Galina, BS; Alexandre Ansorge, MD; Terry D. Amaral, MD

09:08-09:12 **Paper #36: Comparable Correction and Overall Surgical Complication Rates Achieved in Both VCR-Based and Non-VCR-Based Surgical Corrective Maneuvers for the Treatment of Severe Rigid Scoliotic or Kyphoscoliotic Patients**
Nicholas Van Halm-Lutterodt, MD, PhD; Mohed K. Mesregah, MD, PhD; Krishna Mandalia, BS; Yu Wang, MD, PhD; Mercy Bartels-Mensah, MBBS; Wei-Cheng Chen, MBBS; Wei-Hsun Huang, MBBS; Wenxin Lei, RN, BSN; Xinyuan Chen, BA; Aixing Pan, MD, PhD; Ziyang Ye, MS, BS; Gregory Schroeder, MD

09:12-09:21 **Discussion**

09:21-09:25 **Paper #37: Post-Op Tranexic Acid Decreases Chest Tube Drainage Following Vertebral Body Tethering Surgery for Scoliosis**
Lily Q. Eaker, BA; Stephen Selverian, MD; Laura N. Hodo, MD; Jonathan S. Gal, MD; Sandeep Gangadharan, MD; George Ofori-anfo, MD; James Meyers; *Baron S. Lonner, MD*

09:25-09:29 **Paper #38: The Use of Artificial Intelligence in the AIS Surgery: Did the Predictive Model Accurately Depict the Postoperative Compensatory Sagittal Spinopelvic Pareters?**
Afshin Aminian, MD; John Ngo, DO; Evelyn Thomas, DO; Noah Boyer, BS

09:29-09:33 **Paper #39: Clinical and Radiographic Outcomes in Patients With Severe Idiopathic Spine Deformity Treated With HGT + PCO vs. ±VCR**
Arthur Sackeyfio, MD; Oheneba Boachie-Adjei, MD; Derrick Owusu Nyantakyi, BS; Kwadwo Poku Yankey, MD; Henry Ofori Duah, MS, RN; Brenda A. Sides: Amer F. Samdani, MD; Lawrence G. Lenke, MD; Paul D. Sponseller, MD, MBA; Suken A. Shah, MD; Peter O. Newton, MD; Munish C. Gupta, MD

09:33-09:42 **Discussion**

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09:42-09:46 **Paper #40: Self Sliding Growth Guidance for Early-Onset Scoliosis: Clinical and Radiological Results After a Minimum of Six Years (6-14) of Follow-Up**
Hisi M. Mraja, MD; Halil Gok, MD; Ayhan Mutlu, MD; Ugur Tasci, MD; Tunay Sanli, MA; Selhan Karadereler, MD; *Meric Enercan, MD*; Azmi Hzaoglu, MD

09:46-09:50 **Paper #41: Sacral-Alar-Iliac (SAI) Fixation in Children with Spine Deformity: Minimum 10-Year Follow-Up**
Frederick Mun, BS; Ashish Vankara, BS; Krishna Vangipur Suresh, BS; Ad Margalit, MD; Khaled M. Kebaish, MD; Paul D. Sponseller, MD, MBA

09:50-09:54 **Paper #42: Accuracy of CT-Guided Navigated Screw Placement for Vertebral Body Tethering**
David F. Soriano, BS; *A. Noelle Larson, MD*; Todd A. Milbrandt, MD, MS

09:54-10:10 **Discussion**

09:00-10:10

Session 5B. Innovation, Kyphosis and Miscellaneous
Biscayne Ballroom
Moderators: Ronald A. Lehman Jr., MD & Gregory M. Mundis Jr., MD

09:00-09:04 **Paper #43: A Novel Hinge-Link Correction System for Vertebral Column Resection**
Hong Zhang, MD; Daniel J. Sucato, MD, MS; David Ross, MFA

09:04-09:08 **Paper #44: Propensity Matched Cohort Study Comparing Accuracy of Robotic Assisted Spinal Surgery vs. Navigation Alone: Early Experience of 260 Pedicle Screws**
Saman Shabani, MD; Jeremy Huang, BS; Nitin Agarwal, MD; Alma Rechav Ben-Natan, BA; Vivian Le, MPH; Alexander Aabedi, BS; Lee A. Tan, MD; Dean Chou, MD; Praveen V. Mummaneni, MD

09:08-09:12 **Paper #45: Augmented Reality-Assisted Spine Surgery: An Early Experience Demonstrating Safety and Accuracy with 218 Screws**
Fenil R. Bhatt, BS; Lindsay Orosz, MS, PA-C; Anant Tewari, BS; Rita Roy, MD; Christopher R. Good, MD; Thomas C. Schuler, MD; Colin Haines, MD; *Ehsan Jazini, MD*

09:12-09:21 **Discussion**

09:21-09:25 **Paper #46: Return to Work, Activities of Daily Living and Disability Improvement: 12-Month Outcomes of an FDA IDE Trial of Decompression and Tension Band Stabilization for Degenerative Spondylolisthesis**
William F. Lavelle, MD; Rick C. Sasso, MD; S. Tim Yoon, MD; Alan Villavicencio, MD; Ravi S. Bains, MD; Kee D. Kim, MD; Calvin C. Kuo, MD; Michael P. Stauff, MD; Harvinder S Sandhu, MD; Miguelangelo Perez-Cruet, MD; Jeffrey Fischgrund, MD; Matthew J. Mermer, MD; Harel Deutsch, MD; Khalid Sethi, MD; Hid Hassanzadeh, MD; Elizabeth Yu, MD; Umesh S Metkar, MD; Richard D. Guyer, MD; Dennis G. Crandall, MD; Jeffrey L. Gum, MD; Michael Y. Wang, MD; Louis C. Fielding, MD

09:25-09:29 **Paper #47: Adding Satellite Rods to Standard Two-rod Construct in Posterior Correction of Scheuermann Kyphosis: Can it Promote Vertebral Remodeling?**
Sinian Wang, MD; Yong Qiu, MD; Zezhang Zhu, MD; Bin Wang, MD; *Xu Sun, MD*

09:29-09:33 **Paper #48: Insertional Torque and Pullout Strength of Pedicle Screws vs. Titanium Suture Anchors: Towards Development of a Novel Proximal Junctional Kyphosis Prevention Technique**
Christopher McDonald, MD; Andrew S. Zhang, MD; Daniel J. Alsoof, MBBS; Rachel Schilkowsky, MEng; Cilo Osorio, MD; Rodrigo Berreta, BS; Matthew Kovoor, BS; Eren Kuris, MD; Kyle Hardacker, MD; Kevin Disilvestro, MD; Alan H. Daniels, MD

09:33-09:42 **Discussion**

09:42-09:46 **Paper #49: Does Karnofsky Performance Score Improve After Surgery for Metastatic Tumors in Patients with SINS 7-12?**
Saman Shabani, MD; Enrique Vargas, BS; Alexander Aabedi, BS; Alma Rechav Ben-Natan, BA; Nitin Agarwal, MD; Praveen V. Mummaneni, MD; Dean Chou, MD

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FRIDAY, APRIL 8, 2022

09:46-09:50 **Paper #50: Establishment of an Individualized Distal Junctional Kyphosis Risk Index Taking into Account Radiographic, Surgical and Patient Related Components**
Peter G. Passias, MD; Sara Naessig, BS; Navraj Sagoo, BS; Lara Passfall, BS; Waleed Ahmad, BS; Katherine E. Pierce, BS; Peter Tretiakov, BS; Oscar Krol, BS; Rachel Joujon-Roche, BS; Tyler K. Williamson, MS, BS; Bailey Imbo, BA; Virginie Lafage, PhD; Shaleen Vira, MD; Andrew J. Schoenfeld, MD, MS; Themistocles S. Protopsaltis, MD; Han Jo Kim, MD; Alan H. Daniels, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Eric O. Klineberg, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Bassel G. Diebo, MD; International Spine Study Group; *Pierce D. Nunley, MD*

09:50-09:54 **Paper #51: Does Postop VTE Chemoprophylaxis Increase The Risk of Epidural Hematoma and Wound Complications?**
Aonnicha Burapachaisri, BS; Lindsay Kim, BS; Priscilla Varghese, BS; Constance Maglaras, PhD; Brooke K. O'Connell, MS; Yong H. Kim, MD; Tina Raman, MD; *Charla Fischer, MD*

09:54-10:10 **Discussion**

10:10-10:50

Refreshment Break & Exhibit Viewing
Level 2 - Mezzanine

10:50-12:15

Concurrent Sessions 6A-B. Abstract Presentations
6A) Trianon Ballroom, 6B) Biscayne Ballroom

10:50-12:15

Session 6A. Adult Cervical Spine & SI Joint
Trianon Ballroom
Moderators: Christopher P. Ames, MD & Jean-Charles Le Huec, MD

10:50-10:54 **Paper #52: Proximal and Distal Reciprocal Alignment Changes Following Cervical Deformity Correction**
Renaud Lafage, MS; Justin S. Smith, MD, PhD; Themistocles S. Protopsaltis, MD; Eric O. Klineberg, MD; Gregory M. Mundis Jr., MD; Peter G. Passias, MD; Jonathan Elysee, MS; Munish C. Gupta, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Shay Bess, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Christopher P. Ames, MD; International Spine Study Group

10:54-10:58 **Paper #53: When Does the Construct Need to Extend to the Thoracic Spine in Patients Undergoing Correction for Cervical Deformity?**
Peter G. Passias, MD; Lara Passfall, BS; Nicholas A. Kummer, BS; Oscar Krol, BS; Bailey Imbo, BA; Rachel Joujon-Roche, BS; Peter Tretiakov, BS; Tyler K. Williamson, MS, BS; Kevin Moattari, BS; Bassel G. Diebo, MD; Shaleen Vira, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Praveen V. Mummaneni, MD; Dean Chou, MD; Paul Park, MD; *Saman Shabani, MD*; M. Burhan Janjua, MD

10:58-11:02 **Paper #54: Indications for Combined Anterior-Posterior Approach in Cervical Deformity Surgery: Patients Who Benefit From an Additional Anterior Approach**
Peter G. Passias, MD; Bailey Imbo, BA; Oscar Krol, BS; Peter Tretiakov, BS; Rachel Joujon-Roche, BS; Tyler K. Williamson, MS, BS; Stephane Owusu-Sarpong, MD; Jordan Lebovic, MBA; Paul Park, MD; Dean Chou, MD; Shaleen Vira, MD; Praveen V. Mummaneni, MD; Bassel G. Diebo, MD; Andrew J. Schoenfeld, MD, MS; Lara Passfall, BS; M. Burhan Janjua, MD; *Saman Shabani, MD*

11:02-11:11 **Discussion**

11:11-11:15 **Paper #55: Psychological Distress in Patients Undergoing Cervical Spine Surgery: 2-Year Outcomes of a Randomized Controlled Trial**
Peter G. Passias, MD; Lara Passfall, BS; Bailey Imbo, BA; Kevin Moattari, BS; Nicholas A. Kummer, BS; Peter Tretiakov, BS; Rachel Joujon-Roche, BS; Stephane Owusu-Sarpong, MD; Tyler K. Williamson, MS, BS; Shaleen Vira, MD; Bassel G. Diebo, MD; *Michael Dinizo, MD*

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11:15-11:19 **Paper #56: Cervical Myelopathy with Severe Neck Pain: Is Anterior or Posterior Approach Better?**
Andrew K. Chan, MD; Christopher I. Shaffrey, MD; Oren Gottfried, MD; Christine Park, BA; Khoi D. Than, MD; Erica F. Bisson, MD; Mohad Bydon, MD; Anthony L. Asher, MD; Domagoj Coric, MD; Eric Potts, MD; Kevin T. Foley, MD; Michael Y. Wang, MD; Kai-Ming Gregory Fu, MD; Michael S. Virk, MD, PhD; Paul Park, MD; Cheerag D. Upadhyaya, MD; Mark E. Shaffrey, MD; Avery L. Buchholz, MD; Nitin Agarwal, MD; Dean Chou, MD; Steven D. Glassman, MD; Praveen V. Mummaneni, MD

11:19-11:23 **Paper #57: The Antero-Posterior Positionning of Visco-Elastic Cervical Disc Prosthesis Does Not Alter the Outcomes**
Baptiste Boukebous, MD, MS; Oussema Abdelhedi, MD; Lorenzo Serfaty, MD; Cédric Maillot, MD, MS; Mohed Zoghli, MD; Jean-Yves Lazennec, MD, PhD; *Marc-Antoine Rousseau, MD, PhD*

11:23-11:32 **Discussion**

11:32-11:36 **Paper #58: Clinical & Radiological Outcomes Following the Use of Triangular Sacro-iliac Joint Cages in Addition to S2AI screws (Bedrock Technique) to Enhance Spinopelvic Fixation**
Kiran G. Divani, MBBS, FRCS; Nitin Adsul, DNB (ortho); Alvin Pun, FRACS; Michael Mokawem, FRCS; Robert S. Lee, FRCS

11:36-11:40 **Paper #59: Cost-Effectiveness of Sacroiliac Joint Stabilization in Patients Undergoing Multiple-Segment Lumbar Fusion to the Sacrum**
David W. Polly Jr., MD; Stacey J. Ackerman, PhD; Gurvinder S. Deol, MD

11:40-11:44 **Paper #60: Galveston Illiac Screw Techinique with Modified Lateral Connectors: Results of 335 Consecutive Patients in Adult Deformity Surgery**
Hussain Bohra, MBBS, MS; Prakash Sitoula, MS; Bhish Singh, MBBS, FRCSA, MS, FRCS; *Brian Hsu, MBBS, FRCSA*

11:44-11:53 **Discussion**

11:53-11:57 **Paper #61: Where Do Patients with Degenerative Lumbar Pathology Lose Lordosis?**
Ahilan Sivaganesan, MD; Lauren Barber, MD; R K. Alluri, MD; Tianna Bennett, BS; Hna Muzmil, BS; Jeong Hoon Kim, BS; Renaud Lafage, MS; Jonathan Elysee, MS; Basel Sheikh Alshabab, MD; Virginie Lafage, PhD; Sravisht Iyer, MD; *Francis C. Lovecchio, MD*

11:57-12:01 **Paper #62: Resolution of Radiculopathy Following Indirect vs. Direct Decompression in Single Level Lumbar Fusion**
Arnaav Walia, BS; Fares Ani, MD; Gregory Van Perrier, BS; Julianna Bono, BS; Aonnicha Burapachaisri, BS; Hershil Patel, BS; Nathan S. Kim, BA; Brooke K. O'Connell, MS; Constance Maglaras, PhD; Themistocles S. Protopsaltis, MD; Tina Raman, MD; *Charla Fischer, MD*

12:01-12:04 **Paper #63: Static vs. Expandable Interbody Fusion Devices: A Comparison of 1-Year Clinical and Radiographic Outcomes in Minimally Invasive Transforinal Lumbar Interbody Fusion**
Jonathan A. Ledesma, BS; Azra Dees, BA; Cannon G. Hiranaka, BS; Terence Thomas, BS; Mark F. Kurd, MD; Kris Radcliff, MD; D. Greg Anderson, MD

12:04-12:15 **Discussion**

10:50-12:15

Abstract Sesion 6B. Adult Spinal Deformity II
Biscayne Ballroom
Moderators: Michael P. Kelly, MD & Justin S. Smith, MD, PhD

10:50-10:54 **Paper #64: Which Components of the Global Alignment Proportionality Score Have the Greatest Impact on Outcomes in Adult Spinal Deformity Corrective Surgery?**
Oscar Krol, BS; Peter G. Passias, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Breton G. Line, BS; Shaleen Vira, MD; Alan H. Daniels, MD; Bassel G. Diebo, MD; Andrew J. Schoenfeld, MD, MS; Jeffrey L. Gum, MD; Khoi D. Than, MD; Han Jo Kim, MD; Richard Hostin, MD; Munish C. Gupta, MD; Robert K. Eastlack, MD; Douglas C. Burton, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Eric O. Klineberg, MD; Shay Bess, MD; International Spine Study Group

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10:54-10:58 **Paper #65: The Incremental Benefit of Adding Layers of Complexity to the Planning and Execution of Adult Spinal Deformity Corrective Surgery**
Peter G. Passias, MD; Katherine E. Pierce, BS; Bailey Imbo, BA; Peter Tretiakov, BS; Rachel Joujon-Roche, BS; Tyler K. Williamson, MS, BS; Oscar Krol, BS; Renaud Lafage, MS; *Virginie Lafage, PhD*; Gregory M. Mundis Jr., MD; Jeffrey L. Gum, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Shay Bess, MD; Frank J. Schwab, MD; Munish C. Gupta, MD

10:58-11:02 **Paper #66: Optimal Realignment Outweighs Increased Perioperative Risk in ASD Surgery**
Peter G. Passias, MD; *Tyler K. Williamson, MS, BS*; Bailey Imbo, BA; Kevin Moattari, BS; Peter Tretiakov, BS; Rachel Joujon-Roche, BS; Stephane Owusu-Sarpong, MD; Oscar Krol, BS; Jordan Lebovic, MBA; Renaud Lafage, MS; Virginie Lafage, PhD; Praveen V. Mummaneni, MD; Dean Chou, MD; Paul Park, MD; Saman Shabani, MD; M. Burhan Janjua, MD

11:02-11:11 **Discussion**

11:11-11:15 **Paper #67: Have We Made Advancements in Optimizing Surgical Outcomes and Ameliorating Recovery for High Risk Adult Spinal Deformity Patients Over Time**
Peter G. Passias, MD; Lara Passfall, BS; Peter Tretiakov, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Breton G. Line, BS; Shaleen Vira, MD; Jeffrey L. Gum, MD; Khaled M. Kebaish, MD; Khoi D. Than, MD; Gregory M. Mundis Jr., MD; Richard Hostin, MD; Munish C. Gupta, MD; Robert K. Eastlack, MD; Andrew J. Schoenfeld, MD, MS; Dean Chou, MD; Alan H. Daniels, MD; Themistocles S. Protopsaltis, MD; D. Kojo Hilton, MD; Alex Soroceanu, MPH; Raymarla Pinteric; Praveen V. Mummaneni, MD; Michael P. Kelly, MD; Han Jo Kim, MD; Neel Anand, MD; Christopher P. Ames, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Eric O. Klineberg, MD; Shay Bess, MD; International Spine Study Group; *Pierce D. Nunley, MD*

11:15-11:19 **Paper #68: Natural History of Adult Spinal Deformity: How Do Patients with Less Than Optimal Surgical Outcomes Fare Relative to Non-Operative Counterparts?**
Peter G. Passias, MD; *Rachel Joujon-Roche, BS*; Tyler K. Williamson, MS, BS; Peter Tretiakov, BS; Bailey Imbo, BA; Oscar Krol, BS; Lara Passfall, BS; Renaud Lafage, MS; Virginie Lafage, PhD; Jordan Lebovic, MBA; Stephane Owusu-Sarpong, MD; Paul Park, MD; Praveen V. Mummaneni, MD; M. Burhan Janjua, MD

11:19-11:23 **Paper #69: Operation Timing of Adult Spinal Deformity Surgeries: Does the Wait Matter?**
Michael Dinizo, MD; Thomas J. Errico, MD; Karnmanee Srisanguan, BS; *Tina Raman, MD*

11:23-11:32 **Discussion**

11:32-11:36 **Paper #70: Revision Free Loss of Sagittal Correction >3 years After Adult Spinal Deformity Surgery: Who and Why?**
Francis C. Lovecchio, MD; Renaud Lafage, MS; Han Jo Kim, MD; Shay Bess, MD; Christopher P. Ames, MD; Munish C. Gupta, MD; Peter G. Passias, MD; Eric O. Klineberg, MD; Gregory M. Mundis Jr., MD; Douglas C. Burton, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

11:36-11:40 **Paper #71: What is the Incidence, Mechanism, and Protective Strategies for 2-Year Pelvic Fixation Failure after Adult Spinal Deformity Surgery with a Minimum 6 Level Fusion**
Nathan J. Lee, MD; Varun Puvanesarajah, MD; Paul J. Park, MD; William E. Clifton, MD; Kevin Kwan, MD; Cole Morrissette, MS; Jaques L. Willis, BS; Michael Fields, MD; Eric Leung, BS; Fthimnir M. Hassan, MPH; Peter D. Angevine, MD; Christopher E. Mandigo, MD; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman Jr., MD; Lawrence G. Lenke, MD

11:40-11:44 **Paper #72: Identification of Optimal Frailty and Deformity Ranges at Presentation to Achieve Maximum Improvement from Adult Spinal Deformity Corrective Surgery**
Peter G. Passias, MD; Nicholas A. Kummer, BS; Bailey Imbo, BA; Lara Passfall, BS; *Tyler K. Williamson, MS, BS*; Rachel Joujon-Roche, BS; Oscar Krol, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Praveen V. Mummaneni, MD; Paul Park, MD; Dean Chou, MD; Shaleen Vira, MD; Bassel G. Diebo, MD; M. Burhan Janjua, MD

11:44-11:53 **Discussion**

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11:53-11:57 **Paper #73: Comparison of Complications, Outcomes, and Cost in Frail vs. Non-Frail ASD Surgery Patients**
Oscar Krol, BS; Lara Passfall, BS; Shaleen Vira, MD; Stephane Owusu-Sarpong, MD; Bassel G. Diebo, MD; Andrew J. Schoenfeld, MD, MS; Rachel Joujon-Roche, BS; Peter Tretiakov, BS; Bailey Imbo, BA; Tyler K. Williamson, MS, BS; Waleed Ahmad, BS; Renaud Lafage, MS; Virginie Lafage, PhD; Peter G. Passias, MD; Praveen V. Mummaneni, MD

11:57-12:01 **Paper #74: The At-HOME Score: A Novel Scoring System Predicting Discharge Disposition following ASD Surgery**
Khaled M. Kebaish, MD; *Brian J. Neuman, MD*

12:01-12:04 **Paper #75: Health Related Quality of Life Measures in Adult Spinal Deformity: Can We Replace the SRS-22 with PROMIS?**
Peter G. Passias, MD; Katherine E. Pierce, BS; Waleed Ahmad, BS; Tyler K. Williamson, MS, BS; Stephane Owusu-Sarpong, MD; Sara Naessig, BS; *Rachel Joujon-Roche, BS*; Peter Tretiakov, BS; Lara Passfall, BS; Bailey Imbo, BA; Oscar Krol, BS; M. Burhan Janjua, MD; Paul Park, MD; Jordan Lebovic, MBA; Praveen V. Mummaneni, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Tina Raman, MD; Brooke K. O'Connell, MS; Constance Maglaras, PhD; Bassel G. Diebo, MD; Themistocles S. Protopsaltis, MD; Aaron J. Buckland, MBBS, FRCSA

12:04-12:15 **Discussion**

12:15-12:30

Walking Break & Lunch Pickup
Foyers of Escorial / Alhambra, Michelangelo / Raphael, Sandringham and Windsor

12:30-13:30

Industry Workshops
Escorial / Alhambra, Michelangelo / Raphael, Sandringham and Windsor
For the full schedule, please refer to page 190.

13:30-14:00

Walking Break

14:00-15:30

Concurrent Sessions 7A-C. Instructional Course Lectures
7A) Trianon Ballroom, 7B) Biscayne Ballroom, 7C) Chopin Ballroom

14:00-15:30

Session 7A. Enabling Technologies in Spine Surgery: The Evolution of Spine Surgery
Trianon Ballroom
Moderators: Joseph P. Gjolaj, MD & Ronald A. Lehman Jr., MD

14:00-14:10 **Setting the Stage: Custom Rods and Implants to Predict Optimization**
Joseph A. Osorio, MD, PhD

14:10-14:20 **Safety: Technology is Great, but Beware the Radiation for the Patient and Surgical Team**
Joseph P. Gjolaj, MD

14:20-14:25 **Discussion**

14:25-14:33 **Tried and True Navigation: We Can Do Everything We Need Now**
David W. Polly Jr., MD

14:33-14:41 **Robotics is Here and Now and Leading Us Into the Future**
Ronald A. Lehman Jr., MD

14:41-14:49 **Technology is Great But Freehand is Still the Standard**
Lawrence G. Lenke, MD

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14:49-14:55 Discussion

14:55-15:05 Where Will the Future of Robotics Take Us?
Charla Fischer, MD

15:05-15:15 Augmented Reality and Virtual Reality Offer Unlimited Enhancements for Optimizing Surgery
Daniel M. Sciubba, MD

15:15-15:25 We Are All Different: Predictive Analytics and Patient Individuality is Paramount Moving Forward
Justin S. Smith, MD, PhD

15:25-15:30 Discussion

14:00-15:30

Session 7B. The Age of Precision Medicine in Spinal Deformity Surgery
Biscayne Ballroom
Moderators: Christopher P. Ames, MD; Michelle C. Marks, PT, MA; Ferran Pellisé, MD, PhD

14:00-14:08 Tailoring the Procedure to Patient-Specific and Parents Goals
Baron S. Lonner, MD

14:08-14:16 Shared Decision Making, Game Theory, Decision Regret and Decision Node Waiting
Michael P. Kelly, MD

14:16-14:24 Precision Surgery Prep
Han Jo Kim, MD

14:24-14:34 Panel Discussion

14:34-14:42 Precision Realignment: GAP
Ahmet Alanay, MD

14:42-14:50 Precision Realignment: Pediatrics
Kariman Abelin Genevois, MD, PhD

14:50-15:00 Panel Discussion

Case Simulations

15:00-15:08 Risk Calculators, Predicting Specific Complications and Preventing Them
Ferran Pellisé, MD, PhD

15:08-15:16 Surgical Genomic Telemeres and Unknown Unknowns
Christopher P. Ames, MD

15:16-15:30 Roundtable Discussion: Data & the Future
Moderator: Michelle C. Marks, PT, MA

14:00-15:30

Session 7C. A Moving Topic: Cervical Arthroplasty
Chopin Ballroom
Moderators: Hyun W. Bae, MD & Rick C. Sasso, MD

14:00-14:15 Case Discussion
Jens Chapman, MD

14:15-14:30 Long-Term Outcomes of Cervical Arthroplasty
Alexander R. Vaccaro, MD, PhD, MBA

14:30-14:45 Performing Cervical Arthroplasty: Tips & Pearls
Rick C. Sasso, MD

Meeting Agenda

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14:45-15:00 **Expanded Indications for Arthroplasty**
Hyun W. Bae, MD

15:00-15:15 **Contraindications and Complications of Arthroplasty**
Jack Zigler, MD

15:15-15:30 **Panel Discussion**

15:30-16:00

Refreshment Break & Exhibit Viewing
Level 2 - Mezzanine

16:00-17:00

Concurrent Sessions 8A-C. Instructional Course Lectures
8A) Trianon Ballroom, 8B) Biscayne Ballroom, 8C) Chopin Ballroom

16:00-17:00

Session 8A. Cervical Deformity: Where Are We Now?
Trianon Ballroom
Moderators: Eric O. Klineberg, MD & Corey T. Walker, MD

16:00-16:05 **Introduction & Case Presentation**
Eric O. Klineberg, MD

16:05-16:15 **Update on Cervical Alignment (Parameters)**
Virginie Lafage, PhD

16:15-16:25 **Predictive Analytics in Cervical Deformity Defining the 3 Clusters**
Han Jo Kim, MD

16:25-16:30 **Surgical Options for Cluster I: Front or Back**
Robert K. Eastlack, MD

16:30-16:35 **Surgical Options for Cluster II: Posterior Only**
Themistocles S. Protopsaltis, MD

16:35-16:40 **Surgical Options for Cluster III: 3CO vs. Front Back**
Christopher P. Ames, MD

16:40-16:50 **Complications with Cervical Spinal Surgery**
Justin S. Smith, MD, PhD

16:50-17:00 **Case Conclusion & Discussion**

16:00-17:00

Session 8B. Neurological Concerns in Spinal Deformity from the SRS-AANS Task Force
Biscayne Ballroom
Moderators: Regis W. Haid Jr., MD; Lawrence G. Lenke, MD; Praveen V. Mummaneni, MD

16:00-16:08 **Evolution and Importance of Neuromonitoring**
Sigurd H. Berven, MD

16:08-16:16 **Diastatomyelia and Surgical Timing When Proposing Deformity Correction**
Amer F. Samdani, MD

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

16:26-16:34 **Thinking Beyond the Dura: Detethering vs. Spinal Shortening for Tethered Cord**
Dean Chou, MD

Meeting Agenda

FRIDAY, APRIL 8, 2022

16:34-16:42 Chiari Malformations and Timing of Spinal Deformity Surgery
Mari L. Groves, MD

16:42-16:50 Syrinxes: Why CSF Matters for Spinal Deformity
Christopher I. Shaffrey, MD

16:50-17:00 Discussion

16:00-17:00

Session 8C. Plan Ahead, Don't Play by Ear: An Early Career Surgeon Session
Chopin Ballroom
Moderators: Kariman Abelin Genevois, MD; Caglar Yilgor, MD

16:00-16:03 Welcome and Early Career Surgeon Task Force Introduction
Kariman Abelin Genevois, MD

16:03-16:07 Building a VBT Team and Performing the First Case
Steven W. Hwang, MD

16:07-16:16 Discussion

16:16-16:20 Digitized Planning for Adult Spinal Deformity Surgery
Jeffrey M. Hills, MD

16:20-16:29 Discussion

16:29-16:33 How I Reduced My First High-Grade Spondylolisthesis
Kariman Abelin Genevois, MD

16:33-16:42 Discussion

16:42-16:46 Revising Devastating PJK: Lessons Learned
Caglar Yilgor, MD

16:46-16:55 Discussion

16:55-17:00 Call for Candidates for the SRS Mentorship Program
Kariman Abelin Genevois, MD

17:00

Early Career Surgeon Social
Bayfront Ballroom A
Early Career Surgeon Social is supported by Medtronic

Meeting Agenda

SATURDAY, APRIL 9, 2022

08:00-13:00

Registration Open
Level 2 - Mezzanine

Exhibit Hall Closed

09:00-10:20

Session 9. Bandwagon vs. Pendulum Swing
Versailles Ballroom
Moderators: Serena S. Hu, MD; Stefan Parent, MD, PhD; David L. Skaggs, MD, MMM

Pediatrics

09:00-09:05 I am Doing Less Growth-Friendly Surgery in the Youngest EOS
A. Noelle Larson, MD

09:05-09:10 I am Doing Less Growth-Friendly Surgery in the Older EOS
Craig R. Louer, MD

9:10-9:15 Discussion

09:15-09:20 Anterior Release is No Longer Needed for Scheuermann's Kyphosis
Baron S. Lonner, MD

09:20 -09:25 VEPTRs Have Largely Become Historical
John T. Smith, MD

9:25-9:30 Discussion

Adults

09:30-09:35 Dynesis and Other Posterior Lumbar Non-Fusion Techniques
Hyun W. Bae, MD

09:35-09:40 Interspinous Distraction Devices
Hyun W. Bae, MD

09:40-09:45 Discussion

09:45-09:50 Kyphoplasty (Cement Injection) Did Not Quite Pan Out
Khaled M. Kebaish, MD

09:50-09:55 Why We Do Less PSO These Days
Serena S. Hu, MD

09:55-10:00 Discussion

10:00-10:05 Pelvic Incidence Is Not As Important As We Thought
Christopher P. Ames, MD

Both

10:05-10:10 Anterior Fusion for Scoliosis
Amer F. Samdani, MD

10:10-10:15 Discussion

10:15-10:20 Whitecloud Award Announcement

Meeting Agenda

SATURDAY, APRIL 9, 2022

10:20-10:30

Refreshment Break
Versailles Ballroom Foyer

10:30-11:30

Session 10. Current Trends in the Management of Thoracolumbar Spine Trauma
Versailles Ballroom
Moderators: Rick C. Sasso, MD & Alexander R. Vaccaro, MD, PhD, MBA

10:30-10:37 Classification of Thoracolumbar Fractures
Alexander R. Vaccaro, MD, PhD, MBA

10:37-10:44 What's New in the Management of TL Fractures?
Steven C. Ludwig, MD

10:44-10:51 New Concepts in Biomechanics & Classification & Role of Spinopelvic Pareters
Rick C. Sasso, MD

10:51-10:57 Discussion

10:57-11:04 Anterior vs. Posterior Surgery for the Treatment of TL fractures?
Gregory Schroeder, MD

11:04-11:11 Post Traumatic Kyphosis: When and How to Operate?
Harvinder Singh Chhabra, MBBS, MS (Ortho)

11:11-11:18 Surgical Management of TL Fractures in Elderly Patients (Senile Anklyosis, DISH and Osteoporosis)
Christopher K. Kepler, MD

11:18-11:30 Discussion & Case Presentation
Gregory Schroeder, MD

11:30-11:45

Walking Break & Lunch Pickup
Versailles Ballroom Foyer

11:45-13:15

Session 11. Lunch with the Experts: Master Video Techniques
Versailles Ballroom
Moderators: Alanay Ahmet, MD & Stefan Parent, MD, PhD

11:45-11:55 Power Instruments in Spinal Deformity Surgery
David L. Skaggs, MD, MMM

11:55-12:00 Discussion

12:00-12:10 SI Joint Fusion: Surgical Technique & How to Optimize Surgical Outcome
David W. Polly Jr., MD

12:10-12:15 Discussion

12:15-12:25 VBT: How I Do It
Amer F. Samdani, MD

12:25-12:30 Discussion

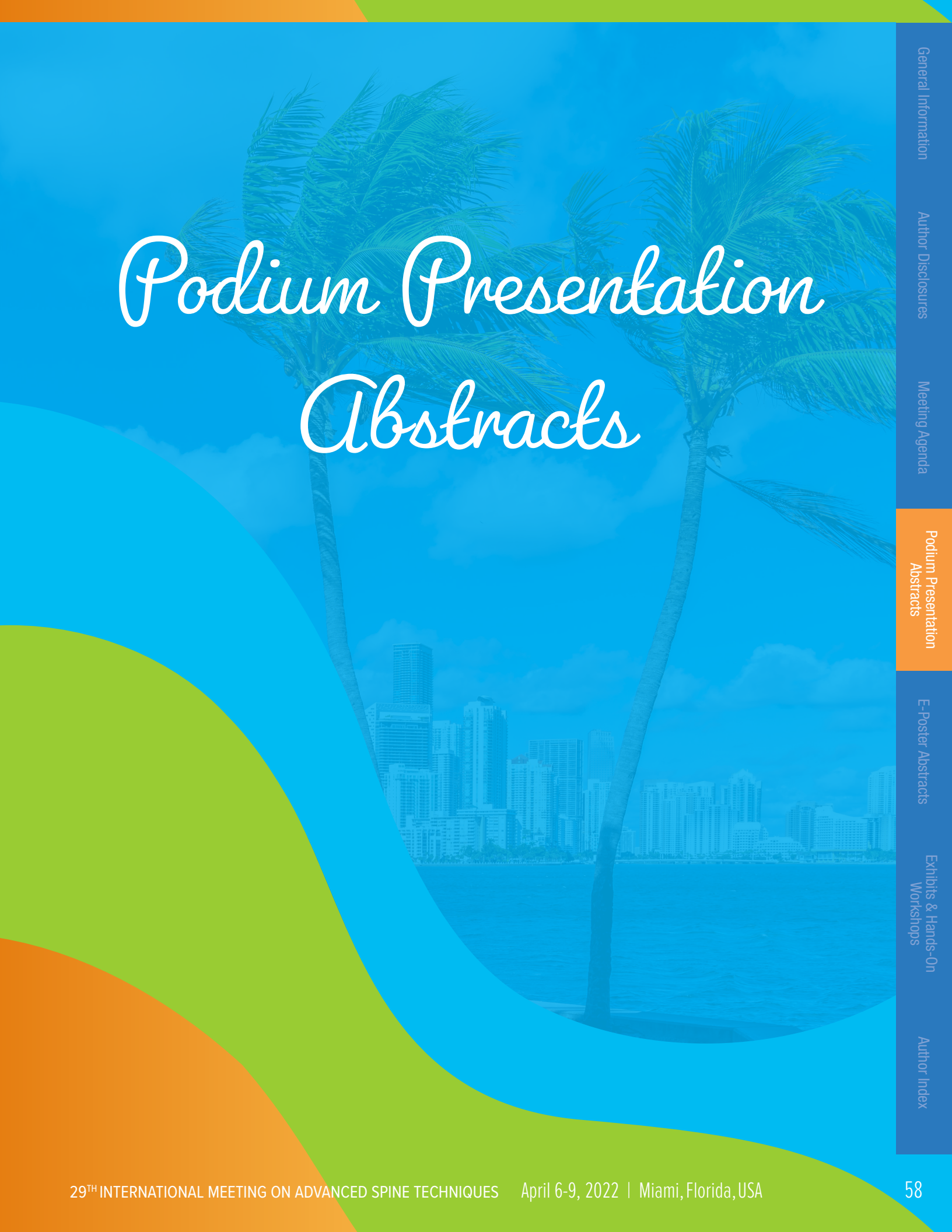
12:30-12:40 Kickstand Rod Technique: How to Best Apply this Intra-Operative Technique
Lawrence G. Lenke, MD

12:40-12:45 Discussion

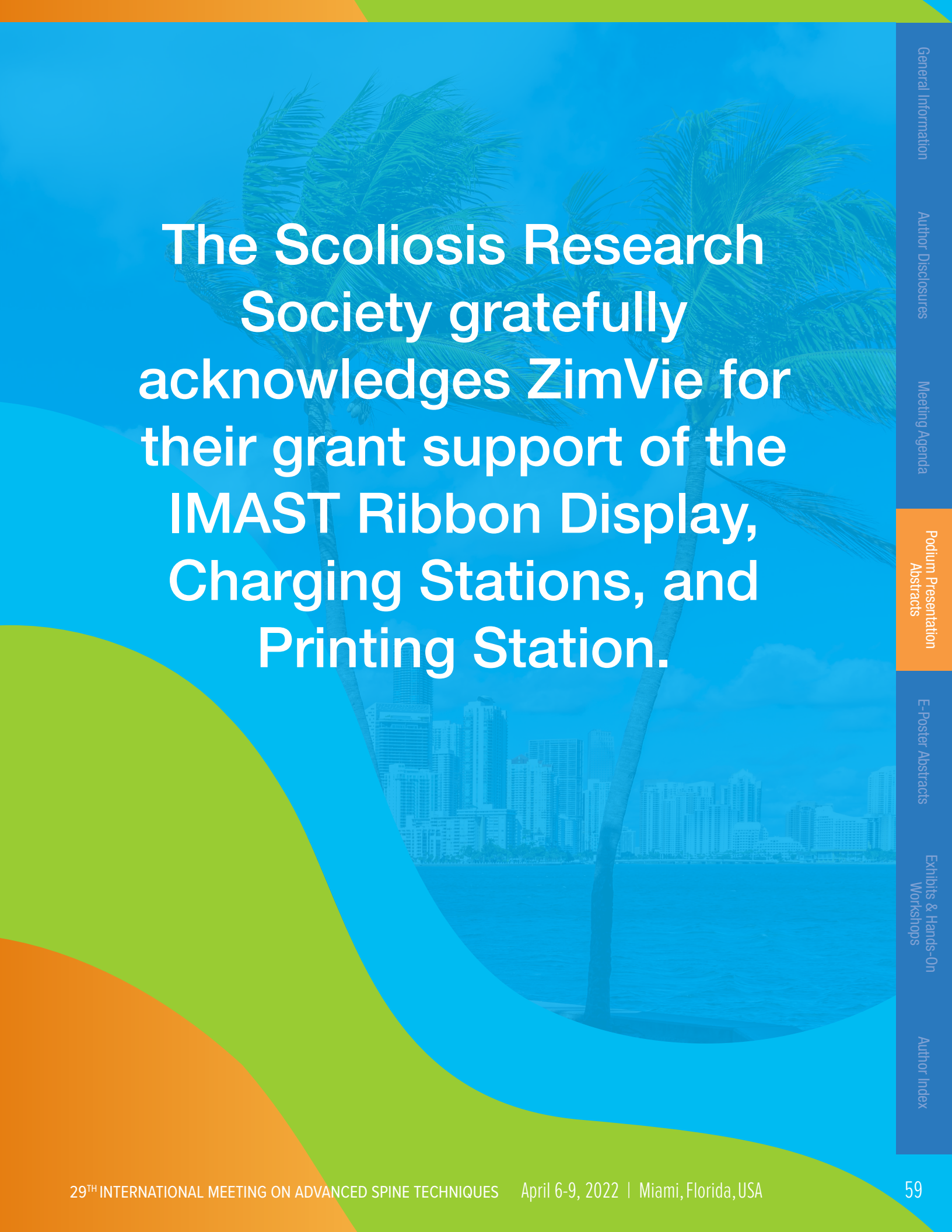
Meeting Agenda

SATURDAY, APRIL 9, 2022

12:45-12:55	Cervico-Thoracic VCR: Pearls & Pitfalls *Christopher P. Ames, MD*
12:55-13:00	Discussion
13:00-13:10	How to Prevent PJK: Tips & Tricks *Serena S. Hu, MD*
13:10-13:15	Discussion
13:15	Adjourn



Podium Presentation Abstracts



The Scoliosis Research Society gratefully acknowledges ZimVie for their grant support of the IMAST Ribbon Display, Charging Stations, and Printing Station.

Podium Presentation Abstracts

1. Outcomes of Single-Sided vs. Bilateral Thoracic and Lumbar Anterior Vertebral Body Tethering in Lenke 1 and 2 Curves with Lumbar C Modifier

Joshua M. Pahys, MD; Amer F. Samdani, MD; Alejandro Quinonez, BS; Steven W. Hwang, MD

Summary

Single center study of 197 Lenke 1/2 patients revealed a higher lumbar coronal curve at 2 years postop for lumbar C modifier vs. A/B curves after vertebral body tethering (VBT). Reoperation rates were significantly higher in the C group undergoing bilateral VBT (CB) compared to AB (31% vs. 14%), primarily for overcorrection. The reoperation rate was significantly increased in patients with preop open triradiate cartilage (C: 52% vs. AB: 27%) vs. <10% for all patients with preop closed triradiate cartilage.

Hypothesis

Anterior vertebral body tethering (VBT) in adolescent idiopathic scoliosis (AIS) patients with Lenke 1/2 curves and lumbar C modifier will result in higher failure rates.

Design

Retrospective review of single center database

Introduction

VBT is an alternative treatment for skeletally immature AIS patients. The outcomes of single sided thoracic VBT vs. bilateral thoracic and lumbar VBT for Lenke 1&2 curves with lumbar C modifier has not been reported.

Methods

197 AIS patients with Lenke 1&2 curves and minimum two year followup were identified. Patients were grouped based on preop lumbar modifier A/B (n=128) or C (n=69). The total C group (CT) was further subdivided into single-sided VBT (CS, n=47) vs. bilateral thoracic and lumbar VBT (CB, n=22).

Results

The preop lumbar Cobb was larger for CT (37°) vs. AB (29°, p<0.01), but all other preop radiographic and demographic data was similar between all groups. All groups had similar preop skeletal maturity scores (Sanders, Risser, and open triradiate cartilage (TRC)). At 2 years postop, the CT group had a larger lumbar Cobb (18.5°) vs. AB (14.7°), p=0.05. The CB group had a higher revision rate (31%) compared to AB (14%), p=0.05. Patients with preop open TRC vs. closed TRC had significantly increased revision rates for all groups: AB: 27%: CT: 52%; CS: 40%; CB: 86%; p<0.001. The majority of revisions were for overcorrection, and six patients (AB: n=3; CT: n=3) required a fusion. Coronal thoracic Cobb>35° was present in 20% of AB vs. 17% of CT patients (p=0.3) and coronal lumbar Cobb>35° was present in 4% of AB vs. 6% of CT patients (p=0.3) at last visit.

Conclusion

197 AIS patients with Lenke 1&2 curves underwent VBT at a single center with minimum two year followup. Patients with a preop lumbar modifier A/B (AB) had improved lumbar coronal Cobb at two years compared to lumbar C modifier patients. The revision rate was significantly higher for lumbar C patients with a bilateral VBT (CB) vs. AB patients (31% vs. 14%, p=0.05). The revision rate, primarily for overcorrection, was significantly increased in patients with preop open triradiate cartilage (CT: 52% vs. AB: 27%, p=0.005).

Take Home Message

Anterior vertebral body tethering for Lenke 1/2 curves with lumbar C modifier had significantly higher failure rates if both curves are tethered and the preop triradiate cartilage is open.

	Lumbar Modifier A/B	Lumber Modifier C: Total	Lumbar Modifier C: Single Sided Thoracic VBT	Lumbar Modifier C: Bilateral Thoracic & Lumbar VBT	p value: A/B vs C
Total patients	128	69	47	22	
Age at surgery years (mean)	12.6	12.6	12.6	12.6	0.9
Preop Sanders (mode)	3	3	3	3	0.8
Preop Open Triradiate Cartilage	32% (n=41/128)	32% (n=23/69)	32% (n=16/47)	32% (n=7/22)	0.8
Preop Main Thoracic Cobb (mean)	51°	53°	53°	53°	0.3
Preop Lumbar Cobb (mean)	29°	37°	32°	46°	**<0.001**
Preop Thoracic Kyphosis (mean)	21°	21°	20°	21°	0.8
Preop Lumbar Lordosis (mean)	46°	47°	47°	48°	0.5
2yr Main Thoracic Cobb (mean)	20°	22°	21°	23°	0.3
2yr Lumbar Cobb (mean)	15°	19°	18°	19°	**0.05**
2yr Thoracic Kyphosis (mean)	22°	24°	24°	25°	0.2
2yr Lumbar Lordosis (mean)	47°	46°	45°	46°	0.6
Followup years (mean)	3.7 (range: 2-7.8)	3.2 (range: 2-6.1)	3.2 (range: 2-6.1)	3.1 (range: 2-5.2)	0.3
Latest F/U Sanders (mode)	8	7	8	7	0.5
Latest F/U % Main Thoracic Cobb >35°	20% (n=25/128)	17% (n=12/69)	21% (n=10/47)	9% (n=2/22)	0.3
Latest F/U % Lumbar Cobb >35°	4% (n=5/128)	6% (n=4/69)	9% (n=4/47)	0% (n=0/22)	0.3
Required Revision Surgery	14% (n=18/128)	23% (n=16/69)	19% (n=9/47)	**31%** (n=7/22)	CT: p=0.1 CS: p=0.5 **CB: p=0.05**
Required Revision Surgery: Preop Closed TRC	8% (n=7/87)	9% (n=4/46)	10% (n=3/31)	7% (n=1/15)	0.5
Required Tether Release for Overcorrection: Preop Closed TRC	2% (n=2/87)	7% (n=3/46)	6% (n=2/31)	7% (n=1/15)	0.3
Required Fusion: Preop Closed TRC	3% (n=3/87)	4% (n=2/46)	3% (n=1/31)	0% (n=0/15)	0.5
Required Revision Surgery: Preop Open TRC	27% (n=11/41)	52% (n=12/23)	40% (n=6/16)	86% (n=6/7)	**0.005**
Required Tether Release for Overcorrection: Preop Open TRC	21% (n=9/41)	30% (n=7/23)	13% (n=2/16)	71% (n=5/7)	CT: p=0.5 CS: p=0.5 **CB: p=0.01**
Required Fusion: Preop Open TRC	0% (n=0/41)	9% (n=2/23)	6% (n=1/16)	14% (n=1/7)	0.1

VBT: Vertebral Body Tethering
F/U: followup
TRC: triradiate cartilage
CT: Total with Lumbar C modifier
CS: Lumbar C with Single Sided Thoracic VBT
CB: Lumbar C with Bilateral Thoracic & Lumbar VBT

2. Anterior Vertebral Body Tethering (aVBT) for Immature Idiopathic Scoliosis: Results on Patients Reaching Skeletal Maturity

Amer F. Samdani, MD; *Stephen Plachta, MD*; Joshua M. Pahys, MD; Solomon Samuel, D. Eng.; Alejandro Quinonez, BS; Steven W. Hwang, MD

Summary

The value of aVBT as a fusion less treatment option for idiopathic scoliosis is evolving. Limited data exists on patient outcomes at skeletal maturity that relies on growth modulation. We analyzed 64 patients and found progressive correction of scoliosis that was maintained at most recent follow-up, >5 years. The enthusiasm for

this technology should be tempered by the high reoperation and conversion to fusion rate.

Hypothesis
aVBT provides sustained growth modulation of idiopathic scoliosis until skeletal maturity.

Design
Single Center Retrospective Review

Introduction
aVBT is promising new technique, with several 2-yr follow-up studies documenting its benefits. Outcomes of aVBT patients who reach skeletal maturity and beyond are necessary to assess the sustainability of growth modulation.

Methods
Under IRB approval, consecutive patients (skeletally immature) with idiopathic scoliosis treated with aVBT were followed to skeletal maturity and followed for >5 years. Both clinical and radiographic data were collected. Outcomes were measured preoperatively, at first erect radiograph (FE), 1-year postoperatively and most recent follow up (FU).

Results
64 patients underwent primary tethers (51 primary thoracic, 4 Lumbar only, 9 tethering both). At surgery mean age was 12.14 ± 1.15 years and Risser 0.33 ± 0.74. Radiographically they achieved correction and stability while reaching skeletal maturity with mean follow-up of 73.09 ± 11.62 months. For the thoracic single tethers, preop cobb angle averaged 45.88 ± 9.02° and corrected to 21.33 ± 11.5° at latest follow-up (p<0.0001, % correction = 53.51%). Similarly, the single lumbar tethers, pre op cobb measured 56.58 ± 11.27° and corrected to 13.70 ± 7.41° at latest follow-up (p=0.0049. % correction = 75.79%). Double tether patients, preop thoracic curves measured 51.39 ± 10.88° and lumbar curves measured 47.61 ± 5.86° and corrected to 23.28 ± 12.69° and 15.14 ± 11.23°, respectively. This gave a mean of 54.7% correction in thoracic and 68.20% correction in Lumbar spine (p=<0.05). Additionally, a high all cause reoperation rate was noted 20/64 (~31%) including conversion to fusion 8/64 (12.5%). Mean time to conversion was 52.63± 11.38 months. Overall, both primary tethers (thoracic/lumbar) and double tethers show significant curve correction from preop to latest follow-up of greater than 5 years.

Conclusion
aVBT at skeletal maturity and minimum of 5 years postop, shows maintenance of correction with no progression. This result must be tempered with a known independent risk of reoperation ~30%.

Take Home Message
aVBT is capable of maintaining correction with >5 yr follow-up. Selecting appropriate indications for this procedure, may influence risk profile and outcomes.

Table #1

	Thoracic Tether only (n=51)			Lumbar tether only (n=4)			Double Tether (n=9)		
Visit	Proximal	Thoracic	Lumbar	Proximal	Thoracic	Lumbar	Proximal	Thoracic	Lumbar
preop	22.58 ± 8.88	45.88 ± 9.02	25.81 ± 7.24	10.45 ± 14.05	26.35 ± 11.72	56.58 ± 11.27	18.71 ± 8.95	51.39 ± 10.88	47.61 ± 5.86
fe	16.50 ± 7.44	21.06 ± 9.97	16.34 ± 6.13	14.02 ± 11.70	18.2 ± 7.04	15.16 ± 7.87	15.73 ± 8.60	28.43 ± 12.10	12.36 ± 9.71
2 year	13.06 ± 8.50	14.53 ± 11.70	10.4 ± 6.56	12.26 ± 9.29	30.63 ± 24.17	26.35 ± 21.32	13.44 ± 8.67	21.64 ± 10.25	14.72 ± 5.24
latest	15.14 ± 8.69	21.33 ± 11.5	16.73 ± 9.64	14.06 ± 4.56	10.58 ± 9.86	13.70 ± 7.41	13.46 ± 4.54	23.28 ± 12.69	15.14 ± 11.23
% Correction Latest to preop	32.95%	53.51%	35.18%	-34.55%	59.85%	75.79%	28.06%	54.70%	68.20%
p-value PreOp to FE	<0.0001	<0.0001	<0.0001	0.8529	0.1686	0.0019	0.0328	<0.0001	<0.0001
p-value Latest to PreOp	<0.0001	<0.0001	<0.0001	0.6487	0.0266	0.0049	0.026	0.0007	0.0049
p-value Latest to FE	0.227	0.8589	0.5511	0.7682	0.4333	0.6245	0.249	0.4413	0.6035

Radiographic Data and Analysis

3. Low Radius of Curvature Growth Friendly Implants Increase the Risk of Developing Clinically Significant Proximal Junctional Kyphosis

Ellen Parker, PhD; Mohammed Al Anazi, MD; *Ron El-Hawary, MD*

Summary
In patients with early onset scoliosis (EOS), low radius of curvature (ROC) (i.e., more curved) posterior distraction implants were associated with a greater increase in thoracic kyphosis. This likely led to a higher risk of developing clinically-significant proximal junctional kyphosis (PJK), in which revision surgery was required.

Hypothesis
We sought to test the hypothesis that EOS patients treated with low ROC (more curved rods) distraction-based treatment will have a greater risk of developing PJK compared to those with high ROC (straighter) implants.

Design
Retrospective review of prospectively collected data.

Introduction
Clinically significant PJK occurs in 20% of children treated with posterior distraction-based growth friendly surgery. In an effort to identify modifiable risk factors, it has been theorized biomechanically that low ROC implants may increase post-operative thoracic kyphosis, and thus may pose a higher risk of developing PJK.

Methods
Data was obtained from a multi-centre EOS database on children treated with rib-based distraction with minimum 2-year follow-up. Variables of interest included: implant ROC at index (220 mm or 500 mm), patient age, pre-op scoliosis, pre-op kyphosis, and scoliosis etiology. In the literature, PJK has been defined as clinically significant if revision surgery with superior extension of the upper instrumented vertebrae was performed.

Results
In 148 scoliosis patients, there was a higher risk of clinically significant PJK with low ROC rods (OR: 2.6 (95%CI 1.09-5.99), $\chi 2$ (1,

n=148)=4.8, p=0.03). Patients had a mean pre-op age of 5.3 years (4.6y 220mm vs. 6.2y 500mm, p=0.002). A logistic regression model was created with age as a confounding variable, but it was not significant (p=0.6). Scoliosis etiologies included 52 neuromuscular, 52 congenital, 27 idiopathic, 17 syndromic with no significant differences in PJK risk between etiologies (p=0.07). Overall, patients had pre-op scoliosis of 69° (67° 220mm vs. 72° 500mm, p=0.2), and kyphosis of 48° (45° 220mm vs. 51° 500mm, p=0.1). The change in thoracic kyphosis pre-operatively to final follow up (mean 4.0±0.2 years) was higher in patients treated with 220mm implants compared to 500mm implants (220mm: 7.5±2.6° vs. 500mm: -4.0±3.0°, p=0.004).

Conclusion
Use of low ROC (more curved) posterior distraction implants is associated with a significantly greater increase in thoracic kyphosis which likely led to a higher risk of developing clinically-significant PJK in EOS patients.

Take Home Message
Lower ROC implants are associated with an increased risk of clinically-significant PJK. These findings have implications for implant ROC selection for the treatment of EOS.

4. Topical Tranexamic Acid Does Not Result in Reduced Blood Loss in Adult Spinal Deformity Surgery: Preliminary Results from a Double-Blinded RCT

Kyle W. Morse, MD; Jordan A. Gruskay, MD; Renaud Lafage, MS; Hamna Muzammil, BS; Evangelia Zgonis, BS; Rachel Knopp, MPH; Virginie Lafage, PhD; Matthew E. Cunningham, MD, PhD; Frank J. Schwab, MD; Han Jo Kim, MD

Summary
Blood loss is a major source of peri-operative morbidity following adult spinal deformity surgery. Topical tranexamic acid (tTXA) may result in reduced blood loss post-operatively. A preliminary analysis was performed following a double-blind randomized control trial examining the effect of the addition of topical tranexamic acid to intravenous during adult spine deformity surgery. There were no differences found in EBL, cell saver infusion, drain output, or transfusion amount at 48 hours for the addition of tTXA compared to placebo.

Hypothesis
The addition of topical tranexamic acid (tTXA) as an adjunct to intravenous TXA (ivTXA) will result in reduced blood loss as measured by 48 hr drain output (DO) and transfusion (T) amount.

Design
Prospective Double-Blind RCT

Introduction
Blood loss is a significant issue in adult spinal deformity (ASD) surgery. Allogenic blood transfusion and/or intra-op blood salvage are often required, which is associated with an increased risk of post-op infection, longer length of stay, and higher hospital costs. ivTXA has been shown to mitigate blood loss in spine surgery but the effect of tTXA has not been thoroughly studied.

Methods
A priori power analysis assuming sample size of 44 pts/arm for a total of 88 to achieve 80% power to detect a reduction in post-op DO with alpha =0.05. Age 18-80 were eligible if undergoing ASD surgery with >=5 levels with instrumentation to pelvis. We excluded accepted contraindications to TXA in addition to intra-op dural tear, cardiac event/stroke within 1yr, seizures, active malignancy, PE/DVT and bleeding disorders. The IV TXA dose was TXA (5mg/ml) 20mg/kg loading with 2mg/kg/hr maintenance. tTXA was applied after instrumentation and bone work and left for >=5min. Pts were randomized to: Control (C) (250cc NS) or Investigational (I) (200cc NS with 5g TXA 100mg/ml (50cc)). Block randomization was performed prior to enrollment. Primary outcome measures were DO and T at 48hrs.

Results
67 pts were enrolled to date with an avg age of 63.1+/-20.0yrs and 72% female. 8 were excluded due to intra-op dural tears and 1 for active malignancy leading to 58 for preliminary analysis. There were no demographic differences between groups (Table 1). There were no differences found in operative time, estimated blood loss, cell saver infusion, DO or T amounts between groups at 24hrs, 48hrs or 72hrs (Table 1).

Conclusion
The addition of tTXA to ivTXA does not appear to result in decreased DO or T amounts post-op, however these results are preliminary and still under our target power analysis. Further investigation is required to complete the randomization protocol.

Take Home Message
In this preliminary analysis of a prospective double-blinded RCT, combination topical and intravenous TXA did not result in decreased blood loss or transfusions following ASD surgery over intravenous TXA alone.

	Investigational Group (N=32)	Control Group (N=26)	P – Value
Demographics			
Age	63.5 ± 11.4	62.7 ± 12.8	0.806
BMI	26.8 ± 6.6	25.6 ± 5.2	0.462
Gender (Female/Male)	23/9	19/7	0.919
Operative Details			
Number of Levels Fused	9.4 ± 3.0	9.4 ± 3.6	0.956
Total Time in Operating Room (minutes)	373.4 ± 80.8	371.5 ± 87.0	0.933
Operative Time (Skin to skin, minutes)	283.1 ± 72.9	276.5 ± 84.9	0.682
Patients with a Smith Peterson Osteotomy	26	19	0.458
Number of Smith Peterson Osteotomy Levels	2.8 ± 1.3	4.1 ± 2.8	0.059
Patients with a Ponte Osteotomy	3	2	0.600
Patients with a Pedicle Subtraction Osteotomy	6	7	0.458
Patients with a Vertebral Column Resections	1	1	1.000
Estimated Blood Loss (cc)	964.4 ± 591.6	1062.5 ± 1068.4	0.663
Cell Saver Infusion (cc)	403.3 ± 289.5	325.2 ± 431.4	0.455
Drain Output (cc)			
24 Hours	486.4 ± 209.8	551.4 ± 241.6	0.295
48 Hours	857.2 ± 366.0	1000.1 ± 556.9	0.274
72 Hours	1021.7± 475.8	1267.0 ± 791.4	0.184
Transfusion Amount (cc)			
24 Hours	413.8 ± 389.2	507.3 ± 474.5	0.546
48 Hours	595.5 ± 368.0	663.9 ± 614.2	0.708
72 Hours	618.8 ± 337.4	795.7 ± 772.3	0.417

Table 1: Demographics and Operative Details

5. Are We Getting Better at 3-Column Osteotomy in Terms of Achieving Optimal Realignment, Minimizing Complications, and Clinical Outcomes in Adult Spinal Deformity?

Peter G. Passias, MD; Oscar Krol, BS; Lara Passfall, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Breton G. Line, BS; Shaleen Vira, MD; Alan H. Daniels, MD; Bassel G. Diebo, MD; Jeffrey L. Gum, MD; Andrew J. Schoenfeld, MD, MS; Khoi D. Than, MD; Han Jo Kim, MD; Richard Hostin, MD; Munish C. Gupta, MD; Robert K. Eastlack, MD; Douglas C. Burton, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Eric O. Klineberg, MD; Shay Bess, MD; International Spine Study Group

Summary
Three-column osteotomies (3CO) have become common in adult spinal deformity (ASD) in cases of severe deformity or iatrogenic sagittal malalignment. Over a seven-year period, the rates of 3CO usage have declined, including in cases of severe deformity, with an increase in the usage of PJK prophylaxis. A better understanding of the utility of 3CO, along with a greater implementation of preventative measures, has led to a decrease in complications, PJF, and a significant improvement in patient reported outcome measures.

Hypothesis
To investigate the evolution of 3CO usage.

Design
Retrospective cohort study of a multi-center prospective adult thoracolumbar deformity database.

Introduction
3CO are commonly utilized in adult spinal deformity surgery (ASD), our goal was to determine changes in usage.

Methods
Operative ASD patients (scoliosis >20º, SVA>5cm, PT>25º, or TK>60º) with available baseline (BL) and 2-year (2Y) radiographic and HRQL data. Patients were stratified into 2 groups by DOS: Group I (2008-2013) and Group II (2013-2018). Severe sagittal deformity was defined by SVA >9.5cm. Univariate and multivariate analysis (MVA) assessed differences in surgical, radiographic, and clinical parameters.

Results
752 ASD patients met inclusion criteria (59.9yrs±14.0, 79%F, BMI: 27.7 kg/m2 ±6.0, ASD-FI: 3.3±1.6, CCI: 1.8 ±1.7) with 138 patients undergoing a 3CO. Controlling for baseline SVA, lumbo-pelvic mismatch , revision status, age, and CCI, Group II was less likely to have a 3CO (21% vs. 31%, OR: 0.6, 95% CI: [0.4-0.97]) compared with Group I and more likely to have an ALIF (45% vs. 35% , OR: 1.6, 95% CI: 1.6-2.3), and LLIF (34% vs. 11%, OR: 3.8, 95% CI: 2.3-6.2). Adjusted analyses showed Group II had a higher usage of supplemental rods (OR: 21.8, 95% CI: [7.8- 61]), and had a lower likelihood of PJF (OR: 0.23, 95% CI: [0.07-0.76) and overall hardware complications by 2 years (OR: 0.28, 95% CI: [0.1-0.8]). In adjusted analysis, Group II had a higher usage of titanium rods (OR: 2.7, 95% CI: 1.03-7.2). Group II had a significantly lower 2Y ODI and higher SF-36 Mental/Physical/Social/Emotional, SRS Activity/Mental/Pain and SRS-Total ($p<0.05$ for all). Full logistic regression results in Table 1.

Conclusion
Over a ten-year period, 3CO utilization has declined among surgeons participating in this study group. This trend was observed even in cases of severe deformity, with an associated increase in the usage of PJK prophylaxis and multi-rod constructs. These trends were associated with a concomitant reduction in complications and PJF, as well as a significant improvement in patient reported outcomes among 3CO patients.

Take Home Message
The rates of 3CO usage have declined with greater usage of PJK prophylaxis leading to a decrease in complications, PJF, PJK, and a significant improvement in patient reported outcome measures.

Variable tested	Odds Ratios (Group II vs Group I)	p-value
Controlling for baseline SVA and PI-LL, history of previous revision, age and Charlson comorbidity index, rates of overall 3CO usage	OR: 0.62, 95% CI: [0.4-0.97]	**0.021**
Controlling for age, CCI, baseline SVA and PI-LL, and history of previous fusion, rates of 3CO usage among SVA or PI-LL matched patients	OR: 0.53, 95% CI: [0.27-0.98]	**0.030**
Controlling for age, and CCI, and history of prior fusion, rates of 3CO usage patients among patients with severe sagittal deformity	OR: 0.45, 95% CI: [0.2-0.8]	**0.012**
Controlling for age, baseline deformity, CCI, and surgical invasiveness, usage of prophylaxis among 3CO cohorts	OR: 2, 95% 95% CI: [.86-4.7]	0.11
Controlling for age, baseline deformity, CCI, and surgical invasiveness, usage of supplemental rods among 3CO cohorts	OR: 21.8, 95% CI: [7.8- 61]	**0.001**
Controlling for age, baseline deformity, CCI, and surgical invasiveness, rates of overall complications among 3CO cohorts	OR: .32, 95% CI: [.117-.853]	**0.023**
Controlling for age, baseline deformity, CCI, and surgical invasiveness, rates of reoperations among 3CO cohorts	OR: .34, 95% CI: [.146-.793]	**0.013**
Controlling for age, baseline deformity, CCI, and surgical invasiveness, development of PJF among 3CO cohorts	OR: 0.23, 95% CI: [.07-.76]	**0.017**
Controlling for age, baseline deformity, CCI, and surgical invasiveness, rod breakage by 2 years among 3CO cohorts	OR: 0.30, 95% CI: [.1-.9])	**0.026**
Controlling for age, baseline deformity, CCI, and surgical invasiveness, hardware complications by 2 years among 3CO cohorts	OR: 0.28, 95% CI: [.1-.8]	**0.019**
Controlling for baseline disability, reaching best clinical outcome in ODI among 3CO cohorts	OR: 2.8, 95% CI: [1.2-6.4]	**0.019**
Controlling for baseline disability, reaching best clinical outcome in SRS among 3CO cohorts	OR: 4.6, CI: [1.3-16]	**0.019**
Controlling for age, CCI, baseline SVA, baseline lumbo-pelvic mismatch, and revision status, usage of titanium rods among 3CO cohorts	OR: 2.7, 95% CI: [1.03-7.2]	**0.044**
Usage of ALIF among overall cohort	OR: 1.6, 95% CI: [1.6-2.3]	**0.025**
Usage of LLIF among overall cohort	OR: 3.8, 95% CI: [2.3-6.2]	**0.001**
Controlling for age, CCI, baseline SVA, baseline mismatch, and revision status, usage of ALIF non among non-3CO patients	OR: 1.8, 95% CI: [1.2-2.6]	**0.008**
Controlling for age, CCI, baseline SVA, baseline mismatch, and revision status, usage of LLIF non among non-3CO patients	OR: 3.6, 95% CI: [2.1-6]	**<0.001**

Regression Results

6. The Impact of Nusinersen Treatment on Scoliosis Progression in Patients with Spinal Muscular Atrophy

Hayley Ip, MS; Sophelia Chan, MD; *Kenny Y. Kwan, MD*

Summary

Nusinersen treatment has been shown to improve motor function in patients with spinal muscular atrophy (SMA) but its effect on musculoskeletal system is not known. We retrospectively reviewed prospectively collected data on 24 patients on Nusinersen treatment with minimum 6 months follow up. >70% of patients had improved or stable motor function. Scoliosis progression continued and was most severe in SMAII (12.4 deg per year), especially between aged 5 and 10 years.

Hypothesis

Nusinersen treatment can improve motor function and slow scoliosis progression.

Design

Retrospective review of prospectively collected data.

Introduction

Nusinersen treatment has improved the motor function, ambulatory status and carers' satisfaction for SMA patients. However its effect on scoliosis and hip subluxation progression is unknown. The aim of this study was to examine the degree of scoliosis progression in SMA patients who were on Nusinersen treatment.

Methods

24 SMA patients with a minimum of 6 month follow up after commencement of Nusinersen treatment was recruited. Demographics, motor function, patient and carers' satisfaction were reviewed. Erect whole spine radiographs before and after treatment were documented.

Results

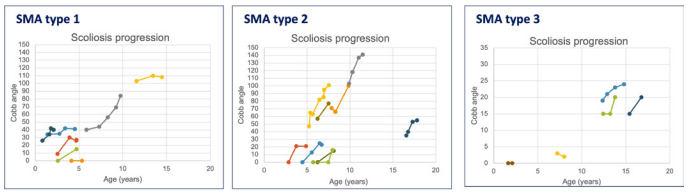
21 patients had erect whole spine radiographs for comparison (Type 1=7, Type 2=9, Type III=5) and were included in the analysis. The mean follow up was 29, 22 and 14 months respectively. Motor function was stable or improved in 18 patients. 57% of Type I patients became sitter (from 0%) and 33% of Type II patients became walker (from 11%) after Nusinersen treatment. Self or parent-reported improvements including stability, hand and leg strength, and muscle strength were seen in all (100%) patients. However, scoliosis progression continued with a mean Cobb progression of 5.9, 12.4 and 2.6 deg per year. Subanalysis of Type II patients showed that progression was most rapid (14.8 deg per year) during aged 5 and 10 years. This rate is similar to previously reported by Wikingarrde et al. (5-12 deg per year for Type II, and 2.9-15 deg per year for Type III).

Conclusion

Nusinersen treatment improved the motor function, ambulatory status patient satisfaction in all types of SMA patients. The rates of scoliosis progression were 5.9, 12.4 and 2.6 per year for SMA Types I, II and III respectively, which were similar to historical cohort.

Take Home Message

Nusinersen treatment does not reduce the rate of scoliosis progression in SMA patients, and close monitoring with expectant surgical management is still required.



Scoliosis progression in Type I, II and III SMA

7. Development and Validation of the Regional Alignment and Proportion (RAP) Score in Operative Cervical Deformity Patients

Peter G. Passias, MD; Katherine E. Pierce, BS; Waleed Ahmad, BS; Sara Naessig, BS; Oscar Krol, BS; Peter Tretiakov, BS; Bailey Imbo, BA; Tyler K. Williamson, MS, BS; Rachel Joujon-Roche, BS; Shaleen Vira, MD; Andrew J. Schoenfeld, MD, MS; Praveen V. Mummaneni, MD; Dean Chou, MD; *Renaud Lafage, MS*

Summary

Yilgor and colleagues developed a Global Alignment and Proportion (GAP) Score that proposed pelvic-incidence based proportional parameters that predicted mechanical complications in adult spinal deformity patients. This study sought to modify the GAP to the cervical spine. Setting surgical goals according to the Regional Alignment and Proportion (RAP) score may decrease the prevalence of postoperative DJK.

Hypothesis
The cervical-specific GAP score (RAP) will decrease postop DJK in operative cervical deformity (CD) patients.

Design
Retrospective

Introduction
Like the global spine, restoration of cervical sagittal alignment is imperative and the aim of corrective adult CD surgery in order to improve patient outcomes and prevent mechanical complications.

Methods
60 surgical CD patients with BL were included from a single center database. RAP score parameters were developed via Delphi approach: ideal McGregor's Slope[MGS] (measured - ideal MGS[0]), relative cervical lordosis(measured - ideal C2-C7[T1S-16.5)), cervical lordosis distribution index ([C2-C7/C2-T3] x 100), relative pelvic version (the measured minus the ideal sacral slope[0.59xPI +9]), and age. RAP was scored between 0-13 and patients were categorized accordingly: <3 Proportional(P), 3-6 Moderately Disproportionate(MD), >6 Severely Disproportionate(SD). Cochran-Armitage tests analyzed the relationship between patients with available RAP categories and development of distal junctional kyphosis(DJK).

Results
Baseline RAP score mean: 5.2/13. This categorized patients: 20% in P state, 55% MD and 25% in a SD. 20% of patients had a mechanical or radiographic complication, including postoperative distal junctional kyphosis, with 8.3% of the cohort undergoing a revision for their DJK. Cochran-Armitage tests found that patients who were moderately or severely disproportionate in their RAP were significantly related to development of mechanical or radiographic complication (4.4756, p= 0.034), but unrelated to other complications or reoperation (p>0.05).

Conclusion
The RAP score is a new method of analyzing the regional proportionality of the cervical spine in the context of global alignment, that predicts mechanical/radiographic complications in operative cervical deformity patients

Take Home Message
Setting surgical goals according to the RAP score may decrease the prevalence of postoperative DJK.

8. Lateral Mass Screws vs. Pedicle Screws at C7: Reoperation Rates for Adjacent Segment Disease (Operative ASD) and Nonunions (Operative Nonunions) in Posterior Cervical Fusions stopping at C7

Kern H. Guppy, MD, PhD; Harsimran S. Brara, MD; Kathryn E. Royse; Jacob H. Fennessy, MD; Jessica E. Harris, MS

Summary
In a retrospective study of 280 patients with posterior cervical fusions (PCFs) stopping at C7 with either lateral mass screws(n=198) or cervical pedicle screws (n=82) at C7, we found no statistical difference in reoperation rates for symptomatic ASD (operative ASD) or symptomatic nonunions (operative nonunion) using either LMS or CPS at C7. Average follow-up time was 7.1 (±0.32) years with average time to operative ASD of 3.4 (±.3.1) years and to operative nonunion of 1.4 (±0.6) years.

Hypothesis
The hypothesis of our study is that in posterior cervical fusions (PCFs) stopping at C7 there is no difference in reoperation rates for symptomatic adjacent segment disease(operative ASD) and symptomatic nonunions(operative nonunions) using lateral mass screws(LMS) vs. cervical pedicle screws(CPS) at C7.

Design
A retrospective study with chart review.

Introduction
The two commonly used fixation techniques at the C7 level in PCFs stopping at C7 are LMS and CPS. The superiority of one method over the other with respect to operative ASD and operative nonunions is unknown.

Methods
A retrospective analysis from our spine registry (Kaiser Permanente) identified a cohort of patients with cervical degenerative disc disease who underwent primary PCFs stopping at C7 with either LMS or CPS at C7. LMS were used at all rostral levels in both groups. Demographic and operative data were extracted from the registry and operative ASD and operative nonunions were adjudicated via chart review. Patients > 6 months follow-up were followed until validated operative ASD or nonunion, membership termination, death, or end of study (03/31/2021). Descriptive statistics and adjusted logistic regression models were calculated for operative ASDs and operative nonunions.

Results
We found 280 patients with PCFs stopping at C7 with either LMS (n=198) or CPS (n=82) at C7 with average follow-up time of 7.1 (±3.2) years and average time to operative ASD of 3.4 (±3.1) years and to operative nonunion of 1.4 (±0.6) years. There were 6 operative ASDs (LMS=4, CPS=2) and 4 operative nonunions (LMS=1, CPS=3). After adjusting for age at index surgery, we found no statistical difference between LMS vs. CPS for either operative ASDs (OR: 1.13 95% CI=0.24-5.35, P=0.877) or operative nonunions (OR: 6.21 95% CI=0.96-40.16, P=0.055).

Conclusion
A large cohort of patients, with PCFs stopping at C7 with an average follow-up of > 7 years, found no statistical difference in reoperation rates for symptomatic ASD (operative ASD) or symptomatic nonunions (operative nonunion) using either LMS or CPS at C7.

Take Home Message
In posterior cervical posterior fusions stopping at C7, there is

no difference in reoperation rates for adjacent level disease and nonunions if LMS or CPS are used at C7.

9. Novel AI-based Algorithm for Automated Cervical Sagittal Balance Analysis Validated on Pre- and Postoperative X-rays of 129 Patients

Sophia Vogt, MD; *Carolin Scholl, MS*; Priyanka Grover, MS; Julian Marks, BS; Marcel Dreischarf, PhD; Ulf-Dietrich Braumann, PhD; Patrick Strube, MD; Sabrina Böhle, MD

Summary
The analysis of the cervical sagittal profile based on measurements of standard parameters is a time-consuming routine clinical task. The presented algorithm automates this task by localizing each cervical vertebral body and placing landmarks on them, which are used to draw axes and compute parameters. The study validates the AI-algorithm by comparing the automatically computed parameters against human expert measurements. It demonstrates that the algorithm can accurately and reliably measure cervical sagittal balance parameters.

Hypothesis
Automatic measurements by the AI algorithm will have excellent agreement with human expert measurements for C2-C7 lordosis, C1-C7 sagittal vertical axis (SVA), C2-C7 SVA, and C7 slope.

Design
Intra- and inter-rater reliability analysis of human vs. automatic measurements.

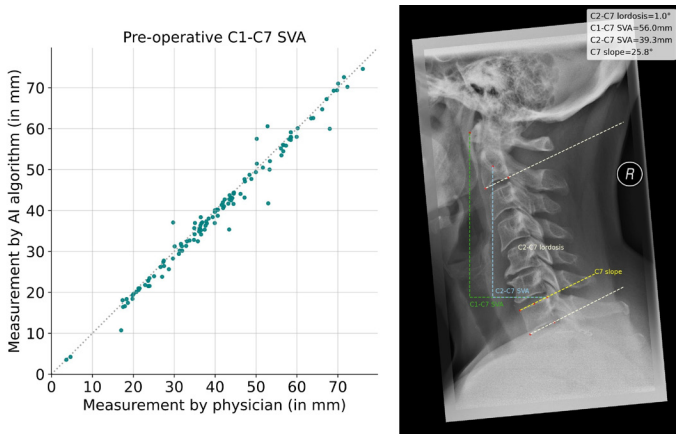
Introduction
The exact analysis of cervical sagittal balance parameters is essential for preoperative planning and postoperative evaluation. However, manual measurements are time-consuming and dependent on the physician's experience. A fully automated artificial intelligence (AI) based algorithm could save time in clinical routine and contribute to an objective analysis.

Methods
Two surgeons measured C2-C7 lordosis, C1-C7 SVA, C2-C7 SVA, and C7 slope in pre- and postoperative lateral cervical X-rays of 129 patients undergoing anterior cervical discectomy and fusion or cervical disk arthroplasty. All parameters were measured twice by the two independent surgeons and compared to the measurements by the AI algorithm consisting of four deep convolutional neural networks. Agreement between raters was quantified by mean errors (95% confidence interval (CI)) and single measure intraclass correlation coefficients (ICC) for absolute agreement (ICC>0.75 considered as excellent).

Results
ICC values for intra- (range: 0.92–0.99) and inter-rater (0.91–0.99) reliability reflect excellent agreement between human raters. The AI algorithm could determine all parameters in 93% of pre- and 91% of postoperative images with excellent ICC values (PreOP range: 0.88-0.99; PostOP 0.85-0.99). Exemplarily for the comparison between the AI algorithm and a surgeon, mean errors were smallest for C1-C7 SVA (PreOP: -0.5mm (95% CI: -0.8– -0.2 mm), PostOP: 0.6mm (0.1–1.0 mm)) and largest for C2-C7 lordosis (PreOP: -2.0° (-2.8– -1.3°), PostOP: -2.5° (-3.7– -1.8°)).

Conclusion
The novel AI-based algorithm can automatically analyze cervical sagittal balance parameters with excellent reliability and accuracy. It may facilitate or even replace routine manual measurements and autonomously analyze large-scale datasets, e.g., nationwide registries.

Take Home Message
The AI-algorithm can accurately and reliably determine cervical sagittal balance parameters. It may alleviate problems connected to manual measurements and be used for the independent analysis of large datasets.



AI vs. physician for C1-C7 SVA; exemplary AI-measurement

10. Randomized Controlled Trial of Instrumented vs. Uninstrumented Posterolateral Fusion for Lumbar Spondylolisthesis

Andreas K. Andresen, MD; Leah Y. Carreon, MD, MS; Mikkel Østerheden Andersen, MD

Summary
In this prospective randomized trial comparing instrumented posterolateral fusion to uninstrumented posterolateral fusion, in patients suffering from symptomatic degenerative spondylolisthesis. We found no difference in patient reported outcome measures between the groups at 2 year follow up. A difference in fusion rates of 94.3% to 31.37% was found in favor of the instrumented group. Although the outcome data were similar between, patients who underwent UPLF had a higher rate of reoperation than in the IPLF group.

Hypothesis
The aims of the study was to investigate if there is a difference

in fusion rates and patient reported outcomes(PROs) between instrumented posterolateral fusion(IPLF) and uninstrumented posterolateral fusion(UPLF).

Design
The study was performed as a prospective, randomized, investigator blinded single center study.

Introduction
Although instrumented posterolateral fusion is the standard of care in North America, in Scandinavia uninstrumented fusion is often the treatment of choice for degenerative spondylolisthesis in patients aged > 60yeras.

Methods
From December 2016 to October 2019, we conducted an open-label, single center trial on patients with symptomatic single-level degenerative spondylolisthesis of 3mm or more. All patients had undergone at least 12 weeks of unsuccessful conservative treatment prior to enrollment. Patients were randomly assigned 1:1 to decompression with IPLF or UPLF. The primary outcome measure was the Oswestry Disability Index (ODI), secondary outcome measures were changes in EuroQoL5D-3L (EQ-5D), Visual Analogue Scale (VAS) for back and leg pain, ShortForm-36 (SF-36) PCS and MCS, and Zurich Claudication Questionnaire (ZCQ), duration of surgery, length of stay in hospital and reoperation rates within 2 years. Fusion rates were evaluated by fine-slice CT-scans at 12 months post op.

Results
108 patients were included in the study, 54 in each group. There were no difference in the baseline demographics or PROs between the two groups. Two (4%) patients in the IPLF and1 (2%) patient in the UPLF and had an intraoperative dural tear(P=0.56). No statistical differences were found in PROs between the two groups at any time point. We found a fusion rate of 94.3% in the IPLF group and 31.37% in the UPLF group ($p<0.001$). There was one re-operation (2%) in the IPLF and 6 (11%) in the UPLF group (p=0.051).

Conclusion
In this trial comparing the outcome in patients who underwent surgery for decompression with UPLF or IPLF, we found no difference in patient reported outcomes after 2 years. Although the outcome data were similar between the groups, patients who underwent UPLF had a higher rate of reoperation than in the IPLF group.

Take Home Message
No difference in PROs or reoperation rates were found between the groups. A difference in reoperation rates of 11% in the UPLF and 2% in the IPLF group was found.

11. Clinical Outcomes Following Direct vs. Indirect Decompression Techniques for Lumbar Spondylolisthesis

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Summary
This study compares 3 and 12-month outcomes for patients with lumbar spondylolisthesis treated with direct decompression (DD) vs. indirect decompression (ID) and interbody fusion. Data were obtained from the Quality Outcomes Database (QOD). DD and ID strategies to treat lumbar spondylolisthesis were similar regarding disability, quality of life, and satisfaction. The ID cohort demonstrated a statistically significant lower level of improvement in back and leg pain at 3 months, which was not maintained at 12 months.

Hypothesis
Patients with lumbar spondylolisthesis treated with ID experience superior clinical outcomes to those treated with DD.

Design
Patient-reported outcomes were retrospectively collected from the lumbar module of the Quality Outcomes Database (QOD), a longitudinal, multi-center, prospective spine outcomes registry.

Introduction
Debate persists regarding the optimal surgical strategy to treat lumbar spondylolisthesis. The development of novel anterior approaches (direct lateral and oblique lumbar interbody fusion) has increased utilization of anterior lumbar interbody fusion procedural codes. These new techniques rely on indirect decompression to treat neural compression and have been shown to provide superior radiographic outcomes but are criticized by proponents of direct decompressive techniques.

Methods
Patients were separated into two treatment groups: DD (posterior lumbar laminectomy with TLIF) or ID (ALIF, LLIF, OLIF and posterior instrumentation/fusion without laminectomy). Propensity scores (PS) for each treatment were estimated using logistic regression dependent on baseline covariates potentially associated with outcomes. The PS's were used to exclude non-similar patients. Multivariable regression analysis was performed with the treatment and covariate as independent variables and outcomes as dependent variables.

Results
4064 patients were included in the DD group and 81 in the ID group. When compared to the DD group at 3 months, the ID group had significantly lower odds of 30% improvement in back pain (OR 0.470, 95% CI 0.287 - 0.769, p = 0.003) and leg pain (OR 0.572, 95% CI 0.334 - 0.982, p = 0.043). These trends were not statistically significant at 12 months for both back pain (p = 0.346) and leg pain (p = 0.166). The DD and ID cohorts did not significantly differ with

respect to 3 or 12-month postoperative improvement in ODI, EQ5D, or satisfaction.

Conclusion
DD and ID strategies to treat lumbar spondylolisthesis were similar regarding disability, quality of life, and satisfaction. The ID cohort demonstrated a statistically significant lower level of improvement in back and leg pain at 3 months, which was not maintained at 12 months.

Take Home Message
This study suggests that, in comparison to direct decompression, indirect decompression for the treatment of lumbar spondylolisthesis does not provide superior long-term clinical outcomes.

12. Should Corrective Re-Alignment Goals be Tailored to Different Frailty States?

Oscar Krol, BS; Lara Passfall, BS; Bailey Imbo, BA; Rachel Joujon-Roche, BS; Peter Tretiakov, BS; Tyler K. Williamson, MS, BS; Stephane Owusu-Sarpong, MD; Waleed Ahmad, BS; Shaleen Vira, MD; Andrew J. Schoenfeld, MD, MS; Jordan Lebovic, MBA; Paul Park, MD; Dean Chou, MD; Renaud Lafage, MS; Virginie Lafage, PhD; *Peter G. Passias, MD*

Summary
Adult spinal deformity is associated with severe pain and disability and literature has shown that surgical intervention can significantly improve patient's quality of life while lessening disease burden. As many patients requiring spine surgery are elderly and often frail, restoration of alignment targets may differ. There is paucity in literature on how different frailty states affect realignment goals.

Hypothesis
Modify the age-adjusted alignment goals using the Frailty Index.

Design
Retrospective cohort study of a prospective multi-center database of ASD patients.

Introduction
Frailty may warrant a lesser degree of correction and should be considered when developing alignment goals.

Methods
Operative ASD patients(scoliosis≥20°, SVA≥5cm, PT≥25°, or TK ≥60°) with available BL and 2Y radiographic/HRQL data included. ASD Frailty Index(FI) stratified patients into Not Frail (NF) and Frail (F) categories. Linear regression analysis established normative radiographic thresholds, using published age specific US-Normative ODI values(Lafage et al.) and FI, based on a cohort of patients with no major complications, no PJK, and a SRS-Satisfaction of >4). Patients were considered "matched" if 2-year postop alignment was within 1 standard deviation(+1SD Overcorrected-1SD Undercorrected).

Results
245 patients included (57±15yrs, 82% female, 26±5.14kg/m2 , ASD-FI: 2.9±1.6, CCI: 1.8 ±1.7). Controlling for age, CCI, and BL deformity, F pts experienced less overall PJK when undercorrected in PILL in the Lafage Schwab age adjusted parameters (.28[.09-.85], p=.024). Correlation was found between BL FI, PT, PILL, SVA, and ODI, ($p<0.05$). Linear regression analysis developed age and frailty adjusted alignment thresholds that increased with age, as determined by Lafage et al, as well as, increased with a higher FI. F pts, corresponding to the same age, were found have a higher average alignment threshold than NF pts in SVA, PI-LL, and PT. Pts that achieved match in the new age and frailty adjusted parameters in PI-LL had lower rates of PJF (5% vs. 15%, p=.014 with improved HRQLs, and those matched in SVA had improved HRQLs when compared to those who were under or overcorrected. Matched SVA patients had a shorter LOS.

Conclusion
Age-Adjusted alignment by Lafage et al. was the first study to recognize that older age warrants a lesser degree of correction, and, the original SRS-Schwab criteria was modified accordingly. In this study, we found higher frailty patients had less PJK when under-corrected in age-adjusted alignment. Alignment targets accounting for both frailty and age were developed.

Take Home Message
Higher frailty patients had less PJK when under-corrected in age-adjusted alignment. Alignment targets accounting for both frailty and age were developed and show improved outcomes.

13. Mechanical Complications and Revision Surgery in Patients with False Type II Alignment After Adult Spinal Deformity Surgery: Minimum Two Year Follow Up

Michael Dinizo, MD; Karnmanee Srisanguan, BS; Thomas J. Errico, MD; *Tina Raman, MD*

Summary
The Roussouly "False" Type II spinal shape has the characteristics of high pelvic incidence (PI), lumbopelvic parameter mismatch, and high pelvic tilt, despite restoration of appropriate sagittal alignment postoperatively. At minimum two year follow-up, the rate of mechanical complications and pseudarthrosis was commensurate with published complication rates of other spinal alignment types. The rate of radiographic PJK was high at 54.3%.

Hypothesis
The rate of mechanical complications and proximal junctional failure may be higher in the "false" Roussouly Type II spinal shape.

Design
Retrospective review of prospectively collected single center database.

Introduction
The "false" Roussouly Type II spinal shape has the characteristics

of high PI, lumbopelvic parameter mismatch, and high pelvic tilt, despite restoration of appropriate sagittal alignment. There is literature to suggest a higher rate of mechanical complications for this alignment shape. We sought to identify the incidence of complications at long term follow-up in patients with "false" Type II alignment.

Methods
ASD patients with minimum two year follow up, PI > 50°, postoperative SVA < 10 mm, and high postoperative PT (based on the GAP score ideal pelvis alignment) were included. The rate of mechanical complications was assessed.

Results
53 patients (Age: 46 ± 21; Levels fused 10.8 ± 4.0) were included in the analysis. The average follow-up time was 28.8 ± 3.9 months. Surgical characteristics included revision surgery (28.3%), interbody fusion (34.3%), dual rod construct with 5.5 mm cobalt chrome rods (94.3%), and all fusions incorporated the pelvis. In the early postoperative period, significant improvement was seen in all coronal and sagittal alignment parameters and these remained stable at final follow-up. The rate of radiographic proximal junctional kyphosis at final follow-up was 54.3%, with a mean proximal junctional angle of 13.0 ± 8.6°. The rate of revision surgery for PJK was 14.3%, with an associated 2.9% rate of neurologic injury. The rate of instrumentation failure was 14.3%. The rate of pseudarthrosis at the lower lumbar levels or lumbosacral junction was 8.6%, with a revision rate of 5.3%. Overall, revision surgery was required in 31.4% of patients.

Conclusion
In this study population of patients with high PI, postoperative lumbopelvic parameter mismatch and high pelvic tilt, the long term rate of mechanical complications and pseudarthrosis was commensurate with published complication rates of other spinal alignment types. The rate of radiographic PJK was high at 54.3%.

Take Home Message
The long term rate of mechanical complications and pseudarthrosis in patients with "false" Roussouly Type II spinal shape was not significantly higher than published rates in other alignment types.

14. The Role of Vitamin D Deficiency in the Onset of Adolescent Idiopathic Scoliosis: A Validation Study on Bipedal Mice Model

Zhen Liu, MD; Jie Li, MD; Zhikai Qian, MD; Ziyang Tang, MD; Kiram Abdukahar, MD; Zongshan Hu, PhD; Zezhang Zhu, MD; Yong Qiu, MD; *Jian Cao, Assistant Professor*

Summary
Accumulating evidence suggested that vitamin D deficiency plays an important role in the development of adolescent idiopathic scoliosis (AIS). Here we validated the effect of Vitamin D supplementation on reducing scoliotic curvature in a bipedal mice model

Hypothesis
We hypothesized that dietary vitamin D supplementation will improve the bone parameters and reduce scoliotic curvature in a bipedal mice model.

Design
preclinical animal study

Introduction
Despite clinical evidence, the potential role of vitamin D deficiency and supplementation on scoliosis development remains to be validated.

Methods
A total of 90 C57B6/j male mice were divided into six groups: vitamin D deficiency (0 IU/Kg, G1), normal vitamin D (1000 IU/Kg, G2), 2000 IU/Kg (G3), 3000 IU/Kg (G4 group) 8000 IU/Kg (G5), 9000 IU/Kg (G6). The bipedal mice model was established at 4-week old. X-ray and Micro-CT was performed to monitor the occurrence of scoliosis and bone microarchitecture. The serum levels of Vitamin D, terminal peptide collagen type I(CTX-1), and Osteocalcin were quantified by ELISA test. Tartrate-resistant acid phosphatase staining of osteoclasts (TRAP) staining of the L5 vertebra was performed to assess the osteoclast activity.

Results
In G1, the incidence and severity of scoliosis were significantly higher from week 8 to week 16 compared to the other 5 groups. Compared to the Cobb angle in G2 with normal diet (16.7°±3.7°), the severity of scoliosis was significantly reduced in G5 and G6 at week 16. The trabecular bone microarchitecture was found to be enhanced in the G5 and G6 groups, indicated by a significant increase in BMD, bone volume fraction, and trabecular thickness. Serum 25(OH)D3 levels were significantly reduced in G1(19.2 ng/ml) compared to that in G2 with a normal diet (42.1 ng/ml) . A high dosage of Vitamin D (G5 and G6) was found to rescue the Vitamin D deficiency and the increased CTX-1 and Osteocalcin in the G1 group. TRAP staining showed an increased osteoclast number in G1, which was attenuated by Vitamin D supplementation in G4, G5, and G6.

Conclusion
The significantly higher occurrence and severity of scoliosis induced by Vitamin D diffident diet suggested that Vitamin D deficiency may play a role in the initiation of AIS.

Take Home Message
Our findings supported the therapeutic potential of dietary Vitamin D supplementation for treating AIS.

15. The Correlation Analysis of Pelvic Incidence minus Lumbar Lordosis with Pelvic Incidence from a Database of 468 Asymptomatic Volunteers

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Summary
Adult volunteers from five countries were enrolled to evaluate the PI-LL normal value in an asymptomatic population. There were significant different variations of PI-LL according to the PI groups (PI<45°; 45°60°). Linear regression analysis allows to define more accurate cutoff of PI-LL mismatch within the 3 groups.

Hypothesis
The objective of the study is to establish the normative value for PI-LL based on the data of 468 asymptomatic volunteers.

Design
Prospective cohort study

Introduction
PI-LL mismatch was established as a sagittal parameter with a threshold of less than 10° for achieving good HRQOL. However, some articles have postulated that the threshold of the PI-LL cannot be set as a fixed numeric value and should consider PI value in the global population. To our best knowledge, there have been studies on PI-LL for postoperative patients with adult spinal deformity, but no studies have been conducted on asymptomatic patients and reported normal range of PI-LL on the basis of PI.

Methods
Full-body low dose stereoradiographic evaluation was done in a multi-ethnic cohort of 488 asymptomatic adult volunteers (Mean age: 40.8; Range: 18-79 years). Patients from 5 different centers were included (France, Japan, Singapore, Tunisia, and the United States). Volunteers were divided into 3 main groups depending on PI values: PI<45°; 45°60°. 3D measurements were performed using a commercially available 2D/3D modelling software. ANOVA and Tukey's HSD for post-hoc analysis were used to determine the differences between groups.

Results
Distribution of Lumbar lordosis (LL) showed significant difference between the three PI groups ($p<0.001$). The average value of LL is increasing with PI value. The PI-LL and PT also showed significant differences in their distributions according to PI groups. Linear regression analysis allowed to define a closed correlation between PI and LL as follows: LL=0.5635 x PI + 27.989 and between PI and PI-LL with the following equation PI-LL = 0.4365xPI -27.989. The means (SD) of PI-LL were -9.86° (9.46) for PI < 45°, -5.95° (9.74) for 45° < PI < 60°, and 2.23° (10.61) for PI > 60°, respectively.

Conclusion
PI showed significant correlation with PT, LL and PI-LL. The normal value of PI-LL considering PI and the linear regression equation in this study could help to evaluate the sagittal alignment and provide reference value for planning to establish the target restoration of sagittal curve in corrective surgery.

Take Home Message
PI-LL evaluation without considering individual PI can mislead surgeons to unexpected surgical outcome. Cutoff PI-LL values should be -9.86° for PI < 45°; -5.95° for 45°60°.

16. Determining the Impact of Proximal Junctional Kyphosis on Cost-Utility in Adult Spinal Deformity Patients

Oscar Krol, BS; Lara Passfall, BS; Stephane Owusu-Sarpong, MD; Waleed Ahmad, BS; Tyler K. Williamson, MS, BS; Bailey Imbo, BA; Rachel Joujon-Roche, BS; Peter Tretiakov, BS; Jordan Lebovic, MBA; *Shaleen Vira, MD*; Peter G. Passias, MD

Summary
With healthcare costs on the rise, hospital have increasingly focused on providing economically efficient medical services. Adult spinal deformity surgery remains an expensive medical interventions with high risk for complications and revisions, especially following mechanical failure in the context of proximal junctional kyphosis (PJK). We sought to evaluate the impact of PJK on associated expenditures following an index surgery for ASD.

Hypothesis
To evaluate the effect of proximal junctional kyphosis on the cost effectiveness of corrective adult deformity surgery.

Design
Retrospective cohort study of a prospective multi-center database of ASD patients.

Introduction
With healthcare costs on the rise, we sought to evaluate the effect of PJK on ASD cost utility.

Methods
Operative ASD patients ≥18 years old with complete baseline (BL) and up to 2Y HRQL and radiographic data. Costs were calculated using the PearlDiver database according to CMS.gov for services within 30 days, including costs of postoperative complications, outpatient healthcare encounters, revisions and medical related readmissions were included. QALY was calculated using Neck Disability Index (NDI) mapped to SF6D index utilized a 3% discount rate to account for residual decline to life expectancy (78.7 years). Cost per QALY by 2Y was calculated for revisions that occurred due to proximal junctional kyphosis.

Results
147 adult spinal deformity patients met inclusion criteria (55.22yrs, 54% Female). Surgical details: EBL of 1823 mL, operative time of 327 min, with .4% undergoing an anterior approach, 90.2%

posterior-only approach, and 9.3% combined approach. Overall 54.3% of patients developed PJK within 2 year postoperatively, with 22% undergoing reoperation for PJK. Average cost of revision surgery due to PJK was $93,688 ± $21,467. The cost for PJK patients, including the cost associated with their revision surgery, was higher ($103,760 vs. $71,000). Baseline ODI (39 vs. 32) and 2Y ODI (39 vs. 27) were higher for PJK patients, however, PJK patients did improve to a greater degree (-12 vs. -10). The overall cost per QALY by 2Y was higher for PJK patients ($116, 170 vs. $95, 347).

Conclusion
Patients that developed PJK had an almost $30,000 higher initial cost at 2 years. When looking at the cost per quality adjusted life years by 2Y, PJK resulted in slightly more than $20,000 in cost. These findings suggest prophylactic measures to mitigate PJK may improve the cost utility of adult spinal deformity surgery and can help policy efforts for adequate resource allocation for these complex patients.

Take Home Message
Patients that developed PJK had a higher initial cost and higher cost per QALY despite a greater degree of improvements, findings can help support resource allocation for prophylactic measures.

17. The Effect of Upper Instrumented Vertebra Level (T9 vs. T10) on Radiologic and Functional Outcomes in the Surgical Treatment of Adult Spinal Deformity in Osteoporotic Patients Over 60 Years of Age

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Summary
Preoperative, early postoperative and last follow up radiographs of osteoporotic adult spinal deformity patients who has upper instrumented vertebra (UIV) of T9 and T10 were compared with respect of PJK ,PJF. T9 Group (T9G) showed none of PJK and PJF while 8 patients of PJK and 4 patients with PJF were found in T10 Group (T10G). Clinical results with ODI scores were better in T9G than T10G

Hypothesis
T9 level will be more stable when selected as than T10 level and will provide better radiologic and clinical outcomes in ASD patients

Design
Retrospective study

Introduction
T10 has been accepted as lowest immobile vertebra in the midthoracic region and has been selected as a UIV in adult spinal deformity for many years. In this study, we compared the radiologic and clinical outcomes of 2 groups in which T9(T9G) or T10(T10G) were selected as the UIV with respect to PJK and PJF rates with min 2 years follow up

Methods
88 pts, >60yrs with mean T scores -3,1(-4,7/-2,5) , who underwent posterior fusion from midthoracic to pelvis for adult spinal deformities were reviewed. T9 Group (T9G) included 45 pts (32F, 13M) and T10 Group (T10G) included 43 pts (30F,13M). In all pts Ulvs. were cemented and a prophylactic vertebroplasty one level above to the UIV were performed. Preop, postop and follow/up pelvic and sagittal parameters including PJK angles were measured. ODI scores were used for clinical evaluation

Results
Mean age was 69 (60-79) years and mean follow/up was 47 (24-182) months in T9G. Mean age was 67 (60-80) years and mean follow/up was 61 (34-144) months in T10G. Preop, early postop and follow/up pelvic, coronal and sagittal parameters were not statistically different(p>0.05). Radiologically, no patient had PJK/PJF in T9G, and 8 pts had PJK (18.6%), 4 pts had PJF in T10G (9.3%). The cases with PJF underwent revision surgery for extension of the fusion up to T4. Mean ODI scores at final follow/up were better in T9G (23) than T10G (33).

Conclusion
In long fusions from midthoracic spine to the pelvis, patients with upper instrumented vertebra at T9 (none PJK/PJF) showed much better radiological outcomes when compared to upper instrumented vertebra at T10 (PJK 18.6%, PJF 9,3%). We believe that T9 level carries different anatomical, biomechanical and sagittal plane characteristics and provide better biomechanical support when compared to T10 level. Clinical results of ODI scores were better in T9 group.

Take Home Message
Upper instrumented vertebra selection of T9 in pts>60 years with adult spinal deformity patients provide better clinical and radiological results in terms of PJK&PJF compared to UIV selection of T10.

18. The Influence of Frailty on PJF: Is Optimal Realignment Superseded by Physiologic Age?

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Summary
Patients receiving surgery for adult spinal deformity (ASD) are often frail and may be at risk of adverse events following these intensive procedures, including proximal junctional failure (PJF). Frailty is a significant independent predictor of PJF development, and while optimizing realignment may minimize this effect, frailty still remains a risk factor. The alarmingly high rates of PJF despite adequate alignment in frail patients warrants further research to determine

whether operating on very frail patients with large deformity is advisable.

Hypothesis
To determine if the benefits of optimal realignment on PJF development can be negated by increasing frailty as determined by physiologic age.

Design
Retrospective cohort study of prospective, multicenter ASD database

Introduction
Frailty increases a patient's risk for adverse events, however, there is a paucity in literature on its role in PJF development.

Methods
Operative ASD patients (scoliosis >20, SVA>5cm, PT>25, or TK>60) with available baseline (BL) and 2-year (2Y) radiographic and HRQL data were included. The Miller Frailty Index (FI) was used to stratify patients into 2 categories: Not Frail (FI <.3) and Frail (>.3). Proximal Junctional Failure (PJF) was defined using the Lafage criteria. Conditional inference tree analysis (CIT) was used to establish thresholds for the association between frailty and the risk of PJF.

Results
245 ASD patients met inclusion criteria (57yrs±15.0, 82%F, BMI: 26.3 kg/m2 ±6.0, ASD-FI: 2.9±1.6, CCI: 1.55 ±1.7). 138 (55%) of patients were Not Frail, and 107 (43%) Frail. Overall rate for PJK was 49%, and 12% for PJF. Controlling for age, BL deformity, and surgical invasiveness, a higher BL Frailty index correlated with increased odds of developing PJF (OR: 1.4, 95% CI: 1.01-1.9) and the risk of developing PJF for F vs. NF patients was 3x higher (OR: 3 95% CI: 1.3-7). Controlling for BL deformity and invasiveness, patients matched in SVA still developed PJF with a high frailty index (OR: 1.7, 95% CI: 1.02-2.8, p=.014). CIT found patients with a frailty index greater than 3.4 had a 2.5x higher likelihood of developing PJF (OR: 2.5, 95% CI: 1.14-5.5, p=.026) and, in a cohort of patients matched in SVA, a frailty index higher than 4.9 led to a 5x higher likelihood of developing PJF (OR: 5, CI: 1.2-20, both p<0.05)

Conclusion
Frailty is a significant independent predictor of PJF development, and while optimizing realignment may minimize this effect, frailty still remains a risk factor. The alarmingly high rates of PJF despite adequate alignment in frail patients warrants further research to determine whether operating on very frail patients with large deformity is advisable.

Take Home Message
Frailty is a significant independent predictor of PJF development, and while optimizing realignment may minimize this effect, frailty still remains a risk factor.

19. Compared to Multi-Rod (≥3) Constructs, Interbody Fusion Does Not Reduce the Rate of Rod Failure at 2-Year Minimum Follow-Up

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Summary
Pseudarthrosis with rod fracture remain a challenging problem in the setting of long constructs for adult spinal deformity (ASD). Both interbody fusion (IBF) and multi-rod constructs have been proposed as ways to prevent this difficult complication. Here we show no difference in rod failure between these techniques at 2 years, suggesting that there is no additional benefit to IBF in these patients.

Hypothesis
At two years, there is no significant difference in rod fracture between ASD patients with IBF compared to those with multi-rod (3R) constructs

Design
Retrospective Cohort

Introduction
Pseudarthrosis with distal mechanical failure is a common complication after long constructs in ASD. Multiple strategies have been proposed to improve fusion rates and reduce the rate of rod fracture, including the use of IBF and multi-rod (≥3) techniques. Whether rod fracture rates are lower with the utilization of interbody cages vs. multi-rod constructs remains unknown.

Methods
ASD patients undergoing fusion of ≥6 levels to ilium and a minimum follow up of 24 months were included. Patients with a history of prior fusion to L4 or below, and those with neuromuscular disease, inflammatory arthritis, or skeletal dysplasia were excluded. Patients were grouped by construct types: 2 rods w/ IBF (IBF) and w/o IBF (2R) and ≥3 rods w/o IBF (3R). Demographics, perioperative and radiographic data, and evidence of rod fracture were collected. ANOVA, chi-square and Fisher exact tests were used to compare across construct types.

Results
71 patients were included, with mean age 65.0 yrs (±8.5) and BMI 26.7 kg/m2 (±5.4). In total, 20 pts had 2R constructs, 12 had IBF, and 39 had 3R. There were no significant differences in sagittal or coronal parameters at baseline or 2 yrs, or in OR time, EBL, or number of levels fused across groups. 76.1% of patients had posterior column osteotomy (2R 75.0%, IBF 50.0%, 3R 84.6%; p=0.063) and 9.9% had 3 column osteotomy. There were 12 total rod fractures (15.2%) with no significant difference between groups (2R 25.0%, IBF 16.7%, 3R 12.8%; p=0.423) and no differences in revision rate for rod fracture.

Conclusion
Compared to multi-rod techniques, the addition of IBF does not reduce the rate of rod fracture at two years after long constructs for ASD. These findings suggest that increasing the rigidity of the construct with the addition of a third rod may be sufficient to prevent rod fractures while IBF may provide no additional benefit at 2 years follow-up.

Take Home Message
Compared to multi-rod (≥3) constructs, IBF provides no benefit in reducing the rate of rod fracture at 2 years.

20. Rod Fractures in Thoracolumbar Fusions to the Sacrum/Pelvis for Adult Symptomatic Lumbar Scoliosis: Long-Term Follow-Up of a Prospective Multicenter Cohort of 160 Patients

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Summary
Since the majority of rod fractures (RF) present >2 yrs following surgery, true occurrence and revision rates remain unclear. To better understand rates of and risk factors for RF and revision surgery, we studied a prospective cohort of 160 patients with primary thoracolumbar-to-pelvis fusions for adult symptomatic lumbar scoliosis (ASLS). At a mean 5.0-yr follow-up (range=0.1-9.2 yrs), 62/160 patients had RFs occurring at a mean of 3.4 yrs postoperatively. Within 2 yrs after RF, 66% of patients underwent revision surgery.

Hypothesis
Most RFs will occur >2 yrs after surgery and assessment of long-term follow-up will allow identification of novel risk factors.

Design
Prospective multicenter observational cohort

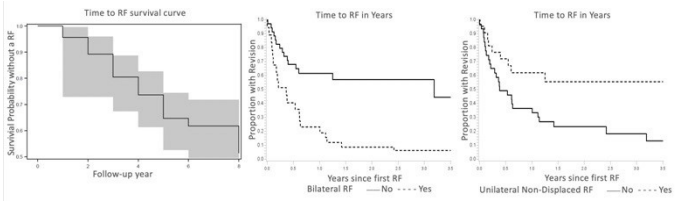
Introduction
Previous reports of RF have been limited by heterogeneous patient populations and relatively short follow-up. However, the majority of RFs present >2 yrs after surgery, thus true prevalence and revision rates remain unclear.

Methods
We reviewed the ASLS-1 database, an NIH-sponsored multicenter prospective study. Inclusion criteria were: age ≥40 yr with ASLS (Cobb >30o and ODI >20 or SRS-22 <4.0 in pain, function or self-image) and primary thoracolumbar fusions to the pelvis of >7 levels. The objectives were to better understand risk factors for RF and assess its incidence and revision rate.

Results
160 patients were included (141 women; mean age 61 yr). At a mean follow-up of 5.0 yrs (range=0.1-9.2 yrs), 93 RFs occurred in 62 (38.8%) patients (41 unilateral, 21 bilateral). Baseline radiographic, clinical and demographic characteristics were similar between patients with and without RF. Mean time to RF was 3.4 yr, 73% occurred >2 yr following surgery and RF incidence at 2 and 4 yrs after surgery was 11% and 24%, respectively. Greater postoperative PI-LL mismatch and PT were observed in the RF group ($p<0.05$). In Cox regression models only diabetes ($p=0.029$, OR=3.27, 95% CI=1.12-9.5) and titanium cages ($p=0.036$, OR 2.56, 95% CI 1.06-6.16) were associated with RF. Within 2 yrs after RF, 66% of patients underwent revision surgery and overall a total of 38 patients (61% of all RF) underwent revision surgery. Bilateral RF was predictive of revision surgery (HR=3.52, 95% CI=1.8-6.9, P=0.0002), while patients with unilateral non-displaced RF were less likely to require revision (HR=0.39, 95% CI=0.18-0.84, P=0.016).

Conclusion
This study provides benchmarks for RF rates following ASLS surgery. These findings demonstrate that RF remains a significant challenge. Long-term follow-up for these patients is warranted and new strategies to improve fusion and reduce RF are needed.

Take Home Message
Although surgery for ASLS offers significant improvement in patient-reported outcomes, RFs can affect patients long after surgery, thus requiring longer-term follow-up, careful preoperative planning and better preventive strategies.



RF Occurrence and Revision Survival Plots

21. Risk Factors for Mechanical Complications Associated with Multi-Rod Constructs in Adult Spinal Deformity: Where and Why do They Occur?

Paul J. Park, MD; Cole Morrissette, MS; Nathan J. Lee, MD; Meghan Cerpa, MPH; Alex Ha, MD; Scott Zuckerman, MD; Ronald A. Lehman Jr., MD; Lawrence G. Lenke, MD

Summary
Multi-rod constructs (MRC) are used in long spinal fusion constructs to reinforce high stress areas such as the lumbosacral junction or 3-column osteotomy sites. Our retrospective study of adult spinal deformity patients found the amount of coronal imbalance correction achieved was significantly correlated with instrumentation failure. The most frequent area of breakage was just one or two levels proximal to the lumbosacral junction, often adjacent to or 2 levels above a transforaminal interbody circumferential fusion.

Hypothesis
Spinal fusion constructs are susceptible to failure proximal to the lumbosacral junction and with greater deformity correction.

Design
Single-center retrospective analysis.

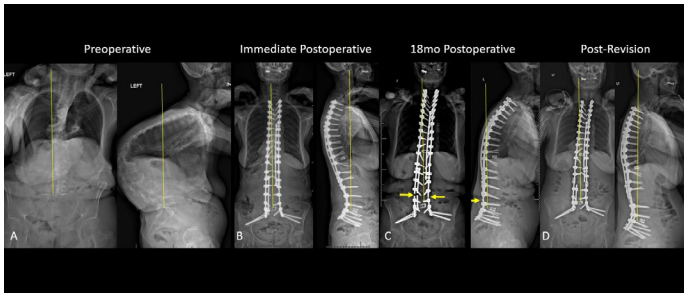
Introduction
In adult spinal deformity (ASD) surgery, multi-rod constructs (MRC) has gained favor to reduce mechanical complications high mechanical stress areas. We describe here MRCs in primary and revision cases, failures of MRCs, and risk factors for failure.

Methods
57 ASD patients with at least 1.7 year follow-up, at least 10 levels instrumented, fusion to pelvis, and a MRC were retrospectively reviewed. Both primary and revision cases were studied with the following variables: age, gender, osteotomy type, radiographic parameters, number of rods, and interbody implantation. Mechanical failure was described as any rod or screw breakage postoperatively.

Results
57 ASD patients, average age 60 years, were included. Average follow-up was 2.4±0.6 years. Average levels fused were 17, with 10 3CO. 6 patients had instrumentation failure with subsequent revision. The average sagittal vertical axis (SVA) correction was 52.1mm vs. 77.2mm and average coronal imbalance (CI) correction was 29.6mm and 47.9mm. Coronal correction >30mm was significantly correlated with rod failure (p=0.02) while SVA >50mm was not (p=0.44). Odds ratio for rod failure with coronal correction >30mm was 6.4. 5 of 6 rod failures occurred at either L3-4 or L4-5. 5 of 6 constructs that failed were 3-rod constructs and occurred just above the lumbosacral junction with transforaminal interbody fusions (TLIF) at the L5-S1 level.

Conclusion
This study on MRCs in ASD surgery found that risk factors for implant failure included greater global coronal correction, and occurred only at levels directly above low lumbar TLIF's and in all cases with less than 4 rods. Thus we suggest considering at least 4 rod constructs for both the lumbosacral region and extending up the lumbar spine cephalad to where interbody fusions have been performed to avoid implant failure in these high demand constructs.

Take Home Message
We recommend using at least 4 rods to span both the LSJ and several levels proximal to low lumbar interbody fusions to avoid failure in these high demand MRC constructs.



A) Preop, B) immediate postop, C) 18mo postop and D) post-revision radiographs following MRC failure.

22. Incidence of Postoperative Neurologic Complications After Adult Spinal Deformity Surgery and Rate of Recovery at 5-Year Follow-Up

Karnmanee Srisanguan, BS; Michael Dinizo, MD; Thomas J. Errico, MD; *Tina Raman, MD*

Summary
Adult spinal deformity (ASD) surgery can entail extensive correction for rigid deformities with an associated risk for neurologic complications. We report an 18.9% neurologic complication rate after ASD surgery. 11.7% of neurologic complications had an associated motor deficit. Complete resolution occurred in of 29.6% patients, partial resolution in 24.6% of patients, and no resolution in 45.8% of patients. Higher BMI, PSO procedure, and history of revision surgery were predictors of sustaining a neurologic complication.

Hypothesis
The rate of complete resolution of neurologic complications after ASD surgery is high.

Design
Retrospective review of prospectively collected database.

Introduction
Existing reports of neurologic complications after ASD surgery often utilize multi-center databases with considerable heterogeneity. The rate of recovery at long term follow up has been less widely examined. We sought to describe the incidence of neurologic complications, and rate of resolution.

Methods
949 patients (Age: 45 ± 24 y; mFI: .41 ± .67; Levels fused: 10 ± 4) underwent ASD surgery. Outcomes evaluated at a mean of 48.9 months follow-up were the rate of neurologic complications, and resolution of neurologic injury.

Results
The neurologic complication rate was 18.9% (179/949). Of the 179 neurologic complications, 150 (83.8%) were new onset postoperative radiculopathies with pain or sensory deficit, 21 (11.7%) were radiculopathies with motor deficit, 7 (3.9%) were

spinal cord injuries, and 1 (0.6%) was cauda equina syndrome. 97/179 patients (54.2%) had either complete resolution (n=53, 29.6%) or partial resolution (n=44, 24.6%) of the neurologic injury at final follow-up, and 82 patients had no resolution (45.8%). Of those who had a postoperative motor deficit, mean strength grading at final follow-up was 4.14 ± 1.46. Of the 179 patients, 30 (16.8%) required revision surgery. Age > 70, current smoking, revision surgery, higher BMI (28.6 vs. 24.3 mg/k2, p<0.0001), higher preoperative SVA (103.8 mm vs. 71.4 mm, p<0.0001) and greater correction of SVA (34.4 mm vs. 17.8 mm, p=0.004) were associated with neurologic complications. Two attending spine surgeons were present for 18.9% of cases with no effect on rate of neurologic complications. BMI (OR:1.04, p=0.029), revision surgery (OR:2.5, p<0.0001), and PSO (OR:2.2, 0.007) were predictors of neurologic complications.

Conclusion
We report an overall neurologic complication rate of 18.9% after ASD surgery with a 29.6% rate of complete resolution and 24.6% rate of partial resolution. Higher BMI, and history of revision surgery were predictors of neurologic complications.

Take Home Message
The neurologic complication rate after ASD surgery was 18.9%, with a 29.6% rate of complete resolution. Risk factors include age > 70, revision surgery, and greater correction of SVA.

23. Metabolic Syndrome and 30/90 Day Outcomes After Adult Spinal Deformity Surgery

Gregory Van Perrier, BS; Aonnicha Burapachaisri, BS; Constance Maglaras, PhD; Michael Dinizo, MD; Themistocles S. Protopsaltis, MD; *Tina Raman, MD*

Summary
Metabolic syndrome (MetS) is defined as a constellation of medical conditions including obesity, hypertension (HTN) and diabetes mellitus (DM) that have been shown to increase the risk of developing cardiovascular disease, as well as surgical complications. In this retrospective study, we demonstrate that patients with adult spinal deformity (ASD) undergoing 1-5 level posterior lumbar fusion has increased rates of overall complications and neurologic complications.

Hypothesis
Patients with ASD undergoing posterior lumbar fusion of 1 through 5 levels with MetS will have increased complications compared to those without MetS.

Design
Retrospective single center cohort study.

Introduction
In this retrospective study, our objective was to examine if patients with adult spinal deformity (ASD) undergoing posterior lumbar fusion of 1 through 5 levels had increased rates of complications or readmission.

Methods
ASD patients who underwent spinal fusion of 1 to 5 levels between 2012 and 2020 included. Patients were subdivided into those who had MetS defined as having hypertension, diabetes mellitus and a body mass index (BMI) greater than equal to 30 kg/m2. Procedural outcomes included length of stay (LOS), 30 day reoperation, and 90 day reoperation. These measures were compared using independent samples t-tests and chi-squared analyses, significance set at p<0.05.

Results
A total of 3453 ASD patients met criteria for fusion, with 226 meeting criteria for MetS (BMI ≥30 kg/m2, HTN, DM). The MetS cohort was significantly older than the non-MetS cohort (63.53 vs. 58.5 years, p<0.01). The average percentage of females was higher in the MetS group (57% vs. 51%), though this was not statistically significant. MetS patients had increased length of stay (LOS) (4.74 vs. 3.91 days, p<0.01), complication rates (27.6% vs. 2.7%, p<0.01). The difference in 30 day readmission rates (3.1% vs. 2.7%) and 90 day readmission rates (3.1% vs. 2.5%) were not statistically significant. There was a significant finding specifically with neurological complications in patients with MetS vs. non-MetS (7.97% vs. 4.5%, p=0.018). Other sources of complications including cardiac, deep vein thrombosis, pulmonary embolism, ileus, infection and mechanical hardware failure were not statistically significant between groups.

Conclusion
Metabolic syndrome, as defined by having HTN, DM and BMI ≥30 kg/m2, has a significant impact on the LOS, overall complication rate and neurological complication rate in patients receiving multilevel lumbar fusion. Given these results, care should be taken to optimize these comorbidities prior to surgical intervention.

Take Home Message
In patients with ASD, those who met the criteria for having metabolic syndrome had increased length of stay, overall complications, and neurological complications following multilevel lumbar fusion than those without.

24. Effect of Osteoporosis and Bisphosphonate on Reoperations in Adult Spinal Deformity

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Summary

Adult spinal deformity is a complex pathology that often requires challenging surgical intervention for treatment. In patients with osteoporosis, there may be increased risk of complications or reoperations. Our results demonstrated that osteoporosis patients treated preoperatively with bisphosphonate had lower rates of reoperations within two years of their index surgery

Hypothesis

Preoperative bisphosphonate use in osteoporosis patients will decrease rates of reoperations

Design

Retrospective review

Introduction

There is paucity in the literature on outcomes of osteoporosis patients treated preoperatively with bisphosphonate

Methods

ASD patients undergoing a fusion were isolated using ICD-9 CM and CPT codes in the PearlDiver database between the years 2008-2015. Patients were stratified based on diagnosis of osteoporosis and whether there was a filled prescription for bisphosphonate 6 months prior to surgery. ASD patients with osteoporosis and bisphosphonate use that underwent corrective intervention were compared with age and sex matched cohorts of osteoporotic and non-osteoporotic controls with no bisphosphonate prescriptions. Means comparison tests compared differences in demographics, comorbidities, 90-day complications, and 2Y reoperation rates. Logistic regression analysis assessed the odds of complication and reoperations controlling for age, sex, and comorbidities(Odds Ratio [95% confidence interval]). Statistical significance was set $p<0.05$.

Results

2,842 operative ASD patients were isolated. 406 patients had osteoporosis and bisphosphonate use, 807 osteoporosis with no bisphosphonate use, and 1,629 non-osteoporosis patients. Table 1 summarizes baseline patient demographics. There were no differences in 90-day complication rates or 2Y reoperations rates between osteoporosis bisphosphonate users and osteoporosis controls ($p>0.05$). Compared to non-osteoporotic patients, osteoporosis patients with bisphosphonate use had significantly lower rates of reoperations at 1Y(68% vs. 80%, OR:0.49[0.39-0.64]) and 2Y(78% vs. 90%, OR:0.39[0.30-0.53], both $p<0.001$).

Conclusion

In a matched cohort, osteoporosis patients treated preoperatively with bisphosphonates had lower rates of reoperations two years post operatively compared to non-osteoporotic controls.

Take Home Message

Osteoporosis patients at high risk for reoperations can be treated with bisphosphonate to mediate risk of reoperation.

Table. 1 Patient Demographics

		Bisphosphonate Users n = 406		Osteoporotic Controls n = 807		Non-Osteoporotic Controls n =1,629		P-value	
								Bisphosphonate vs Osteoporosis	Bisphosphonate vs Non-Osteoporosis
Age, years	<65	112	28%	222	28%	449	28%	1	1
	65-69	94	23%	186	23%	375	23%		
	70-74	112	28%	224	28%	453	28%		
	75-79	75	18%	150	19%	300	18%		
	80-84	13	3%	25	3%	52	3%		
Male Sex		31	8%	59	7%	124	8%	0.930	1
Female Sex		375	92%	748	93%	1505	92%		
Comorbidities									
Obesity (BMI>30 kg/m^2)		47	12%	174	22%	345	21%	<0.001	<0.001
Chronic Kidney Disease		51	13%	124	15%	196	12%	0.221	0.836
Diabetes Mellitus		105	26%	260	32%	527	32%	0.027	0.014
Congestive Heart Failure		41	10%	103	13%	168	10%	0.208	0.971
COPD		148	36%	331	41%	543	33%	0.141	0.259
PVD		46	11%	131	16%	186	11%	0.028	1
Coronary Artery Disease		97	24%	204	25%	408	25%	0.647	0.676
Hyperlipidemia		296	73%	659	82%	1,213	74%	0.001	0.564
Hypertension		330	81%	670	83%	1,317	81%	0.722	0.639
Smoking		99	24%	213	26%	353	22%	0.493	0.267
Alcohol		7	2%	16	2%	30	2%	0.930	1

BMI, Body Mass Index; COPD, Chronic Obstructive Pulmonary Disease; PVD, Peripheral Vascular Disease

25. Impact of Navigation on 30-Day Outcomes for Pediatric Deformity Surgery

Austen Katz, MD; Junho Song, BS; Sayyida Hasan, BS; Jeff Silber, MD; David Essig, MD; Vishal Sarwahi, MD, MBBS

Summary

16,950 pediatric patients (356 navigated) underwent posterior-only deformity surgery. Navigated (NAV) cases were longer and yielded fewer RVUs-per-minute than conventional cases. Despite controlling for patient-related and procedural-factors, NAV independently-predicted 1.9-times, 2.9-times, and 3.2-times increased-odds of reoperation, deep-wound infection, and sepsis, respectively, but no longer predicted morbidity or transfusion. Readmission remained similar. Reoperation most frequently occurred for wound-related events, suggesting increased risk of infectious-related events with NAV. Further, we identified factors associated with poorer outcomes, which can be targeted in at-risk patients.

Hypothesis

Pediatric deformity patients treated with navigation (NAV) will have

less adverse events and reoperations, consistent with degenerative literature.

Design
Retrospective database study

Introduction
NAV has increasingly been used to treat degenerative disease, with improved radiographic accuracy and positive clinical outcomes. However, short-term outcomes research on treating pediatric deformity with NAV is limited. This is the first large-scale database study to compare short-term outcomes in pediatric deformity with and without NAV.

Methods
Deformity surgery patients were identified in the 2012-2018 pediatric-NSQIP datasets (CPT 22800-22804). Patients with severe preoperative comorbidities, infection, or anterior, revision, lesion, or nonelective surgery were excluded. Regression was used to compare readmission, reoperation, morbidity, and specific complications between NAV and conventional, and to control for predictors.

Results
16,950 patients (356 with NAV) were included. NAV cases had greater preop hematocrit (40.5vs39.9,p=0.005) and OR time (352vs284min,p<0.001), but similar RVUs (58.4vs60.1) and fewer RVUs per minute (0.21vs0.23,p<0.001). NAV had greater reoperation (6.2vs3.1%,p=0.001), morbidity (75.6vs67.5%,p=0.001), deep-wound infection (2.5vs0.8%,p=0.003), transfusion (73.6vs65.9%,p=0.002), and sepsis (2.2vs0.7%,p=0.007) rates. Readmission was similar (5.9vs3.9%,p=0.055). In multivariate analysis, NAV predicted reoperation, deep-wound infection, and sepsis (p≤0.019). Obesity (OR=2.472), developmental delay (OR=1.926), OR time (OR=1.002), hospital stay (OR=1.040), and total RVUs (OR=1.005) predicted reoperation (p<0.001). Black race (OR=1.193,p=0.002), Hispanic ethnicity (OR=1.401,p<0.001), seizure (OR=1.384,p=0.004), OR time (OR=1.005,p<0.001) and total RVUs (OR=1.009,p<0.001) predicted morbidity. Female gender was protective of readmission (OR=0.787,p=0.021).

Conclusion
NAV cases were longer and had fewer RVUs-per-minute. NAV had a 92% greater odds of reoperation, and predicted deep-wound infection and sepsis. This is explained, in part, by greater OR time and transfusion. Site-related factors played the largest role in reoperation.

Take Home Message
Navigated pediatric deformity surgery independently predicted reoperation, deep-wound infection, and sepsis despite controlling for patient-related factors and case-complexity. NAV no longer predicted morbidity or transfusion, while readmission rates remained statistically-similar.

Table 1. Baseline differences in patient demographic, comorbidity, laboratory, and procedural factors, and primary outcomes by presence or absence of computer assisted surgery.

	With CAS, *n* (%)	Without CAS, *n* (%)	*P*	Cases available
	N = 356	N = 16,594		16,950
Demographics				
Mean age (years; SD)	13.8 (2.8)	13.8 (2.7)	0.866	16,950
African American race	39 (11.8%)	2,696 (18.2%)	**0.003**	15,120
Hispanic ethnicity	31 (8.8%)	1,625 (10.6%)	0.292	15,712
Female gender	245 (68.8%)	11,575 (69.8%)	0.704	16,950
Comorbidities				
Obese	56 (16.3%)	2,416 (15.3%)	0.619	16,132
Pulmonary comorbidity	69 (19.4%)	2,795 (16.8%)	0.206	16,950
Cardiac comorbidity	26 (7.3%)	1,453 (8.8%)	0.337	16,950
Esophageal/GI disease	33 (9.3%)	1,692 (10.2%)	0.567	16,950
Developmental delay	79 (22.2%)	3,505 (21.1%)	0.625	16,950
Seizure disorder	31 (8.7%)	1,580 (9.5%)	0.605	16,950
Cerebral palsy	30 (8.4%)	1,571 (9.5%)	0.507	16,950
Structural CNS abnormality	49 (13.8%)	2,202 (13.3%)	0.786	16,950
Neuromuscular disorder	72 (20.2%)	3,668 (22.1%)	0.397	16,950
Preoperative steroid use	3 (0.8%)	179 (1.1%)	1.000[a]	16,950
Nutritional support	26 (7.3%)	1,274 (7.7%)	0.793	16,950
Hematologic disorder	10 (2.8%)	309 (1.9%)	0.193	16,950
Congenital malformation	86 (24.2%)	5,077 (30.6%)	**0.009**	16,950
Childhood malignancy	5 (1.4%)	166 (1.0%)	0.450	16,950
ASA-class ≥3	108 (30.4%)	5,055 (30.5%)	0.977	16,932
Lab Values (mean; SD)				
White cell count	7.0 (2.3)	6.9 (2.3)	0.758	14,089
Hematocrit	40.5 (3.6)	39.9 (3.4)	**0.005**	14,481
INR	1.1 (0.1)	1.1 (0.1)	0.672	9,657
Procedural Factors				
Operative time	352 (134)	284 (108)	**<0.001**	16,940
Length of stay	5.7 (7.3)	5.3 (5.7)	0.304	16,909
Total RVUs	65.2 (23.8)	60.1 (26.7)	**<0.001**	16,950
RVUs per minute	0.21 (0.09)	0.23 (0.12)	**<0.001**	16,940
Total RVUs subtracting CAS	58.4 (24.8)	60.1 (26.7)	0.238	16,948
Unadjusted Primary Outcomes				
Readmission	21 (5.9%)	647 (3.9%)	0.055	16,950
Reoperation	22 (6.2%)	513 (3.1%)	**0.001**	16,950
Mean days to reoperation	16.3 (7.4)	14.1 (8.4)	0.229	
Morbidity	269 (75.6%)	11,199 (67.5%)	**0.001**	16,950

[a]Fisher's Exact Test. Bold values indicate significance (*P*<0.05). ASA, American Society of Anesthesiologists. RVU, Relative value unit. CAS, computer assisted surgery. GI, gastric/intestinal. CNS, central nervous system. SD, standard deviation. Pulmonary comorbidities include ventilator dependence, asthma, chronic lung disease, chronic oxygen support, tracheostomy, or structural pulmonary or airway abnormalities. Cardiac comorbidities include previous cardiac surgery and cardiac risk factors.

Table 1

26. Robotics Coupled with Navigation (RAN) for Pediatric Spine Surgery: Initial Intraoperative Experience with 162 Cases

Nicole Welch, BA; Frank Mota, MD; Craig Birch, MD; Lauren Hutchinson, MPH; *Daniel J. Hedequist, MD*

Summary
Accurate pedicle screw placement is paramount in pediatric spine deformity surgery due to the proximity of vital structures. Limited literature on RAN begins to showcase heightened accuracy associated with its use. This retrospective study assessed intraoperative efficacy, accuracy, efficiency, techniques, and complications of RAN screw placement in patients with varying diagnoses. In 162 cases, 99.59% of screws were executed successfully and no neurologic deficits were observed. Adoption of a high speed navigated drill reduced the likelihood of lateral screw malposition.

Hypothesis
RAN will increase the accuracy and efficiency of screw execution.

Design
Level III

Introduction
This study reports on the initial experience of RAN and its role in advancing pediatric spine surgery.

Methods
A review of patients who underwent spine surgery using RAN from

2019-2021 was conducted. Perioperative metrics, screw execution and accuracy, technical difficulties, and other outcomes were summarized. In cases with postoperative CT scans, screws were analyzed for containment. Fisher's exact tests were used to assess the relationship between procedural factors and screw malposition.

Results

162 patients were included with an average age at surgery of 15.1 years. The most common diagnosis was AIS (n=80) (Table 1.1) with an average Cobb angle of 65° (range, 40°-128°). Of the 1467 screws attempted using RAN, 1461 were executed successfully (99.59%) (Table 1.2). All failures were in Type D pedicles and were lateral deviations recognized with routine intraoperative fluoroscopy. In cases with post screw 3D imaging, 180 screws (100%) were placed with complete containment (Grade A). The remaining screws were deemed accurate by mirroring fluoroscopy positions with planned computer software screw positions. In seven cases (4.32%) loss of accurate registration was noted by safety check prior to drilling at the planned level. There were no neurologic deficits and no returns to the operating room. Two technique changes occurred during the review. 1) Adoption of a high speed navigated drill: T1 (last 74 cases). 2) Drilling all pilot holes robotically first, then placing screws free-hand within the robotically established screw tracts to avoid torque causing motion and subsequently disrupting registration: T2 (last 39 cases). Adoption of T1 was less likely to result in screw malposition as no screws skived lateral with the technique (p=0.03, Fisher's exact test). T2 trended toward statistical significance for avoidance of both screw malposition and loss of RAN registration. There was no loss of registration after adopting this technique.

Conclusion

This study highlights the safety and screw accuracy associated with the use of RAN in pediatric patients.

Take Home Message

RAN remains novel in pediatric spine literature and this study is the largest to date analyzing the accuracy and safety of its use in pediatric spine deformity surgery.

Table 1.1 Summary of cohort diagnoses (N=162).

Characteristic	Freq.	(%)
Adolescent Idiopathic Scoliosis	80	49.38%
Spondylolisthesis	26	16.05%
Congenital Scoliosis	10	6.17%
Neuromuscular Scoliosis	20	12.35%
Tumor	2	1.23%
Other, including Kyphosis	24	14.81%

Table 1.2 Summary of cohort outcomes (N=162).

Characteristic	Freq.	(%)
Total Surgical Time *(minutes; mean (IQR))*	294.79	(226-348)
Total RAN Time *(minutes; mean (IQR))*	52.30	(38-64)
Successfully Executed Screws	1461	99.59%
Return to Operating Room for Screw Malposition	0	0.00%
Technical Difficulties	2	1.23%
Loss of Registration	7	4.32%
Intraoperative Complications	1	0.62%
Neurologic Deficits	0	0.00%
Estimated Blood Loss (EBL) *(mL; mean (IQR))*	326.64	(100-450)

*IQR, interquartile range.

27. Beware of Open Triradiate Cartilage: 1 in 4 Patients will Lose Greater than 10 Degrees of Correction Following Posterior Only Fusion

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Summary

Posterior pedicle screw fixation allows for 3-column control of spinal deformity from a single approach, mitigating the potential effects of the crankshaft phenomenon in skeletally immature patients. However, concerns of deformity progression and adding-on remain in these patients. At 5-year follow-up, immature patients with open triradiate cartilage (OTRC) treated with posterior only fusion had a 25% risk of losing greater than 10 degrees of primary curve correction.

Hypothesis

Patients with OTRC at the time of surgery will have similar outcomes at 5 years post-fusion to those with closed triradiate cartilage (CTRC).

Design

Longitudinal

Introduction

Previous studies demonstrated increased risk of curve progression following PSF of skeletally immature patients, defined by OTRC. These effects may be underestimated as patients were not likely skeletally mature at their 2 year follow-up. This study reports 5 year outcomes of OTRC patients treated with PSF compared to a matched cohort with CTRC or OTRC treated with a combined anterior-posterior fusion.

Methods
A multicenter, prospective database was reviewed for AIS patients with OTRC treated with pedicle screw fixation. This group was compared to a matched cohort of CTRC. Postop follow-up of 2 and 5 years was required for inclusion. A total of 3 groups were compared: CTRC, OTRC-posterior fusion (OTRC-P), and OTRC-combined anterior/posterior fusion (OTRC-A/P). Radiographic and patient reported outcomes (SRS-22) were compared between groups.

Results
142 subjects were included (67 CTRC, 67 OTRC-P, 8 OTRC-A/P). Primary curve type (p=0.592) and size (p=0.117) were similar between groups at all time points. Compensatory curve size was similar at all time points for the OTRC-P and CTRC groups, with a slight increase for the OTRC-A/P group from first erect to 5 years. At 2 years, the OTRC-P group had >10 degrees loss of correction in 22% of patients which increased to 25% at 5 years, compared to 6% in CTRC and 0% in the OTRC-A/P at 5 years (p=0.002). No significant differences were found in loss of correction of the compensatory curve or in SRS-22 scores.

Conclusion
Compared to those with CTRC or those treated with anterior/posterior fusion, patients with OTRC treated with posterior fusion had an increased risk of primary curve progression greater than 10 degrees. While the majority of this occurred by 2 years, some continued loss of correction occurred after 2 years. This did not affect patient reported outcomes.

Take Home Message
At 5 years postop, patients with OTRC treated with posterior only fusion had a 25% risk of having greater than 10 degrees loss of correction in the instrumented curve.

28. Does a dedicated "Scoliosis Team" and Surgical Standardization Improve Outcomes in Adolescent Idiopathic Scoliosis Surgery and is it Reproducible?

Vishal Sarwahi, MD, MBBS; Jesse M. Galina, BS; Terry D. Amaral, MD; Sayyida Hasan, BS

Summary
A standardized AIS approach including a dedicated operative team, pre-operative work up, postoperative multi-disciplinary management, and streamlined surgical steps improves outcomes and efficiency.

Hypothesis
A dedicated a "Scoliosis Team" and Surgical Standardization Improves Outcomes in Adolescent Idiopathic Scoliosis Surgery and is Reproducible.

Design
Retrospective Review

Introduction
In 2011, we implemented a standardized approach including a "scoliosis team" of dedicated anesthesiologists, operating room nurses, surgical technicians, and neurophysiologists who utilized standardized pre-operative work-up, use of anti-fibrinolytics and intrathecal morphine, and a multi-disciplinary postoperative care model.

Methods
A retrospective review was conducted of a prospective AIS database from 2009-2018 at 2 institutions (IA and IB). In each institution, a non-standardized group (NST) and a standardized group (ST), were compared. Demographics and perioperative outcomes were recorded. In 2015, the surgeons changed institutions (to IB). Reproducibility was determined between institutions (IA vs. IB). Median (IQR), Kruskal-Wallis, and Fisher's exact test were used.

Results
325 AIS patients were collected from the database. The non-standardized group (NST) included 44 patients, while the standardized group (ST) included 281 patients. Age (p=0.21), BMI (p=0.48), preoperative Cobb angle (p=0.48), levels fused (p=0.42), and correction percentage (p=0.39) were all similar. Standardized protocol patients had lower estimated blood loss (EBL) (700 ml vs. 325 ml, p<0.001), shorter anesthesia time (437 min vs. 384 min, p=0.004), shorter surgical time (310 min vs. 248 min, p<0.001), and shorter length of stay (LOS) (7 days vs. 5 days, p<0.001). IA (n=101) and IB (n=105) were compared. Age (p=0.21), BMI (p=0.48) and preoperative Cobb angle (p=0.48) were similar. EBL (p<0.001), anesthesia time (p<0.001), surgical time (p<0.001), and LOS (p<0.001) were significantly lower in IB.

Conclusion
Standardization of the perioperative approach for AIS correction with a dedicated team resulted in significantly decreased blood loss, surgical time, and length of stay. The ability to implement these changes across multiple institutions while continuing to improve perioperative outcomes demonstrates the reproducibility of this protocol.

Take Home Message
A standardized AIS approach including a dedicated operative team, pre-operative work up, postoperative multi-disciplinary management, and streamlined surgical steps improves outcomes and efficiency.

29. Impact of Socioeconomic Status on Brace Wear: Not All Patients are the Same

Bharadwaj Jilakara, BA; *Todd A. Milbrandt, MD, MS*; Stuart L. Weinstein, MD; Lori A. Dolan, PhD; A. Noelle Larson, MD

Summary
We used the BrAIST dataset to determine if socioeconomic status (SES) was associated with brace compliance and curve progression to surgery. Although Cobb angle, bone age, and hours of brace wear

were stronger predictors of curve progression, we found that low SES was associated with decreased hours of brace wear.

Hypothesis
We hypothesized that low SES is associated with decreased bracing compliance and higher progression rates to a 50-degree surgical magnitude curve (failure of treatment).

Design
Prospective Cohort Study

Introduction
A multicenter trial (BrAIST) recently showed brace wear effectiveness for scoliosis treatment. We used the BrAIST dataset to determine if socioeconomic status (SES) was associated with brace compliance and curve progression to surgery.

Methods
Our prospective trial studied the effects of brace wear on significant curve progression. Patient ZIP codes were used to determine the % households below the poverty line, which was used as an SES proxy. Canadian patients were excluded due to metric differences. In the United States overall, 21% of children under 18 years old live under the poverty line. Thus, patients in ZIP codes with more than 21% of households below the poverty line were considered low socioeconomic status (low SES), and all others high SES. 135 total braced patients who were followed to skeletal maturity had ZIP code data available for analysis.

Results
The table below summarizes sample characteristics by SES status. Low SES patients wore the brace for a mean of 8.3 hours per day vs. 11.4 hours per day for high SES patients (p=0.026). For the first 6 months of brace wear, patients with lower SES wore the brace a mean of 8.8 hours per day vs. 12.6 hours for those with higher SES (p=0.011). On multivariate analysis, SES was not a significant predictor for treatment failure, while Sanders bone age and Cobb angle at presentation were highly significant (model, p<0.0001).

Conclusion
Although Cobb angle, bone age, and hours of brace wear were stronger predictors of curve progression, we found that low SES was associated with decreased hours of brace wear. Several factors ranging from decreased social support to lack of feasibility may have contributed to fewer brace wear time.

Take Home Message
Further steps need to be taken in treating disadvantaged communities, perhaps through additional follow-ups where brace wear significance could be highlighted to encourage more wear time.

	Low SES* (n=33)	High SES (n=102)	p-value
Cobb Angle (mean, range)	30 (28, 32)	30 (28, 31)	0.55
Age (mean, range)	12.4 (12.0, 12.8)	12.4 (12.2, 12.7)	0.98
Risser 0	23 (70%)	57 (56%)	0.16
Average Hours Brace wear per Day in First 6 Months	8.8 (6.0,11.6)	12.6 (11.3, 13.9)	0.02
Average Hours Brace wear per Day Entire Treatment Period	8.2 (5.8, 10.8)	11.4 (10.2, 12.7)	0.02
Treatment Failure (Progression of curve to 50 degrees)	10 (30%)	23 (23%)	0.36

*Defined as residing in a ZIP code where > 21% of households live below the poverty line.

Summary of Sample Characteristics and Outcome by Socioeconomic Status (SES)

30. Tools for Your Toolbox: Testing a Decision-Making Aide for Scoliosis Patients

Paige Cummings, BS; *A. Noelle Larson, MD*; Todd A. Milbrandt, MD, MS

Summary
The conversation regarding scoliosis fusion or observation is difficult for both the families and physicians. Our Scoliosis Shared Decision-Making Tool revealed that it has the power to sway the conversation and facilitate the transfer of information. Further work to refine it will improve is efficacy.

Hypothesis
The Scoliosis Shared Decision-Making Tool could influence the conversation of scoliosis treatment.

Design
This was a prospective single-institution study of patients undergoing a clinical discussion of surgery vs. observation

Introduction
The decision between spinal fusion vs. observation patients with adolescent idiopathic scoliosis (AIS) requires effective communication between the patient and clinician. A Scoliosis Shared Decision-Making Tool was created after reviewing consented videotaped encounters in the clinic and tested prospectively.

Methods
24 total patients were enrolled between 2017-2021. The Tool was either used (group ST) or not (group NT). Following the videotaped encounter, the surgeon and the patients completed a survey reporting the quality of the conversation and the treatment decision.

Results
In the NT group, 11 (69%) reported choosing spinal fusion surgery, 4 (25%) observation, and 1 (6%) other decision. In addition, 3 (19%) patient decisions were discordant with what the clinician would have advised. In the ST group, 1 (13%) patient reported choosing surgery, 5 (62%) observation, and 2 (25%) other decision. Within these 8 encounters there were 4 (50%) patient decisions discordant with what the clinician would have advised. In every discordant decision, the surgeon indicated they would have chosen fusion surgery when the patient and family chose observation or "other decision." The

results of the quality survey revealed that 63% of patients and 50% of the parents in the ST group thought it was very helpful which was similar to the NT group (66% and 53%). Clinicians' opinions revealed a "very helpful" in 38% in the ST group and 33% in the NT group.

Conclusion
In our first attempt at creating a Scoliosis Shared Decision-Making tool, the results were mixed. We found that with the tool, only 13% of patients chose fusion surgery compared to 50% when the tool was not used. Clinicians thought the decisions that families made with the tool was discordant with what they would have advised. Our Tool may be slanted towards more non-operative evidence and with these results in mind, it will be revised. The quality of the encounter was not affected by the tool.

Take Home Message
A Scoliosis Decision Making tool significantly influenced conversations between clinician and patient.

31. Defining Different Distal Adding-On Patterns After Thoracic-only Vertebral Body Tethering

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Summary
Data from 42 Lenke 1&2 AIS patients who had undergone thoracoscopic VBT, and were followed-up until skeletal maturity suggests that >50% of the cases are associated with new Cobb formation and distal adding-on. Unlike adding-on after posterior spinal fusion, which is a relatively early complication related to level selection and remaining growth, adding-on after VBT shows various patterns as VBT is a dynamic system and uninstrumented lower curve is also affected by mechanical phenomena such as correction/overcorrection and tether breakage.

Hypothesis
Distal adding-on patterns, as well as its risk factors may be different in VBT compared to PSF

Design
Retrospective analysis of prospectively collected data

Introduction
VBT allows gradual spontaneous follow-up curve correction after surgical correction as the patient grows. There is a lack of evidence regarding uninstrumented curve behavior and distal adding-on phenomenon in VBT patients.

Methods
Data were collected preoperatively, before discharge, and at each follow-up. Demographic, perioperative, clinical, radiographic data and complications were recorded. Surgical, follow-up and total correction percentages were calculated. Stable vertebra (SV), last touched vertebra (LTV), End vertebra (EV), rotation and angulation of UIV, LIV and 2 levels above & below were analyzed. New Cobb formation was defined as a progressive increase in the number of vertebrae included within the primary curve distally. Increase in deviation of LIV+1 from CSVL was set to >5mm. Increase in angulation of the disc below LIV was set to >5°.

Results
42 Lenke 1 and 2 patients (38F, 4M, 12.4±1.2 years) with a mean follow-up of 42 (24-69) months were included. Mean preoperative and final Sanders stages were 4 (2-7) and 7 (7-8), respectively. All adding-on patterns were related with a new Cobb formation and >5mm deviation of LIV+1 from CSVL. Real adding-on was apparent by increased rotation and was associated with higher magnitude of pre-operative LIV rotation (i.e. LIV being more proximal or distal to neutral vertebra). Correction/overcorrection related pseudo-adding-on displayed negative LIV tilt. Tether breakage related pseudo-adding-on was accompanied by worsening of a previously achieved correction, generally closer to the distal end of the construct. None of the adding-on patterns showed a significant trend towards having >5° increase in angulation of the disc below LIV.

Conclusion
New Cobb formation with distal extension of lower end vertebra is common after VBT surgery in Lenke type 1&2 patients, yet this does not always imply real adding-on. Various uninstrumented distal curve behaviors related to correction/overcorrection and tether breakage might result pseudo-adding-on in different patterns.

Take Home Message
Real adding-on after VBT resembles that of adding-on following PSF. There are several pseudo-adding-on patterns that occurs independent of level selection and growth, which may develop well after 1-year follow-up.

32. Anterior Vertebral Body Tethering for Idiopathic Scoliosis: How Well Does the Tether Hold Up?

Dhruv S. Shankar, BS; Lily Q. Eaker, BA; Theodor Di Pauli von Treuheim, B. Eng; Jared C. Tishelman, MD; Zacharia Silk, FRCS; Baron S. Lonner, MD

Summary
In this single-surgeon retrospective cohort study, we quantified tether breakage rates in 72 patients who underwent anterior vertebral body tethering for idiopathic scoliosis. Tether breakages at 1 and 2 years after surgery were identified from follow-up radiographs. We calculated a 2-year breakage rate of 26%. Curve correction was reduced in patients with broken tethers.

Hypothesis
Patients with broken tethers at 2 YR FU will have reduced curve correction compared to patients with intact tethers.

Design
Single-surgeon retrospective cohort study

Introduction
Durability of outcomes of vertebral body tethering (VBT), particularly incidence of tether breakage (TB), is unknown. We aimed to study TB rates and their impact on radiographic outcomes in VBT in the largest single surgeon series to date.

Methods
Inclusion criteria included AIS diagnosis, undergoing VBT, and minimum 2-year follow-up (FU). A tether was deemed broken if there was an increase in angulation >5° between adjacent screw heads on 1 and 2-year FU X-rays compared to 1st erect. Median time to TB was estimated using Kaplan-Meier survival analysis. Differences in breakage rates between single-cord and double-cord tethers were evaluated using two-sample z-test. Differences in curve correction between patients with and without broken tethers at 2 years were evaluated using Mann-Whitney U test.

Results
72 patients were included. At 2 years, 18 patients (26%) had experienced TB. Median time to TB was significantly shorter for thoracolumbar vs. thoracic single-cord tethers (p=0.01). TB mostly occurred in major curve tethers (68%) and thoracolumbar tethers (79%). Double cords were primarily used in thoracolumbar curves (85%) and TB rates between thoracolumbar single-cord (35%) and double-cord tethers (25%) were not significantly different (p = 0.42). Mean major curve correction at 2-year FU was lower (p = 0.02) in patients with TB (48° to 24°, 50%) vs. those with intact tethers (53° to 21°, 60%), but the proportion of major curves corrected to less than 35° was similar (94% vs. 100%). 2 patients underwent reoperation, only one of whom had a broken tether and was treated with posterior spinal fusion.

Conclusion
TB rate was 26% at 2 years following VBT. Broken tethers are associated with loss of major curve correction. Rates are higher for thoracolumbar curvatures and double cords may not be able to overcome TB.

Take Home Message
Postoperative tether breakage occurs in slightly greater than ¼ of VBT patients, predominantly occurs in thoracolumbar curve tethers, and is associated with reduced major curve correction 2 years postoperatively.

Table 1. Summary of cohort variables (n = 72).

Perioperative Variables		
	Count (%)	Mean (standard deviation)
Age in years		14 (2)
Female sex	53 (74%)	
BMI		20.2 (3.7)
Major Cobb angle		52° (8°)
Curves tethered		
Thoracic	27 (38%)	
Thoracolumbar	18 (25%)	
Both	27 (38%)	
Tether cord numbers		
Single cord	86 out of 99 tethered curves (87%)	
Thoracic	52 out of 86 single-cord tethers (60%)	
Thoracolumbar	34 out of 86 single-cord tethers (40%)	
Double cord	13 out of 99 tethered curves (13%)	
Thoracic	2 out of 13 double-cord tethers (15%)	
Thoracolumbar	11 out of 13 double-cord tethers (85%)	
Postoperative Variables		
	Count (%)	Mean (standard deviation)
Cumulative tether breakage rates by postoperative year		
1 year breakage rate	2 (3%)	
2 year breakage rate	18 (26%)	
Tether breakage rates by cord number		
Single cord	15 out of 86 single-cord tethers (17%)	
Thoracic	4 out of 52 thoracic single-cord tethers (8%)	
Thoracolumbar	11 out of 34 thoracolumbar single-cord tethers (32%)	
Double cord	3 out of 13 double-cord tethers (23%)	
Thoracic	0 out of 2 thoracic double-cord tethers (0%)	
Thoracolumbar	3 out of 11 thoracolumbar double-cord tethers (27%)	
Breakage sites by curve location		
Thoracic	4 out of 19 breakage sites (21%)	
Thoracolumbar	15 out of 19 breakage sites (79%)	
Breakage sites by curve type		
Major curve	13 out of 19 breakage sites (68%)	
Minor curve	6 out of 19 breakage sites (32%)	
2-year major curve correction by breakage status		
Intact tethers		53° (8°) corrected to 21° (9°), 60% (15%)
Broken tethers		48° (7°) corrected to 24° (8°), 50% (16%)
Reoperations		
	Count (%)	Reason for reoperation
All reoperations	2 (3%)	
Patients with intact tethers	1	1.) Radiculopathy requiring revision of screw.
Patients with broken tethers	1	1.) Lumbar tether breakage, revised with double cord and PSF of thoracic curve.

33. Segmental Correction Technique Results in Earlier Tether Breakage Compared to Global Correction Technique: A Matched Cohort Analysis

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Summary
This study reports on 28 patients with ≥1-year follow-up, who had undergone all-thoracoscopic VBT using different surgical curve correction techniques; Segmental Correction vs. Global Correction. Patients were 1-to-1 matched according to Sanders Stages, Lenke Curve Types, Main Thoracic (MT) and Thoracolumbar/Lumbar (TLL) Curve magnitudes and Surgical Location (Thoracic vs. Thoracolumbar vs. Double-curve). Analyses revealed earlier tether breakage in Segmental Correction group (mean 11.9, range 9.6 - 15.4 months) compared to Global Correction group (mean 26.5; range 23.1 - 30.9 months).

Hypothesis
Correction technique might have an influence on VBT results

Design
Retrospective analysis of prospectively collected data

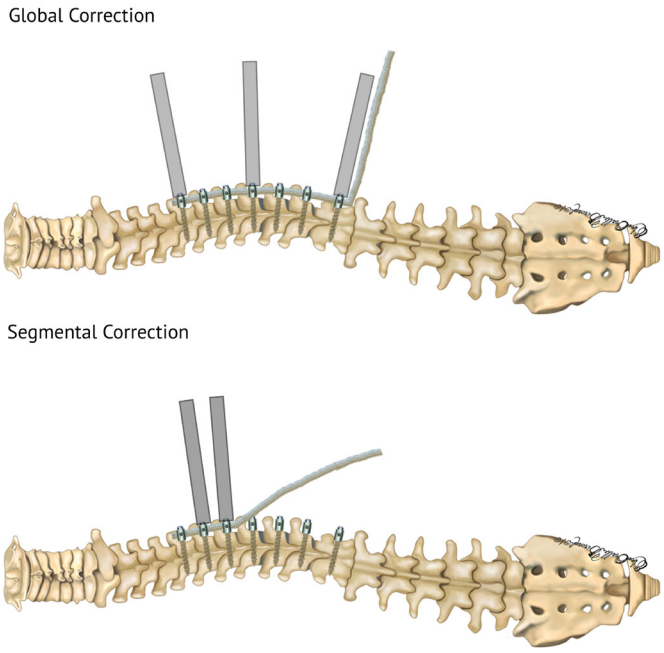
Introduction
VBT is a novel technique with multiple unknown. Among others, surgical correction technique might have an impact: Some instrument designs allow for Segmental Correction where each segment is manipulated and tightened, pushing a caudal screw to the cranial one. Other instrument designs allow for Global Correction where the tightening is always at the caudal-most level while segmentally manipulating the screws, incrementally pulling cranial segments caudally (Fig).

Methods
Demographic, perioperative, radiographic data and complications were recorded. Broken tethers were indicated by ≥6° increase of angulation between adjacent screws between any two postop radiographs. The acquisition time of the latter radiograph was marked as the tether breakage time. Descriptive statistics are given.

Results
28 pts (14 in each group) (25F, 3M; 12.9±1.7 yrs) with a mean f-up of 24 (12-65) months were included. Median Sanders: 3.5 (2-7), Median Risser: 0 (0-5). 8 patients were Lenke 1A, 6 were 1Ar, 4 were 5c and 10 were 1B-C, 2A-C and 3C. The mean preop MT curve was 53° (24-77°); mean preop TLL curve was 37° (23-64°). 6 patients had both curves addressed while 12 had thoracic VBT and 10 had thoracolumbar VBT. A mean of 8.8 (5-12) levels were tethered. Patients grew 5cm in average (0-13 cm). MT curve was corrected to 26° (10°-47°) which was stable on average at 23° (-8°-43°). TLL curve was corrected to 16° (2°-30°) which was stable on average at 15° (1°-34°). There were 4 tether breakages in the Segmental Correction group at a mean of 11.9m (9.6-15.4) of f-up, which resulted in a mean of 9.7° (7.6°-13.7°) of segmental correction loss. There were 4 tether breakages in the Global Correction group at a mean of 26.5m (23.1-30.9) of f-up, which resulted in a mean of 7.3° (6.1°-9.2°) of segmental correction loss.

Conclusion
Of the broken tethers, Segmental Correction resulted in approximately 14 months earlier tether breakage compared to Global Correction technique. Longer f-up is warranted to compare overall breakage rates.

Take Home Message
Among other factors such as patient selection, remaining growth, curve size and initial correction, instrument design and surgical correction technique might have an influence on the timing of tether breakages.



34. Minimally Invasive Surgery for Neuromuscular Scoliosis

Vishal Sarwahi, MD, MBBS; Jesse M. Galina, BS; Sayyida Hasan, BS; Alexandre Ansorge, MD; Terry D. Amaral, MD

Summary
The aim of this case control study was to report a retrospective, consecutive series of patients with neuromuscular scoliosis who were treated with posterior minimally invasive surgery (MIS) and to compare it to a control group operated through a standard posterior midline approach.

Hypothesis
The use of MIS for patients with neuromuscular scoliosis results in a significant correction of spinal deformity.

Design
Retrospective Survey

Introduction
Our objectives were to report the correction of the deformity and record the peri-operative morbidity.

Methods
We retrospectively collected data of 37 consecutive patients with neuromuscular scoliosis treated with MIS using one incision and a muscle-splitting approach by two senior surgeons (RD and VS) between December 2013 and November 2018. All 37 MIS patients were available for analysis. The MIS group data was compared to consecutive control cases operated by a single senior surgeon (VS) using a standard posterior midline approach between April 2005

and February 2017. Of 122 control patients included, 103 were available for analysis. In the MIS group, there were 27% (n=10) vs. 47% (n=48) males and 73% (n=27) vs. 53% (n=55) females. The mean age was 14 years in the MIS and the control group (standard deviation (SD) 3.8 vs. 3.4) with a mean body mass index (BMI) of 18.4 vs. 19.3 kg/m2 (SD 5.9 vs. 6.1 kg/m2).

Results
In the MIS group, mean primary Cobb angle was corrected from 69.9° vs. 67.7° (SD 17.3° vs. 24.4°) pre-operatively to 29.4° vs. 25.4° (SD 15.3° vs. 17.3°) post-operatively with a mean correction of 59% vs. 63%, (SD 16.8% vs. 18.4%, $p < 0.001$). Intraoperative complications occurred in 2.7% (n=1) of the MIS patients (one dural breach), respectively in 6.8% (n=7) of the control patients (3 pneumothorax, 4 hemorrhagic shocks). In the MIS group, mean ORT was 345 minutes (SD 79.8) vs. 407 minutes (SD 120.7); the mean EBL was 573 ml (SD 362.8) vs. 1108 ml (SD 910.3), the mean allogenic blood transfusion rate was 57% (SD 0.5) vs. 87% (SD 0.33), the mean ICU LOS was 4.5 days (SD 10.8), respectively 5.6 days (SD 12.6) and hospital LOS was 11 days (SD 11.2), respectively 14.9 days (SD 13.9).

Conclusion
The use of MIS for patients with neuromuscular scoliosis results in a significant correction of spinal deformity, with a lower EBL, need for allogenic blood transfusion, and LOS. The rate of intra-operative complications was significantly lower in MIS and perioperative complications rate was similar.

Take Home Message
MIS resulted in a significant correction of the deformity with significantly lower rate of allogenic blood transfusion and a mean ICU and hospital LOS of 4.5 and 11 days respectively.

35. Single Incision Minimally Invasive Surgery (MIS) for AIS Patients: The Best of Both Worlds

Vishal Sarwahi, MD, MBBS; Sayyida Hasan, BS; Jesse M. Galina, BS; Alexandre Ansorge, MD; Terry D. Amaral, MD

Summary
1MIS offers a middle ground to the surgeon who prefers soft tissue preservation and its significant benefits without increasing surgical time and complexity of the approach.

Hypothesis
MIS techniques, single or three incision, yield superior outcomes to standard PSF.

Design
Ambispective cohort study

Introduction
MIS has started to increase in popularity as surgeons move towards soft tissue and blood preservation. However, MIS has slowly gained in popularity due to technical demands and increased surgical time compared to the standard PSF approach. However, 1MIS utilizes the beneficial features of 3MIS and PSF, with the potential to have the best of both approaches.

Methods
Surgeries performed over 2008-2018 were included. Cohorts were formed based upon surgical approach: standard PSF vs. 1MIS vs. 3MIS. Additional analysis was done comparing the two MIS techniques. Demographic, radiographic, and perioperative were collected for the 3 groups. Perioperative parameters such as blood loss, fixation points, and surgical time, etc. were obtained. Kruskal-Wallis and Fisher's exact test were performed.

Results
465 patients met our inclusion criteria, 296 PSF, 138 3MIS, and 31 1MIS. 1MIS patients were significantly older compared to PSF and 3MIS (1MIS: 16 vs. 3MIS: 14.9 vs. PSF: 15, $p = 0.028$). However, PSF patients had significantly higher BMI (19.9 vs. 19.7 vs. 21.2, $p < 0.001$) 3MIS patients were older compared to the PSF and 1MIS (16 vs. 15.1 vs. 14.8, $p = 0.016$). PSF patients had significantly larger preop and postop Cobb angles compared to 1MIS and 3MIS (55 vs. 48.5 vs. 50, $p <0.001$) (18.8 vs. 13.8 vs. 15.6, $p = 0.020$), respectively. EBL (ml) was significantly higher in PSF than in 1MIS and 3MIS (500 vs. 350 vs. 375, $p < 0.001$). 14% of PSF patients received a transfusion compared to 6% in 3MIS and 6% in 1MIS. 3MIS had significantly fewer fixation points than PSF and 1MIS (18 vs. 22 vs. 20.5, $p<0.001$). Surgical time was significantly lower in 1MIS than in PSF and 3MIS (231.2 vs. 263.9 vs. 283.3, $p<0.001$).

Conclusion
MIS techniques yield significant perioperative benefits. 3MIS allows for significantly less blood loss and fewer fixation points than PSF; however, the surgical time is significantly longer. 1MIS had significantly less blood loss, and the surgical time was shorter than PSF and 3MIS.

Take Home Message
1MIS offers a middle ground to the surgeon who prefers soft tissue preservation and its significant benefits without increasing surgical time and complexity of the approach.

36. Comparable Correction and Overall Surgical Complication Rates Achieved in Both VCR-Based and Non-VCR-Based Surgical Corrective Maneuvers for the Treatment of Severe Rigid Scoliotic or Kyphoscoliotic Patients

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Summary
Vertebral column resection (VCR-based) surgery is a powerful corrective technique for correcting severe rigid spinal deformities but also associated with significant risk of major perioperative and

neurological complications according to reported outcomes. This practically means that it is a technically demanding technique. Other non-VCR-based surgical maneuvering techniques for correcting severe rigid spinal deformities to achieve satisfactory patient outcomes also do exist. Combined studies that compare complication outcomes between these categorical approaches can meta-analytically infer where the complication rates resonate more.

Hypothesis

To investigate whether VCR-Based] and Non-VCR-Based corrective surgeries show similar morbidity and complication outcomes.

Design

Systematic Review and Meta-Analysis

Introduction

Even though VCR can achieve favorable corrective outcomes in severe spinal deformities, the accompanying neurological complications rates can be very high. Hence, the efficacy of other surgical maneuvers in severe rigid scoliosis or kyphoscoliosis patients is worth exploring. Meta-review studies on complication outcomes between VCR-based and non-VCR-based corrective maneuvers in the surgical management of these patients are highly lacking.

Methods

A comprehensive literature review and meta-analysis was performed from January 2000 to September 2021. The selection criteria included: i) studies comparing VCR-based vs. non-VCR-based techniques ii) English articles with case series of ≥10 patients, iii) studies with defined average Cobb angle of ≥80o and flexibility of <30%, iv) reported complication rates, and v) a minimum 2-year follow-up period. Odds ratios (ORs) and 95% confidence intervals (CIs) were computed for complication incidence between the two surgical approaches while statistical significance was set at $p<0.05$.

Results

Of the 174 patients analyzed, 52.30% (n=91) and 47.70% (n=83) were VCR-based and non-VCR-based. The incidence of dural tears/nerve injuries/significant intraoperative neuromonitoring changes was significantly higher; [OR=6.78, CI= (1.75 to 26.17), I2=0%, (p=0.006)] in the VCR-based technique compared to the non-VCR-based techniques. The overall surgical complication incidence was higher in the VCR-based group but not statistically significant, [OR=6.78, CI= (0.51 to 11.90), I2=69%, (p=0.26)].

Conclusion

Our study indicates that both VCR-based and non-VCR-based surgical maneuvers show comparable overall complication outcomes while a significantly higher perioperative neurological complication incidence resonates more in the VCR-based group compared to the non-VCR-based surgical group. Approximately, ≥ 50% correction was achieved in both surgical groups.

Take Home Message

1. VCR-based technique is associated with 6.78 times higher with neurological complications compared to non-VCR-based techniques.
2. The average correction rates were 53.4% and 52.3% for VCR-based and non-VCR-based techniques, respectively.

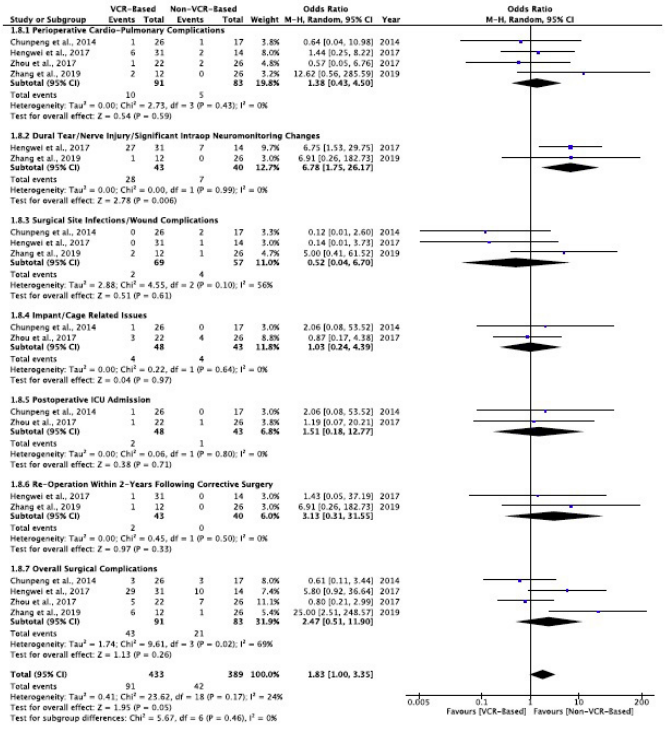

Fig.1

37. Post-Op Tranexamic Acid Decreases Chest Tube Drainage Following Vertebral Body Tethering Surgery for Scoliosis

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Summary

24 hours of post-operative intravenous TXA reduces chest tube drainage and retention time following VBT for correction of adolescent idiopathic scoliosis.

Hypothesis

Post-op tranexamic acid (TXA) significantly reduces chest tube drainage and retention time.

Design

Retrospective; Single Center

Introduction

Anterior vertebral body tethering (VBT) is a non-fusion surgical option for the treatment of Adolescent Idiopathic Scoliosis requiring

chest tube(s) (CT). We sought to assess the efficacy of post-op IV TXA in reducing CT drainage and retention following VBT.

Methods

35 VBT patients who received 24 hours of post-op IV TXA (2 mg/kg/hr) were compared to 49 who did not. Between group comparisons were performed using Wilcoxon Rank Sum tests and chi-squared tests. Multivariate linear regression analysis was used to assess the relationships between TXA and both CT drainage and retention time controlling for demographic and intra-operative maneuvers.

Results

There were no group differences at baseline (Table). Intra-op, there were no differences in EBL or levels instrumented (p>0.05). Post-op, there were no differences in LOS (TXA 4.8±2.0 vs. Non-TXA 4.9±2.7 days; p=0.8631) or length of ICU stay (TXA 2.0±0.8 vs. Non-TXA 2.3±1.0 days; p=0.2900). Thoracic (TH) and thoracolumbar (TL) curve chest tubes were analyzed separately. For TH CT, there was significantly less total CT drainage in the TXA group (TXA 569.4±337.4 mL vs. Non-TXA 782.5±338.9 mL; p=0.0028) and shorter CT retention time (TXA 3.0±1.3 vs. Non-TXA 3.9±1.4 days; p=0.0032). For patients with TL CT, there was significantly less total CT drainage in the TXA group (TXA 206.8±152.2 mL vs. Non-TXA 395.7±196.1 mL; p=0.0025) and shorter CT retention time (TXA 1.7±1.3 vs. Non-TXA 2.7±1.0 days; p=0.0014). Following multivariate analysis, use of TXA (p=0.0285) and disc releases (p=0.0166) were the only predictors of drainage in T CTs. TXA (p=0.0036) and BMI (p=0.0434) were the only predictors of TL drainage. The use of TXA (p=0.0176) and disc releases (p=0.0120) were the only predictors of T CT retention time and use of TXA (p=0.0112) was the only predictor of TL CT retention time.

Conclusion

Post-op TXA is associated with a significant decrease in CT drainage and retention time. CT retention is decreased by one day for those that receive TXA.

Take Home Message

The use of 24 hours of post-op IV TXA following VBT surgery for scoliosis correction is associated with a significant decrease in both CT drainage and retention time.

	TXA	No TXA	P-Value
Age	14.2±1.9	13.9±2.3	p= 0.8943
Gender	89% F	76% F	p=0.1656
Major Cobb (°)	51.3±7.7°	52.9±9.7°	p= 0.7095
BMI	20.2±3.0	20.1±3.3	p=0.7543
Instrumented Curve			
Thoracic	17 (49%)	29 (59%)	0.3089
Thoracolumbar	4 (11%)	8 (16%)	
Both	14 (40%)	12 (25%)	
Cords			
Single	12 (34%)	26 (53.1%)	0.0883
Double	23 (66%)	23 (46.9%)	

Chest Tube Drainage by Day

	Thoracic			Thoracolumbar		
	TXA	No TXA	p-Value	TXA	No TXA	p-Value
DOS	177.6±70.2 (56.0-340.0) *N=31*	251.4±111.6 (85.0-600.0) *N=41*	0.0031	106.7±65.2 (15.0-310.0) *N=18*	135.6 ±57.5 (60.0-270.0) *N=20*	0.0942
POD1	188.4±80.8 (34.0-420.0) *N=31*	242.7±95.9 (54.0-538.0) *N=41*	0.0091	65.3±55.8 (13.0-208.0) *N=18*	163.3±95.8 (52.0-422.0) *N=20*	0.0007
POD2	137.8±98.4 (10.0-390.0) *N=28*	160.3±92.7 (10.0-380) *N=40*	0.2167	74.4±84.0 (2.0-210.0) *N=5*	80.8±45.8 (4.0-190.0) *N=13*	0.6212
POD3	102.6±77.8 (2.0-290.0) *N=14*	143.4±113.7 (5.0-565.0) *N=31*	0.2064	85.0±35..4 (60.0-110.0) *N=2*	61.2±28.2 (30.0-102.0) *N=6*	0.2405
POD4	71.7±70.0 (0-200) *N=6*	110.3±90.5 (16.0-280.0) *N=11*	0.4510	75.0 *N=1*	-	-
POD5	190.0 *N=1*	60.7±36.8 (10.0-100.0) *N=7*	0.1878	10.0 *N=1*	-	-
POD6	260.0 *N=1*	10.0 *N=1*	-		-	-
POD7	130.0 *N=1*	-	-		-	-
Total Drainage	569.4±337.4 (180.0-1620.0)	782.5±338.9 (250.0-1740.0)	0.0028	206.8±152.2 (58.0-569.0)	395.7±196.1 (113.0-866.0)	0.0025
Length of CT (Days)	3.0±1.3 (1.8-7.8)	3.9±1.4 (1.0-6.4)	0.0032	1.7±1.3 (0.3-5.1)	2.7±1.0 (1.3-4.8)	0.0014

Daily chest tube output

38. The Use of Artificial Intelligence in the AIS Surgery: Did the Predictive Model Accurately Depict the Postoperative Compensatory Sagittal Spinopelvic Parameters?

Afshin Aminian, MD; John Ngo, DO; Evelyn Thomas, DO; Noah Boyer, BS

Summary

Use of artificial intelligence (AI) in the surgical planning process accurately predicted sagittal spinopelvic compensatory parameters following adolescent idiopathic scoliosis (AIS) surgery.

Hypothesis

The predictive model accurately depicts postoperative compensatory changes in sagittal spinopelvic parameters in patients with AIS undergoing spinal fusion with implantation of pre-contoured patient-specific rods (PSR).

Design

Data was collected retrospectively from a prospectively collected database in patients in Lenke class 1 & 2 undergoing posterior spinal fusion (PSF) with implantation of PSR.

Introduction

Utilization of AI in preoperative sagittal plane planning of adult spinal deformity (ASD) has shown benefits in predicting the compensatory changes in the unfused segments and assists in rod shape design.

This is the first reported series of the use of AI in sagittal plane planning in AIS surgery.

Methods
From 7/2018 to 12/2020, 54 consecutive cases of patients with AIS underwent PSF, by a single surgeon, with 6.0mm Ti PSR. Surgeon-planned thoracic kyphosis (TK) and pre-contoured rod shape were used to achieve desired TK and the location of the inflection point. A model was used to predict postoperative pelvic tilt (PT) and lumbar lordosis (LL). Sagittal and coronal radiographic measurements were obtained at preoperative visit and 1-year postoperative visits (Figure). 45 patients with minimum 1-year follow-up were included. Statistical analysis was performed, including the Wilcoxon rank-sum test for the TK, PT, and LL between the planned and 1 year follow-up data.

Results
Median TK gain from preoperative to 1-year follow-up period was 8° for the whole cohort (p=0.002). The predicted PT and LL compared to the respective 1-year follow-up data showed no statistical significance. The hypokyphotic subgroup (TK<20°) (n=15) demonstrated no statistical significance among planned and 1-year data (Table). Preoperative Planned 1-year TK 17.0° 31.0° 32.0° LL -53.0° -60.0° -64.0° PT 10.9° 11.5° 11.0°

Conclusion
AI accurately predicted the compensatory changes in the spinopelvic parameters of the unfused segments after AIS surgery.

Take Home Message
Predicting compensatory changes of spinopelvic parameters with AI based on planned TK, the surgeon can more accurately select the patient-specific TK in AIS surgery.

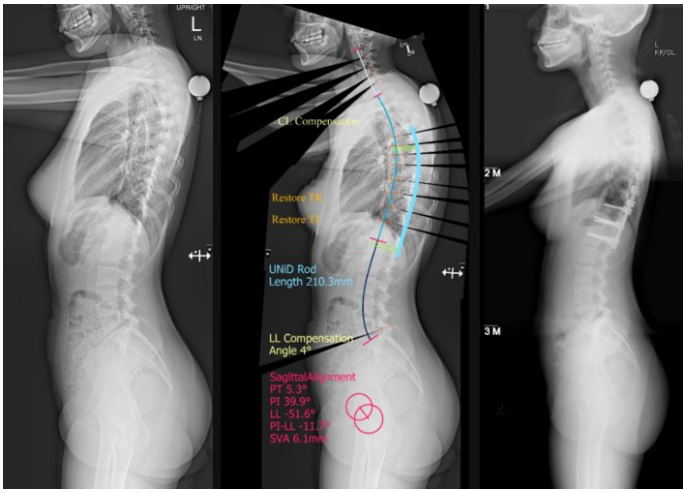

Figure. Preoperative, planned and 1-year sagittal XR

39. Clinical and Radiographic Outcomes in Patients With Severe Idiopathic Spine Deformity Treated With HGT + PCO vs. ±VCR

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Summary
VCR is a technically demanding risky procedure that may be required in severe idiopathic spine deformity patients. We find from this paper that clinical and radiographic outcomes in patients treated with HGT + PCO have comparable outcomes to those treated with VCR

Hypothesis
Clinical and radiographic outcomes in severe idiopathic spine deformity patients treated with VCR are better that those treated with HGT + PCO

Design
Prospective observational multi center cohort

Introduction
Severe idiopathic spine deformities present a challenge with surgery. HGT has been proven to reduce curve magnitudes preoperatively. VCR is a powerful technique for correcting severe deformities. This study sought to determine whether there is variations in clinical and radiographic outcomes in patients treated with VCR±HGT vs. HGT+PCO

Methods
52/89 idiopathic scoliosis patients and Kyphoscoliosis patients with 2-year f/u enrolled in the FOX pediatric database from 17 international sites were queried for clinical and radiographic outcomes

Results
VCR±HGT (20pts) vs. HGT+PCO group (32pts). Average age were 15.0±2.65 vs. 15.3 ±2.7. Coronal cobb averaged 114.4±22.8deg vs. 126.2 ± 22.5deg, p=0.07, sagittal cobb averaged 99.6deg ±43.5deg vs. 116.6 ±30.4deg, p=0.103. CDAR and S-DAR were 16.3±5.8 vs. 16.4 ±3.8 and 14.1±8.0 vs. 16.51±5.9, p>0.05, respectively. Immediate post-op coronal cobb correction averaged 53.1±15.3% vs. 47.3± 16.1%, p= 0.216. Immediate post-op sagittal cobb correction averaged 42.9± 18.2 % vs. 39.7 ±22.5%, p=0.6011. 2yr-follow-up coronal and sagittal correction was similar between the two groups, p>0.05. Post-op neurologic complication rates were 10% vs. 3.1%, p=0.301. Implant complication rates were 5.0% vs. 3.1%, p=0.732

Conclusion
Clinical and radiographic outcomes in severe idiopathic spine deformity patients treated with HGT + PCO are comparable to those treated with VCR

Take Home Message
In severe idiopathic spine deformity patients, HGT + PCO achieves satisfactory clinical and radiographic outcomes comparable to VCR

40. Self-Sliding Growth Guidance for Early-Onset Scoliosis: Clinical and Radiological Results After a Minimum of Six Years (6-14) of Follow-up

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Summary
Preoperative, early postoperative, and follow-up radiographs of 17 early-onset scoliosis patients who underwent Self Sliding Growth Guidance (SSGG) technique were evaluated. SSGG technique provided and maintained satisfactory curve corrections on both planes, allowed self-growing of the spine with a rate of 1.04 mm growth per month, decreased the number of repeated lengthening procedures, shown to have low complication rates, prevented PJK and DJK since it is not a distraction based system after minimum 6 years follow up

Hypothesis
SSGG maintains correction of EOS deformity on both planes, reduce the number of lengthening procedures and avoid autofusion with min 6yrs f/up

Design
Retrospective

Introduction
SSGG technique was developed to allow growth during treatment of EOS and obviate the need for repeated lengthening procedures. The aim of this study is to evaluate the clinical, radiologic results of SSGG both in pts who underwent final fusion and those who did not, with min 6 yrs f/up

Methods
17 (10f,7m) pts with EOS treated with SSGG were evaluated. The etiology of pts was idiopathic in10, syndromic in4 and NF in3. Preop, early post-op and f/up radiographs were compared for coronal and sagittal cobb and lengthening of the trunk. All complication data were retrieved from hospital charts.

Results
Av. age at the index surgery was 6.5 yrs (3-10). Mean f/up was 96 m(72-170).Ave MT curve of 57° was corrected to 21° with a 65% correction rate. Ave TL/L curve of 47° was corrected to 16° with a 68% correction rate. Preop TK of 31° and LL of 55° was maintained at 35° and 57°,respectively.Mean increase in T1-T12 length was 0.77mm and 1.04mm per month in T1-S1 height. There were no rod breakages, PJK, neurologic impairment or infection. 1 syndromic pt had skin ulcer and autofusion. Among all the pts 2 screws were revised for loosening. Set screw dislodgement was found in 15(88%)of the pts during the sliding period. In the last 6 yrs with use of special type pedicle screws there was no new set screw dislodgements. In 4 pts (23%) distal sliding foundation was converted to proximal due to correction loss during f/up. In 11 pts (64%) final fusion was performed after achieving ultimate spinal growth. SSGG prevented 98 planned lengthenings. Mean SRS22 scores were 4.07.

Conclusion
SSGG technique is a method of early-onset kyphoscoliosis treatment that can control the coronal, sagittal, and axial plane deformities due to multiple fixation points. It enables a lesser number of scheduled repeated surgical procedures compared with the TGR technique. SSGG demonstrated low complication rates, avoided spontaneous fusion, prevented PJK and DJK since it is not a distraction-based system.

Take Home Message
In contrast to the Traditional Growing Rod system, Self-Sliding Growth Guidance is a dynamic growth guidance technique that allows self-growing of the spine and maintains correction on both planes.

41. Sacral-Alar-Iliac (SAI) Fixation in Children with Spine Deformity: Minimum 10-Year Follow-Up

Frederick Mun, BS; Ashish Vankara, BS; Krishna Vangipuram Suresh, BS; Adam Margalit, MD; Khaled M. Kebaish, MD; Paul D. Sponseller, MD, MBA

Summary
As the SAI technique is still relatively new, there is limited literature on the long-term outcomes of SAI fixation in children. The purpose of this study was to investigate the outcomes of children with spine deformity, who were treated with SAI screws, and had a minimum 10-years of follow-up. SAI screws are a safe and effective method for pelvic fixation in children with spine deformity. The outcomes at ≥10-years are satisfactory, with minimal pelvic obliquity and curve progression.

Hypothesis
SAI fixation will maintain correction of pelvic obliquity at 10-years follow-up.

Design
Retrospective Review

Introduction
SAI screws are used to achieve pelvic fixation in spine deformity patients. The purpose of this study was to investigate the outcomes of children with spine deformity, who were treated with SAI screws, and had a minimum 10-years of follow-up.

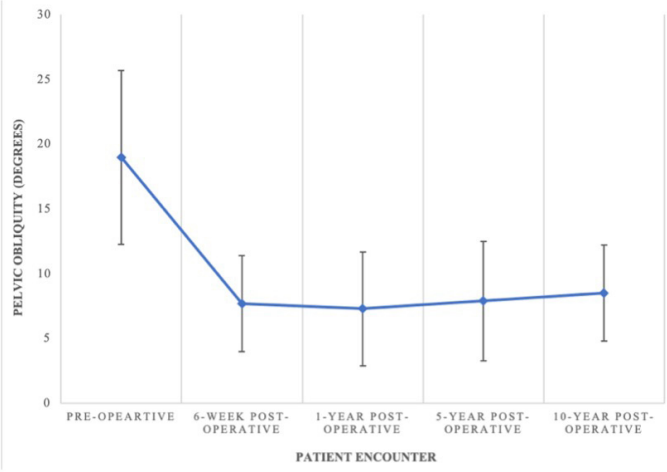
Methods
We reviewed the demographic, clinical and radiographic records of 40 patients aged ≤18 years treated using SAI screws, who had at least a 10-year follow-up visit. Pelvic obliquity and the major coronal curve were recorded at the pre-operative visit, and 6-weeks, 1-year,

5-year, and 10-year post-operative visits. Data included SAI screw dimensions, rate of screw revision, pain at the screw, presence of lucency >1cm around the screw, screw loosening or breaking, and deep wound infections.

Results
The average age at surgery was 14.1, and the most common diagnosis was cerebral palsy (65%). Pre-operatively, the mean pelvic obliquity was 20.3±8.3 degrees and the major coronal curve was 84.8±21.8 degrees. At the 10-year follow-up, pelvic obliquity was 8.4±4.0 degrees, and the major coronal curve was 18.5±12.3 degrees. There was no significant difference in pelvic obliquity or coronal curve when comparing the 10-year follow-up visit with the 6-weeks, 1-year, and 5-year post-operative visits. Average screw dimensions were 7.6 x 68.8 mm. Two patients (5%) required SAI screw revision, all of which were replaced with an equally sized or longer screw. By the 10-year follow-up, 4 patients (10%) had at least one complication. Of these patients, 3 (7.5%) had pain at either SAI screw, 4 (10%) had lucency around the screw, 3 (7.5%) had broken or loose screws, and 2 (5%) had deep wound infections at the screw site. There were no intra-pelvic protrusions, vascular or neurologic complications from the screws.

Conclusion
SAI screws are a safe and effective method for pelvic fixation in children with spine deformity. Outcomes at ≥10-years are satisfactory, with minimal pelvic obliquity and curve progression.

Take Home Message
SAI screws are a safe and effective method for pelvic fixation in children with spine deformity. The outcomes at ≥10-years are satisfactory, with minimal pelvic obliquity and curve progression.



Mean pelvic obliquity of our patient cohort at their pre-operative, and 6-week, 1, 5, and 10-year post-operative visits

42. Accuracy of CT-Guided Navigated Screw Placement for Vertebral Body Tethering

David F. Soriano, BS; *A. Noelle Larson, MD*; Todd A. Milbrandt, MD, MS

Summary
On incidental postoperative CT, 71/99 navigated vertebral body tethering screws had ideal length and position. 7/99 screws were too long after upsizing based on intraoperative radiographs. Among screws divergent from the middle 1/3 of their vertebral body, 2 were anterior and 13 posterior. 3 patients (5 vertebrae) had rib head erosions adjacent to the screw heads.

Hypothesis
Use of CT-guided navigation for placement of anterior spinal instrumentation results in optimal screw length and positioning.

Design
Retrospective review.

Introduction
Anterior thoracoscopic spinal instrumentation for treating AIS is gaining popularity. Although most surgeons use fluoroscopy-guided screw placement for VBT, the optimal approach is unknown. In contrast to spinal fusion, the VBT construct is mobile, allowing any portion of the screw not contained in bone to disrupt adjacent structures. For instance, CSF leak has been reported post-VBT from a minor spinal canal breach. We thus sought to evaluate the quality of screw position, length, and implant complications following CT-navigated VBT surgery.

Methods
110 pediatric scoliosis patients underwent CT-navigated placement of anterior vertebral body screws for VBT, with bicortical fixation preferred. 15 patients underwent incidental postoperative CT, enabling review of a total of 99 screws. Following 3D image alignment along the vertebral endplate, 99 screws were assessed in the axial plane for appropriate length (within 2mm of the far cortex), vertebral body location (middle 1/3), and screw-head to rib-head impingement.

Results
From the 15 patients with postoperative CT, 84/99 screws had ideal length, and 84/99 screws were in the middle 1/3 of the vertebral body, with 2 anterior and 13 posterior to this optimal area. On review, one patient for whom 4 screws were intraoperatively upsized, based on radiographic appearance, had these 4 screw-tips in close proximity to the aorta. 5 screw-heads from 3 patients were noted to impinge on a rib-head, one of whom had continuous pleuritic pain leading to implant removal 4 years post initial operation, providing significant pain relief (Fig 1). There were no vascular injuries or CSF leaks.

Conclusion
VBT differs from fusion by preserving vertebral mobility, but as a result, prominent implants can impinge on adjacent structures. We

found that CT-guided navigation can assist screw placement and length selection. Care should be taken to avoid rib-head to screw-head impingement.

Take Home Message
Critical for this motion-preserving surgery, intraoperative navigation provides significant assistance in screw placement and length selection.

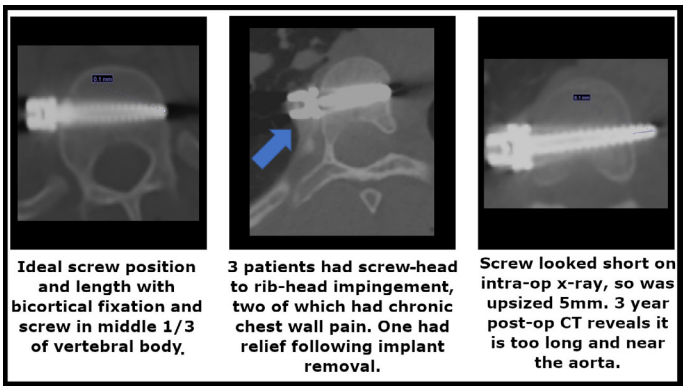


Fig1.

43. A Novel Hinge-Link Correction System for Vertebral Column Resection

Hong Zhang, MD; Daniel J. Sucato, MD, MS; David Ross, MFA

Summary
A novel hinge-link was developed and is attached to the concave screws to provide 3-dimensional stability with simultaneous correction of the deformity in VCR procedure. Scoliosis was created in a pig model. Two-week later, the VCR was performed to correct the deformity using the hinge-link. The mean correction of the deformity was 94% correcting to 2.0°. The hinge-link can provide significant correction of the deformity with appropriate mild shortening at the resected levels and overall lengthening without neurologic deficits.

Hypothesis
A vertebral column resection (VCR) offers the greatest potential correction for the most severe scoliosis, but is technically demanding with increased operative time, blood loss, and especially high neurologic risks.

Design
A novel hinge-link correction system was developed and is attached to the concave screws to provide 3-dimensional stability with simultaneous correction of the deformity with rigid control of the spine to prevent spinal cord injury. The VCR hinge allows the surgeon to easily, safely and simultaneously translate the segments in the coronal and sagittal planes while providing opportunities for compression and/or distraction while being fixed rigidly to the spine.

Introduction
The purpose of this study was to surgically assess the hinge-link in a porcine model.

Methods
Scoliosis was surgically created in four 4-month-old pigs from T10 to L4. Two weeks later, the VCR procedure was performed using the hinge-link. Two temporary rods were connected using the hinge-link on the concave side. Deformity correction in the coronal and sagittal planes was performed by adjusting the hinge (Figure 1A), while the resected gap was gradually compressed and shortened. Deformity correction and spine length parameters were measured pre (Figure 1B) and postoperatively (Figure 1C).

Results
The right thoracic scoliosis deformity averaged 33° prior to the VCR. All animals tolerated the VCR procedure awakening neurologically intact and ambulated for 24 hours. The mean operative time was 3.7 hours with a mean blood loss of 619 ml. The hinge-link provided rigid control of the resection gap during the correction maneuvers. The mean correction of the deformity was 94% correcting to 2.0°. At the resection gap the average shortening was 5.7 mm despite lengthening of the instrumented segments by 7.1 mm.

Conclusion
The hinge-link can provide significant correction of the deformity with appropriate mild shortening at the resected levels and overall lengthening without neurologic deficits. The rigid control of the spine segments provided by this device should allow for improved correction with decreased neurologic deficits and potentially shorter surgical time.

Take Home Message
A hinge-link can provide excellent control of the spine segments and allow for improved correction of the deformity with decreased neurologic deficits and potentially shorter surgical time in VCR procedure.

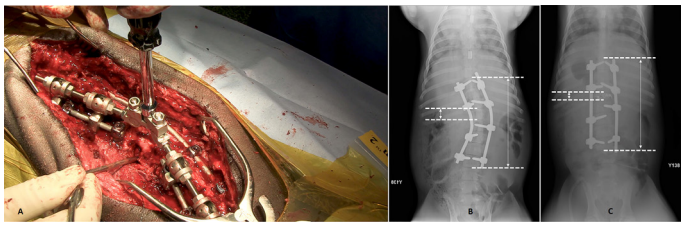


Figure-1

44. Propensity Matched Cohort Study Comparing Accuracy of Robotic Assisted Spinal Surgery vs. Navigation Alone: Early Experience of 260 Pedicle Screws

Saman Shabani, MD; Jeremy Huang, BS; Nitin Agarwal, MD; Alma Rechav Ben-Natan, BA; Vivian Le, MPH; Alexander Aabedi, BS; Lee A. Tan, MD; Dean Chou, MD; Praveen V. Mummaneni, MD

Summary
The goal of robotic usage in spine surgery is to increase the precision and accuracy of pedicle screw placement and decrease postoperative complications. However, in this study cohort of propensity-matched robotic-assisted surgeries and navigated surgeries, the rate of screw misposition was higher in the robotic group. Based on this early experience, several factors were identified that contributed to inaccurate screw placement. Awareness of these limitations may help early adopters with their learning curve in robotics.

Hypothesis
Screw accuracy is similar in early robotic vs. navigated assisted pedicle screw placement

Design
retrospective

Introduction
Recent technological advances have augmented the use of both robotic and navigated assisted spinal surgery. However, the superior strategy to facilitate screw accuracy remains unknown.

Methods
A retrospective, propensity score matched cohort study was utilized to compare pedicle screw placement in patients who underwent thoracolumbar fusion with robotic arm assistance vs. navigation alone. Spine surgery cases at a quaternary care institution from 2019-2021 were queried. The Gertzbein and Robbins System was utilized to grade screw placement accuracy. Indications included deformity, degenerative thoracolumbar spondylosis, and spinal tumor. Unpaired two sample T-test was used to compare age, sex, body mass index (BMI), and type of surgical approach (i.e. minimally invasive vs. open) between the two groups. T-test and Chi-square test were utilized to determine which covariates are confounding.

Results
In the robotic group, a total of 129 screws were placed (121 had perioperative computed tomography (CT) for screw placement verification). In the navigated group, a total of 131 screws were placed (all had perioperative CT for screw placement verification). The pedicle screw placement inaccuracy was statistically significantly greater in the robotic group at 10.7% (13/121) compared to 3.1% (4/131) in the navigated group ($p = 0.04, < 0.05$). Out of the 13 misplaced screws in the robotic group, only one required revision. There were no significant differences in demographic findings between the groups, including age, sex, and BMI ($p > 0.05$). The main factor contributing to screw misposition was medial or lateral displacement of the robotic trocar by a hypertrophied lumbar facet and sloped transverse process.

Conclusion
Early experiences with robotics in spine surgery may be correlated with higher rates of screw misposition. Future developments for robotics must include solutions to prevent drill or trocar skiving to minimize medial or lateral screw deflection.

Take Home Message
Early robotic pedicle screw placement is associated with higher mispositioned screw. Awareness of these limitations may help early adopters with their learning curve in robotics.

45. Augmented Reality-Assisted Spine Surgery: An Early Experience Demonstrating Safety and Accuracy with 218 Screws

Fenil R. Bhatt, BS; Lindsay Orosz, MS, PA-C; Anant Tewari, BS; Rita Roy, MD; Christopher R. Good, MD; Thomas C. Schuler, MD; Colin Haines, MD; *Ehsan Jazini, MD*

Summary
Accurate screw guidance techniques are critical to achieving satisfactory fixation in spine surgery, and there is growing interest in augmented reality as a navigation tool to improve safety and accuracy. This study of 32 patients and 218 screws shows that augmented reality has the potential to be as safe and accurate as more traditional methods for the placement of pedicle, cortical, and pelvic screws.

Hypothesis
Augmented reality-assisted spine surgery is an effective, safe, and accurate method of navigation for posterior thoracolumbar fusion.

Design
Prospective cohort study

Introduction
In spine surgery, screw guidance techniques continue to evolve to improve safety and accuracy while providing minimally invasive options and improved outcomes. Augmented reality (AR) is a novel technology to assist in screw placement and has shown promising results in early cadaveric and feasibility studies. This study aims to contribute an initial experience to the limited in vivo studies available by demonstrating safety and accuracy in the largest cohort of patients to date using a head-mounted device (HMD) AR system.

Methods
Consecutive adult patients undergoing AR-assisted thoracolumbar fusion surgery between 2020-2021 with a minimum of 2 week follow-up were included in this multi-surgeon, single center prospective cohort study. Preoperative, intraoperative, and postoperative data were collected to include demographics, complications, revision surgeries, and AR performance. Intraoperative 3D imaging was used to assess screw accuracy using the Gertzbein and Robbins (G-R) grading scale.

Results
32 patients (40.6% male) were included giving a total of 222 screws executed with the FDA approved HMD-AR system. Intraoperatively, 4 (1.8%) screws were deemed misplaced and replaced freehand. The remaining 218 (98.2%) screws were placed accurately, there were no intraoperative adverse events or complications, and AR was not abandoned. Of the 208 AR-placed screws with 3D imaging intraoperatively, 97.1% were considered clinically accurate (91.8% Grade A, 5.3% Grade B). There were no postoperative surgical complications or revision surgeries during the 2 week follow-up.

Conclusion
This early experience study demonstrated that HMD-AR assisted spine surgery is a safe and accurate method of placing pedicle, cortical, and pelvic fixation. An accuracy rate of 97.1% among all 3 surgeons novice to AR technology suggests ease of integration into the surgical workflow and minimal learning curve. Larger studies are needed to continue support this compelling evolution in spine surgery.

Take Home Message
This study showed a 97.1% screw accuracy rate with no complications or revisions using a head mounted AR device which supports the use of this novel technology in spine surgery.

46. Return to Work, Activities of Daily Living and Disability Improvement: 12-month Outcomes of an FDA IDE Trial of Decompression and Tension Band Stabilization for Degenerative Spondylolisthesis

William F. Lavelle, MD; Rick C. Sasso, MD; S. Tim Yoon, MD; Alan Villavicencio, MD; Ravi S. Bains, MD; Kee D. Kim, MD; Calvin C. Kuo, MD; Michael P. Stauff, MD; Harvinder S. Sandhu, MD; Miguelangelo Perez-Cruet, MD; Jeffrey Fischgrund, MD; Matthew J. Mermer, MD; Harel Deutsch, MD; Khalid Sethi, MD; Hamid Hassanzadeh, MD; Elizabeth Yu, MD; Umesh S. Metkar, MD; Richard D. Guyer, MD; Dennis G. Crandall, MD; Jeffrey L. Gum, MD; Michael Y. Wang, MD; Louis C. Fielding, MD

Summary
Significant advantage of earlier recovery in decompression and stabilization with the tension band (D+PTB) to decompression and transforaminal lumbar interbody fusion (D+TLIF) patients (earlier return to work and increased ADL) compared to decompression and transforaminal lumbar interbody fusion (D+TLIF) patients with similar improvements in disability after 1 year.

Hypothesis
Compare decompression and stabilization with the tension band (D+PTB) to decompression and transforaminal lumbar interbody fusion (D+TLIF) for symptomatic DS.

Design
Prospective ongoing FDA IDE study (NCT03115983)

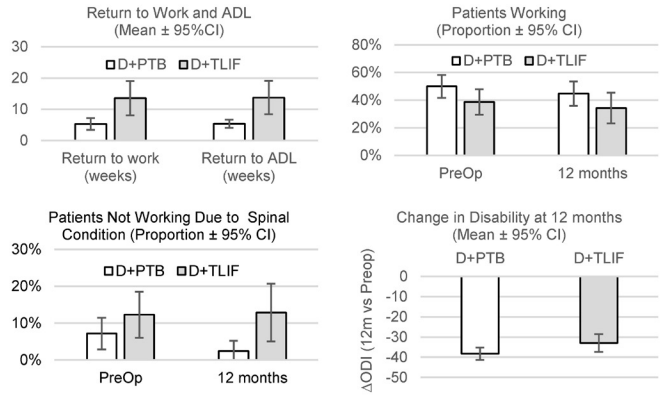
Introduction
Symptomatic degenerative spondylolisthesis (DS) may be treated with decompression alone; however, addition of instrumented fusion is usually considered essential to achieve durable results. As an alternative to fusion, a novel paraspinous tension band is proposed for segmental stabilization after decompression for DS. Return to activities of daily living, work (as applicable) and reduction in disability are important outcomes of both standard of care and novel, investigational procedures.

Methods
246 subjects (140 D+PTB, 106 D+TLIF) were ≥12m postoperative. Queried, compared and analyzed records for preoperative and 12-month postoperative outcomes for work status, return to work (RTW), activities of daily living (ADL) and Owestry Disability Index (ODI) scores.

Results
Preoperatively, work status=50% of D+PTB and 39% of D+TLIF subjects (p=0.04) and no work due to spinal condition (NWSC)=7% D+PTB and 12% D+TLIF (p=0.09). At 12-month postoperative, work status=45% of D+PTB and 34% of D+TLIF subjects (p=0.09) and NWSC=2% D+PTB and 13% D+TLIF (p<0.01). The proportion of D+PTB NWSC was significantly lower 12 months postoperative compared to preoperative (p=0.04). Mean±SD RTW time for D+PTB/D+TLIF subjects=5.3±6.6 vs.13.6±11.7 weeks (p<0.01) and return to ADL=5.4±6.4 vs.13.8±18.8 weeks (p<0.01). Mean±SD reduction in disability at 12 months from baseline=38.3±18.2 (D+PTB) vs. 33.0±21.8 (D+TLIF), (p=0.06) with effect sizes of -2.1 and -1.5, respectively.

Conclusion
Significant advantage of earlier recovery in D+PTB patients (earlier return to work and increased ADL) compared to D+TLIF with similar improvements in disability after 1 year. Longer-term follow-up assessment of propensity score-selected subjects will demonstrate whether this advantage and long-term outcomes are durable.

Take Home Message
Significant advantage of earlier recovery in D+PTB patients (earlier return to work and increased ADL) compared to D+TLIF with similar improvements in disability after 1 year.



Diagnostic Parameters

47. Adding Satellite Rods to Standard Two-Rod Construct in Posterior Correction of Scheuermann Kyphosis: Can it Promote Vertebral Remodeling?

Sinian Wang, MD; Yong Qiu, MD; Zezhang Zhu, MD; Bin Wang, MD; *Xu Sun, MD*

Summary

To evaluate the contribution of adding satellite rods to correction maintenance in Scheuermann's kyphosis (SK) patients, we collected the radiographic data and patient-reported outcomes preoperatively, immediately postoperatively, and at the latest follow-up, and compared between the 2-RC group and the S-RC group. Reversal in wedge deformation of vertebrae was observed in SK patients. Patients treated with S-RC had greater vertebral remodeling and less correction loss.

Hypothesis

Patients treated with S-RC had greater vertebral remodeling and less correction loss.

Design

A retrospective cohort study of patients with SK was performed. In total, 45 SK patients aged 10–20 years at surgery were included. All patients received at the least 24 months of follow-up and had Risser sign greater than grade 4 at latest follow-up.

Introduction

This study aimed to investigate reversal of vertebral wedging and to evaluate the contribution of adding satellite rods to correction maintenance in patients with adolescent Scheuermann's kyphosis (SK) after posterior-only instrumented correction.

Methods

Patients receiving placement with a standard 2-RC construct composed the 2-RC group, and those with enhanced instrumentation with satellite rods adding to 2-RC via duet screws were assigned to the S-RC group. Radiographic data and patient-reported outcomes were collected preoperatively, immediately postoperatively, and at the latest follow-up, and compared between the two groups.

Results

The correction loss was slightly but significantly less in the S-RC group during follow-up (1.0°±0.7° vs. 2.3°±1.2°, $p < 0.001$). The ratio between anterior vertebral body height (AVBH) and posterior vertebral body height (PVBH) of deformed vertebrae notably increased in SK patients from postoperation to the latest follow-up ($p < 0.05$). Loss of correction of global kyphosis was significantly and negatively correlated with increased AVBH/PVBH ratio. Compared with the 2-RC group, the S-RC group had significantly greater increase in AVBH/PVBH ratio during follow-up ($p < 0.05$). The two groups had similar preoperative and postoperative Scoliosis Research Society–22 questionnaire scores for all domains.

Conclusion

Reversal in wedge deformation of vertebrae was observed in SK patients. Patients treated with S-RC had greater vertebral remodeling and less correction loss. The biomechanical benefits of stress dispersion, coupled with increased stability and weight bearing ability, make it a powerful technique promoting structural remodeling and protecting against correction loss.

Take Home Message

Reversal in wedge deformation of vertebrae was observed in SK patients. Patients treated with S-RC had greater vertebral remodeling and less correction loss.

48. Insertional Torque and Pull-out Strength of Pedicle Screws vs. Titanium Suture Anchors: Towards Development of a Novel Proximal Junctional Kyphosis Prevention Technique

Christopher McDonald, MD; Andrew S. Zhang, MD; Daniel J. Alsoof, MBBS; Rachel Schilkowsky, MEng; Camilo Osorio, MD; Rodrigo Berreta, BS; Matthew Kovoor, BS; Eren Kuris, MD; Kyle Hardacker, MD; Kevin Disilvestro, MD; Alan H. Daniels, MD

Summary

Proximal junctional kyphosis (PJK) is a devastating complication after spinal deformity surgery with a high need for revision surgery. A novel method for PJK prevention includes placing suture anchors, rather than pedicle screws, above the spinal construct to function as a tether. This biomechanical investigation examined the insertional torque and pullout strength of pedicle screws compared to suture anchors on 6 cadaveric vertebrae (12 pedicles). Suture anchors had less insertional torque and pullout strength compared to pedicle screws.

Hypothesis

We hypothesize that titanium suture anchors will have a lower insertional torque and pullout strength compared to pedicle screws and can thus act as a force tapering device which could

be theoretically used in the prophylaxis against proximal junctional kyphosis.

Design
This is a biomechanical study utilizing one dissected cadaveric spine from T8-L3.

Introduction
Proximal junctional kyphosis (PJK) is a common and devastating complication after spinal deformity surgery with a high need for revision surgery. PJK often leads to poor patient outcomes and large societal costs, which has led to the development of multiple prophylactic methods which have yet to eliminate PJK.

Methods
A novel method for PJK prevention includes placing suture anchors, rather than pedicle screws, above the spinal construct to function as a tether. This biomechanical investigation examined the insertional torque and pullout strength of pedicle screws compared to suture anchors on 6 cadaveric vertebrae (12 pedicles).

Results
The mean insertional torque was 0.802 ± 0.477 N*m for pedicle screws and 0.368 ± 0.310 N*m for suture anchors (p=0.047). The mean pullout strength was 973.16 ± 202.03 N for pedicle screws and 206.94 ± 181.78 N for suture anchors (p<0.01).

Conclusion
This study demonstrated that suture anchors had both less insertional torque and pullout strength compared to pedicle screws and may provide a more physiologic stress taper at the upper instrumented vertebrae of long-segment spinal constructs to help prevent proximal junctional kyphosis or catastrophic proximal junctional failure. Further research is needed to examine the biomechanics of this in long-segment constructs as well as in vivo performance of suture anchors as proximal junctional kyphosis prophylaxis.

Take Home Message
Suture anchors have less insertional torque and pullout strength compared to pedicle screws and may provide a more physiologic stress taper at the upper instrumented vertebrae of long-segment spinal constructs.

49. Does Karnofsky Performance Score Improve After Surgery for Metastatic Spine Tumors in Patients with SINS 7-12?

Saman Shabani, MD; Enrique Vargas, BS; Alexander Aabedi, BS; Alma Rechav Ben-Natan, BA; Nitin Agarwal, MD; Praveen V. Mummaneni, MD; Dean Chou, MD

Summary
To study whether patients with SINS 7-12 with Bilsky grade 2 and 3 cord compression will benefit from surgery and have improvement in their KPS score post-operatively.

Hypothesis
Patients with SINS 7-12 with Bilsky grade 2 and 3 compression will have improvement in their KPS post operatively.

Design
retrospective

Introduction
In patients who are potentially unstable, with Spinal Instability Neoplastic Scores (SINS) 7-12, it is unclear if surgery improves their Karnofsky performance score (KPS).

Methods
SINS 7-12 metastatic spinal tumor patients were retrospectively reviewed with pre- and post-operative KPS. Follow-up ranged from 1 month to 13 years. Baseline clinical characteristics including age, sex, SINS score, Bilsky grade, neurologic function, and preoperative KPS were collected. Postoperative KPS scores were collected at first follow-up visit which averaged about 3 months post-operatively. Paired, nonparametric Wilcoxon signed-rank test to determine significance of improvement in KPS after surgery. Ordinal logistic regression was used to identify factors associated with the change in KPS.

Results
Sixty six patients were evaluated. The median SINS score was 11 with a mean follow-up of 3.7 years. Postoperatively, significant improvement in KPS occurred from a median of 50 to 70 (p = 0.0003). Ordinal logistic regression showed that patients with pre-operative KPS of 70 and 80 had more improvement compared to patients with KPS at very low (20) or very high (90) ranges. This improvement in KPS was observed independent of the Bilsky grade, (grade 2, p = 0.045; grade 3, p = 0.001). However, improvement in KPS was associated with ASIA motor improvement on univariate ordinal logistic regression (OR = 1.05, CI = 1.02 – 1.10, p = 0.004), and this effect was maintained after controlling for Bilsky cord compression grade on multivariate models (p = 0.005).

Conclusion
Potentially unstable metastatic tumor patients with SINS score 7-12 appear to have improved KPS scores with surgery.

Take Home Message
KPS improves post operatively in patients with Bilsky grade 2 and 3 cord compression in patients with potentially unstable spine (SINS 7-12).

50. Establishment of an Individualized Distal Junctional Kyphosis Risk Index Taking into Account Radiographic, Surgical and Patient Related Components

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Summary

Distal junctional kyphosis (DJK) is a radiographic finding identified after patients(pts) undergo instrumented spinal fusions which can lead to decreased mobility in the affected spinal segments. There is a lack of consensus of the true etiology of DJK, since it is multifactorial in nature.

Hypothesis

Identification of distal construct factors and patient-specific radiographic and surgical factors will create a useable DJK score.

Design

Retrospective cohort study

Introduction

This study aims to create a scoring system that will allow for immediate post-operative risk-assessment that includes baseline (BL) factors of the distal construct and preoperative radiographic changes.

Methods

CD pts with BL and 3M radiographic parameters included. A patient-specific DJK score was created through use of unstandardized Beta weights of a multivariate regression model predicting DJK. DJK was defined by a <-10° change from BL to post-op from the end of fusion construct to the 2nd distal vertebra. The equation consisted of Distal construct factors[A)Δ BL-3M inclination angle, B)BL inflection point, C)ΔLIV angle, D)combined approach] and Radiographic factors[E)ΔTS-CL, F)Δ PT, G)Δ C2-C7, H)ΔT4-T12]. Accuracy of the models were assessed along with mean probabilities within the cohort of developing DJK post-op.

Results

55 CD pts included (61yrs, 65.5%F, 28.3kg/m2). 36.4% of these pts developed DJK (45% 3M, 35% 6 months. At BL DJK pts were more frail, and had more combined (70% vs. 31%) and anterior approaches (50% vs. 28.6%; all p<0.05). Primary analyses demonstrated a correlation between DJK, combined approach, and Δ C2-C7(all p<0.05). Multivariate regression analysis identified individualized scores via creation of a DJK equation: -2.4+0.13(A)-0.63(B)+0.2(C)+2.75(D)- 0.17(E)+0.11(F)-0.02(G)-0.02(H)-0.69(I). The equation has an 82.1% accuracy of predicting DJK with a mean probability of developing DJK to be 83%. Individualized scores were calculated and had a minimum score of -12.53 and a maximum of 17.1. Having a score>5 predicted DJK 63.8% of the time. The new DJK score strongly predicted high EBL>600mL (R2=0.5, p=0.03) and extended operative time>338min (R2=0.36, p=0.02).

Conclusion

This study identified an equation with 85.7% accuracy for predicting Distal Junctional Kyphosis with use of distal construct, radiographic, and other patient-specific factors. A score>5 at early 3 months post-op was associated with development of DJK.

Take Home Message

This score is a novel risk assessment tool that identifies a combination of patient factors never identified collectively before in relation to predicting Distal Junctional Kyphosis.

Table 1: Multivariate Modeling including Distal Construct, Radiographic, and Surgical Variables

Dependent Variable	Independent Variables	Beta [95% Confidence Interval]	Unstandardized Beta	Standardized Beta	P-value	Model R-Squared	Model p-value
Total Model							
DJK	(Constant)	-	-2.4	1.2	0.09	0.546	<0.05
	A.) Inclination Difference (BL to 3M)	[1.0-1.3]	0.13	1.14	**0.03**		
	B.) Pre Inflection Point above C6	[0.04-5.6]	-0.63	0.52	0.59		
	C.) LIV angle difference (BL to 3M)	[0.87-1.7]	0.20	1.22	0.24		
	D.) Combined Approach	[1.1-217.4]	2.75	15.6	**0.04**		
	E.) TS-CL Difference (BL to 3M)	[0.67-1.0]	-0.17	0.84	0.12		
	F.) PT Difference (BL to 3M)	[0.89-1.3]	0.11	1.11	0.32		
	G.) C2-C7 Difference (BL to 3M)	[0.86-1.1]	-0.02	0.97	0.7		
	H.) T4-T12 Difference (BL to 3M)	[0.86-1.0]	-0.02	0.97	0.66		
	I.) osteoporosis	[0.008-30.5]	-0.69	0.49	0.74		
DJK Equation=	-2.4+0.13(**A**)-0.63(**B**)+0.2(**C**)+ 2.75(**D**)- 0.17(**E**) +0.11(**F**)- 0.02(**G**) - 0.02(**H**) - 0.69(**I**)						

51. Does Postop VTE Chemoprophylaxis Increase The Risk of Epidural Hematoma and Wound Complications?

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Summary

The efficacy and potential risks of VTE chemoprophylaxis in patients with lumbar laminectomies with or without fusion are limited in the current literature. This study found that chemoprophylaxis following lumbar laminectomies with or without fusion has the potential risk of increased intra- and post-operative complication rates. It is also associated with moist wounds and dressings. Nevertheless,

chemoprophylaxis was not associated with increased rates of epidural hematomas, wound infections, wound drainage, or return to OR at 30 or 90 days.

Hypothesis

Chemoprophylaxis after lumbar laminectomy does not increase risk of epidural hematomas and return to OR.

Design

Retrospective analysis of lumbar laminectomies with or without fusion from 2018-2020 at a single academic medical center.

Introduction

Benefits of chemoprophylactic (CP) agents in preventing venous thromboembolism (VTE) must be weighed against potential risks. This study evaluated the association between CPs and wound complications and hematomas after lumbar laminectomy with and without fusion.

Methods

Retrospective chart review lumbar laminectomies with and without fusion from 2018-2020 was performed for demographics, surgical characteristics, CP agents, postop complications, epidural hematomas, and wound drainage. Patients on CP were compared to patients not on CP via T-test and chi-square. Propensity score matching controlled for age, ASA, and levels fused.

Results

598 patients were included (n=299 no CP, n=299 CP). No differences in demographics nor surgical characteristics were found except for EBL, operative time and intraoperative complications. In the CP group, 59.5% were on Enoxaparin, and 34.8% were on Aspirin; 83.6% started CP on POD1 and 3.7% on POD2. Rates of epidural hematomas, infections and postop I&Ds were not associated with CP. Moist wounds or dressings were more frequent with CP (37.5%vs24%, p<0.001), but there were no differences in wound dehiscence and daily drain output between the groups. Overall postop complication rate was greater for CP mainly due to differences in cardiac complications (7%vs2.3%, p=0.007). No significant differences were found for re-op rates at 30 and 90 days between the groups. Rate of transfusions was not associated with CP. VTE rate was not significantly different between CP and no CP.

Conclusion

VTE CP following lumbar laminectomies with or without fusion is not associated with increased rates of epidural hematomas, wound infections, wound drainage, or return to OR at 30 or 90 days. There were higher rates of post-op cardiac complications and moist wounds or dressing in the CP group.

Take Home Message

In patients with lumbar laminectomies, chemoprophylaxis is not associated with epidural hematomas, wound infections, wound drainage or return to OR at 30 or 90 days.

Table 1: Effect of chemoprophylaxis on demographics, surgical characteristics and postoperative outcomes

		INPATIENT CHEMOPROPHYLAXIS*		
		No	Yes	p value
		n=299	n=299	
Demographics	BMI	29.42± 7.51	30.01± 6.71	0.315
	CCI	4.11± 2.53	4.27± 2.67	0.469
	Age	65.33± 12.3	65.74± 12.15	0.686
	ASA Grade	2.53± 0.57	2.54± 0.59	0.778
	Gender (%F)	45.2%	43.8%	0.742
	Race	64.2% W, 10.7% AA, 8.7% A, 16.4% other	64.5% W, 10.7% AA, 10.0% A, 14.72% other	0.906
	Payor Type (%private)	66.7%	62.2%	0.256
Surgical Characteristics	Fusion	66.9%	67.6%	0.862
	Levels Fused	1.02 ± 0.9	1.09 ± 1.00	0.367
	Laminectomy Upper Vertebra	22.27 ± 0.99	22.28 ± 1.04	0.936
	Laminectomy Lower Vertebra	24.01 ± 1.59	24.14 ± 1.58	0.327
	MIS vs Open Lami (%open)	7.0%	7.0%	1.000
	EBL (mL)	230.02 ± 237.83	294.15 ± 347.43	0.009
	Op Time (min)	197.11 ± 92.23	231.5 ± 105.43	0.000
	Intraop Complications	2.7%	7.7%	0.006
	Intraop Transfusion	2.3%	4.0%	0.244
Post-Operative Variables	LOS (days)	3.24± 5.94	4.04± 2.69	0.034
	Return to OR in 30 Days	1.3%	2.3%	0.361
	Return to OR in 90 Days	2.0%	2.7%	0.589
	Postop Complications **	14.0%	23.4%	0.003
	cardiac	2.3%	7.0%	0.007
	neuro	3.7%	5.0%	0.422
	pulm	1.0%	1.0%	1.000
	airway edema	0.0%	0.0%	
	ileus	2.0%	5.0%	0.046
	urinary	3.3%	5.4%	0.229
	death	0.0%	0.0%	
	mechanical	0.0%	0.0%	
	Postop transfuion	1.7%	4.0%	0.085
	VTE (%)	1.3%	3.0%	0.161
	VTE First Diagnosed Date (POD)	13.75± 15.54	13.78 ± 19.06	0.998
	All Hematomas/ Seromas	2.0%	1.3%	0.524
	Superficial Seromas/ Hematomas	0.7%	0.3%	0.563
	Deep Seromas/ Hematomas	1.0%	1.0%	1.000
	Canal/ Epidural Hematomas	0.7%	0.0%	0.157
	All Hematomas/ Seromas Drx Date (POD)	26.50 ± 29.54	36.00 ± 38.91	0.671
	I&D procedure	1.0%	0.7%	0.653
	Date of I&D (POD)	27.00 ± 38.16	19.00 ±13.12	0.749
	Wound Dehiscence	0.0%	0.3%	0.317
	Moist wound or Dressing	24.1%	37.5%	0.000
	Wound dehiscence Earliest Date Observed (avg POD)	1.00		
	Avg Drain Duration (days)	9.70±12.29	6.74±7.87	0.003
	Avg Daily Drainage (mL)	147.76±102.36	160.49±109.16	0.206

*defined as patients on chemoprophylaxis on POD 0 or onwards in the inpatient setting
**cardiac, neuro, pulm, airway, ileus, urinary, death, mechanical , vte, hematomas/seromas, deep infection, superficial infection

Table 1: Effect of chemoprophylaxis ondemographics, surgical characteristics, and post-operative outcomes.

52. Proximal and Distal Reciprocal Alignment Changes Following Cervical Deformity Correction

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Summary
C0-C2 hyperextension is a painful compensatory mechanism to maintain horizontal gaze. The magnitude and impact of relaxation of this hyperextension following cervical deformity (CD) correction are not well understood. In this cohort both proximal and distal reciprocal alignment changes occurred following CD correction, including relaxation of C0-C2 hyperlordosis and an increase in thoracic kyphosis (TK). Controlling for horizontal gaze and TK change, there was a significant increase in the reserve extension between C0-C2 with associated improvement in pain and disability.

Hypothesis
Correction of cervical sagittal malalignment allows for relaxation of C0–C2 hyperextension and improved clinical outcome.

Design
Retrospective review.

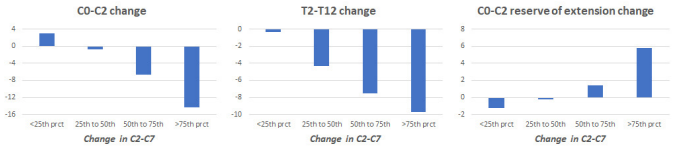
Introduction
Hyperextension of C0-C2 is a painful compensatory mechanism used to maintain horizontal gaze that is analogous to high pelvic tilt to maintain upright posture. The magnitude and impact of relaxation of this hyperextension following CD correction are not well understood.

Methods
CD patients undergoing surgery excluding the occiput and pelvis were included. Range of motion (ROM) and reserve of extension (REX) were calculated across C2-C7 and C0-C2. The association between C2-C7 correction and change in C0-C2 REX was investigated while controlling for horizontal gaze, followed by stratification into ΔC2-C7 percentiles.

Results
65 pts were included (61.8yo±9.6, 68%F). At baseline, pts had cervical kyphosis (C2-C7: -11.7°±18.2; TS-CL: 38.6°±18.6), negative global alignment (SVA: -12mm±71), and hyperlordosis at C0-C2 (33.2°±11.8). The ROM was 25.7°±17.7 and 21.3°±9.9 at C2-C7 and C0-C2, respectively, with a REX of ~9° for each segment. Limited C0-C2 ROM and REX correlated with NDI (r=-0.371 & -0.394) and decreased general health (r=0.455 & 0.512) (all p<0.005). The mean number of levels treated was 7.0±3.1 (24.6% ACDF, 43.1% posterior), with 49.2% receiving an osteotomy. At 1 yr, C2-C7 increased to 5.5°±13.4, SVA became neutral (12mm±54), C0-C2 decreased to 27.7°±11.7, and TK increased to -49.4°±18.1 (all p<0.001). C2-C7 ROM decreased significantly to 9.5°±14.1 and increased to 27.6°±8.1 at C0-C2 without change in REX. Controlling for horizontal gaze, change in C2-C7 lordosis significantly correlated with increased TK (r=-0.615, p<0.01), decreased C0-C2 (r=-0.686, p<0.001), and increased C0-C2 REX (r=0.414, p<0.015). Larger C0-C2 ROM and REX correlated with decreased NDI (r=-0.571 & -0.470 p<0.05). Stratification by ΔC2-C7 is shown in the Figure. Analysis on patients with 2-yr data (N=42) showed similar trends.

Conclusion
CD correction can significantly impact proximal and distal compensation. Restoration of alignment resulted in increased C0-C2 reserve extension and was associated with improved clinical outcome.

Take Home Message
Increased C2-C7 correction was associated with increased TK and decreased C0-C2. While controlling for horizontal gaze, increases in C2-C7 correction were associated with increased C0-C2 extension reserve and improved outcomes.



53. When Does the Construct Need to Extend to the Thoracic Spine in Patients Undergoing Correction for Cervical Deformity?

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Summary
Thoracolumbar malalignment is often seen in patients presenting with cervical deformities. For operative cervical deformity (CD) patients, it is unknown when the thoracic spine should be included in the construct. This study found that treatment success in patients with fusion constructs extending into the thoracic spine may be predicted by the location of the deformity apex, measures of surgical invasiveness, and preoperative deformity severity.

Hypothesis
CD patients in whom fusion to the thoracic spine is warranted have a specific patient profile.

Design
Retrospective cohort

Introduction
Thoracolumbar malalignment is often seen in patients presenting with cervical deformities. For operative cervical deformity (CD) patients, it is unknown when the thoracic spine should be included in the construct.

Methods
Included: operative CD pts with BL and up to 2-year(2Y) data. Patients with UIV at or above C4 and LIV extending beyond C7 were isolated. Patients were stratified by LIV: T1-T4 [Short Fusion], beyond T4 [Long Fusion]. An optimal outcome at 2Y postop was defined as 1) no occurrence of DJF and 2) met Virk et al. good clinical outcome [≥2 of the following: NDI<20 or meeting MCID, mild myelopathy (mJOA ≥14), NRS-Neck≤5 or improved by ≥2 points from BL]. Multivariate regression analysis and ROC curve assessed predictors of long fusion and optimal outcome vs. short fusion and treatment failure, with conditional inference tree(CIT) for continuous predictors.

Results
72 CD patients included (61yrs, 60%F, 29.4kg/m2, levels fused: 7.8±3.2). 59 pts had fusions with LIV of T4 or above, while 13 had fusions extending below T4. 32 pts (44.4%) met optimal outcome, with no difference in fusion length(p=0.2). 8 long fusions had treatment success, while 35 short fusion pts had treatment failure. Regression identified predictors of success in pts with long fusion: sacral slope ≤33.5°(OR: 15.0), not undergoing high grade(PSO or VCR) osteotomy (OR: 15.0) and Ames descriptor type C(OR: 13.5); all p<0.05. ROC curve accounting for these factors yielded AUC of 82.0%. Predictors of treatment failure in pts with short fusion were: levels fused >6(OR: 4.3), Ames descriptor type CT(OR: 11.5), Ames cSVA modifier grade 1 or 2 at BL(OR: 4.56), and Flatneck Lafage morphotype(OR: 4.5); all p<0.05. ROC curve for these factors yielded AUC of 84.3%.

Conclusion
Treatment success in patients with fusion constructs extending into the thoracic spine vs. treatment failure in patients with short fusions may be reliably predicted by the location of the deformity apex, measures of surgical invasiveness, and preoperative deformity severity.

Take Home Message
Treatment success in longer fusions is related to location of the deformity apex in the cervical spine and having deformity where adequate correction does not necessitate high grade osteotomy.

54. Indications for Combined Anterior-Posterior Approach in Cervical Deformity Surgery: Patients Who Benefit From an Additional Anterior Approach

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Summary
A combined anterior-posterior approach for cervical deformity (CD) corrective surgery has been associated with a greater mechanical advantage, but carries increased complications. A combined anterior-posterior approach offers more advantages for patients with a greater degree of cervical deformity or neurological deficits at baseline reflected by greater improvement in radiographic alignment and a significant decrease in deficits following CD corrective surgery with a combined approach technique.

Hypothesis
To determine the patients who benefit of undergo combined AP approach in CD correction surgery.

Design
Retrospective cohort study of single-surgeon database

Introduction
A combined anterior-posterior approach for cervical deformity (CD) corrective surgery has been associated with a greater mechanical advantage, but carries increased complications. There is paucity in the literature investigating the patient profile which warrants the more invasive AP approach in CD patients.

Methods
Included: operative CD patients >18 years. Patients with anterior-only approach were excluded. These patients were then stratified by surgical approach (posterior-only or anterior-posterior). Means comparison tests analysis compared optimal outcome patients by approach and assessed patient outcomes such as, complications, neurological deficits, improving in HRQLs or radiographically.

Results
165 operative CD pts were included. Of the included patients, 102(61.8%) had a posterior only approach and 63(38.2%) had an anterior-posterior approach. At BL, AP patients were more likely to have worse deformity as reported by C2-C7 SVA (33.5 vs. 26.7; p=0.028) and TS-CL (33.5 vs. 26.7; p=0.028). At 1Y postop, AP patients were more likely to improve radiographically as per Ames horizontal gaze modifier (13.3% vs. 3.6%; p=0.038). Although no difference was found for improvement in the remainder of the Ames modifiers, collectively AP patients were more likely to improve in at least one of the criteria at 1Y postop (35.6% vs. 19.0%; p=0.039). AP patients were more likely to no longer report bowel or bladder incontinence at 1Y postop (6.7% vs. 0.0%; p=0.017). AP patients were also more likely to improve in baseline motor weakness at 1Y postop (11.1% vs. 2.4%; p=0.037).

Conclusion
A combined anterior-posterior approach offers more advantages for patients with a greater degree of cervical deformity or neurological deficits at baseline. This is reflected by greater improvement in radiographic alignment and a significant decrease in deficits following CD corrective surgery with a combined approach technique.

Take Home Message
A combined anterior-posterior approach offers more advantages for patients with a greater degree of cervical deformity or neurological deficits at baseline.

55. Psychological Distress in Patients Undergoing Cervical Spine Surgery: 2-Year Outcomes of a Randomized Controlled Trial

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Summary
Recent studies have suggested that in patients with neck pain, both psychological and physical symptoms need to be addressed. Cognitive behavioral therapy (CBT) works to address risk factors through education about pain, modification of maladaptive beliefs, and increasing patient's self-efficacy. Despite limited sample size, clear trends in our cohort of operative cervical spine patients show that improved psychological and functional outcomes may be achieved with preoperative CBT intervention. Further investigation is warranted to validate these findings.

Hypothesis
Brief psychological intervention has positive long-term effectiveness on psychological and functional outcomes in cervical spine surgery.

Design
Prospective, blinded, and placebo-controlled trial

Introduction
Recent studies have suggested that in patients with neck pain, both psychological and physical symptoms need to be addressed.

Methods
To date, 48 patients age>18yrs with symptomatic cervical degenerative disease have been enrolled in the RCT. All patients underwent elective cervical surgery of ≤5 levels and had an NDI>20%. Patients who met psychological distress criteria [DRAM >17 and <33, FABQ >49/<66, or PCS >30/<52] were randomized to a treatment group (CBT or placebo [Sham]). Patients exceeding these criteria were assigned to the DRAM Observational [DRAM] group. CBT and Sham groups received 6 sessions prior to surgery. The control and DRAM groups had no preop intervention. Baseline (BL) to 2-year (2Y) changes in HRQLs were assessed by randomization group.

Results
48 surgical patients enrolled (53.6yrs, 49%F, 29.6kg/m2, levels fused 2.2±1.5). By randomization group: 17(35.4%) CBT, 12(25.0%) Sham, 10(20.8%) Control, and 9(18.8%) DRAM. All pts had HRQL data collected preoperatively; 33 pts(68.8%) completed 2Y follow-up. Mean HRQLs for each group at BL and 2Y are reported in Table 1. Overall, the following number of pts improved in HRQLs from BL to 2Y: PCS – 21, FABQ – 16, mJOA – 18, NDI – 24, EQ5D – 17, VAS – 21, NRS Neck – 20, NRS Arm – 21. Univariate analysis showed that pts in the CBT group trended toward a higher rate of improvement in PCS (56% vs. other groups: 41%, p=0.338), FABQ (50% vs. 28%, p=0.133), NDI (69% vs. 45%, p=0.124), EQ5D (50% vs. 31%, p=0.209), VAS (63% vs. 38%, p=0.114), NRS Neck (56% vs. 38%, p=0.236), and NRS Back (63% vs. 38%, p=0.114). These trends were maintained when comparing the CBT group with individually Control, Sham, or DRAM groups.

Conclusion
While limited by sample size, clear trends in our cohort of operative cervical spine patients show that improved psychological and functional outcomes may be achieved with preoperative CBT intervention. Further investigation is warranted to validate these findings.

Take Home Message
Despite limited size, trends in our cohort of operative cervical spine patients show that improved psychological and functional outcomes may be achieved with preoperative CBT intervention. Further investigation is warranted.

Table 1. Mean HRQL scores at baseline and 2-years postop for a cohort of 33 patients with cervical degenerative disease.

Time Point	HRQL	CBT (n=13)	Sham (n=8)	Control (n=7)	DRAM (n=5)
BL	PCS	31.9	34.1	17.6	36.6
2Y	PCS	16.0	22.0	17.6	26.8
BL	FABQ	40.9	41.9	23.7	56.4
2Y	FABQ	37.1	43.3	42.7	54.8
BL	mJOA	14.4	12.3	16.3	13.2
2Y	mJOA	15.2	12.6	15.4	15.2
BL	NDI	29.5	26.0	18.9	36.6
2Y	NDI	17.9	22.1	19.4	23.2
BL	EQ5D	10.2	9.9	6.4	10.4
2Y	EQ5D	8.0	8.6	8.9	10.6
BL	NRS Neck	7.3	6.0	5.6	7.6
2Y	NRS Neck	4.3	5.3	5.3	5.0
BL	NRS Arm	5.2	6.3	4.4	6.6
2Y	NRS Arm	2.5	4.6	3.6	3.6
BL	VAS	46.4	39.3	62.3	37.0
2Y	VAS	71.9	47.3	60.1	48.8

Outcome metrics:
Pain Catastrophizing Scale(PCS)
Fear Avoidance Beliefs Questionnaire(FABQ)
Neck Disability Index(NDI)
modified Japanese Orthopedic Association(mJOA)
Visual Analog Scale(VAS)
EuroQol Five Dimensions(EQ5D)
Numeric Rating Scale(NRS) for neck and arm pain

56. Cervical Myelopathy With Severe Neck Pain: Is Anterior or Posterior Approach Better?

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Summary
In patients with cervical spondylotic myelopathy (CSM) and severe neck pain, both multilevel anterior cervical discectomy and fusion (ACDF) and posterior cervical laminectomy and fusion (PCF) achieved comparable neck pain outcomes at 12 months. However, multilevel

ACDF was associated with superior disability, functional status, satisfaction, and return to baseline activities at 12 months.

Hypothesis
There is no difference between multilevel ACDF or PCF regarding postoperative neck pain in patients operated for cervical myelopathy presenting with severe neck pain.

Design
Retrospective analysis of a prospective registry

Introduction
For patients with CSM presenting with severe neck pain, it is unclear if a multilevel ACDF or PCF is superior for postoperative neck pain.

Methods
This was a retrospective analysis of the CSM Quality Outcomes Database registry. Patients who received a sub-axial fusion of 3 or 4 segments with VAS-neck pain of 7 or greater at baseline were included. Twelve-month outcomes (VAS-neck, VAS-arm, NDI, mJOA, EQ-5D, EQ-VAS) were compared for those undergoing ACDF vs. PCF.

Results
We compared 73 patients (58.4%) undergoing 3- or 4-level ACDF and 52 patients (41.6%) undergoing 3- or 4-level PCF. Preoperatively, ACDF had worse baseline NDI (52.7±15.1 vs. 47.0±16.6; p=0.047), but similar neck pain (p>0.05). Twelve-month follow-up rates were similar: ACDF 74.0% and PCF 73.1%. In multivariable adjusted analyses, there was no significant difference in the degree of neck pain change, rate of neck pain improvement, rate of pain-free (VAS-neck=0) achievement, and rate of reaching a minimum clinically important difference (MCID) in VAS neck pain (defined as 2.6 improvement) between the two groups (p>0.05) at 12 months. However, ACDF was associated with lower mean NDI (ß=-8.64; 95%CI [-16.10 - -1.18]; p=0.02), greater NDI improvement (ß=-10.60; 95%CI [-18.10 - -3.06]; p=0.006), higher mean mJOA (ß=1.78; 95%CI [0.54-3.03]; p=0.006), greater mJOA improvement (ß=1.49; 95%CI [0.22 – 2.75]; p=0.02), and higher NASS satisfaction (OR=0.45; 95%CI [0.20-0.98]; p=0.046) at 12 months. ACDF demonstrated a higher rate of 12-month return to baseline activities (OR=1.20; 95%CI [1.00-1.43]; p=0.045).

Conclusion
In patients with CSM and severe neck pain, both multilevel ACDF and PCF achieved comparable neck pain outcomes at 12 months. However, multilevel ACDF was associated with superior disability, functional status, satisfaction, and return to baseline activities at 12 months.

Take Home Message
In patients with CSM and severe neck pain, both multilevel ACDF and PCF achieved comparable neck pain outcomes. However, multilevel ACDF was associated with superior disability, functional status, and satisfaction.

Multivariate comparison of clinical outcomes at 12 months (ref=PCF)	ß or Odds Ratio	95% CI	Adjusted p-value
Primary Outcomes			
VAS neck pain, 12 months	-0.80	-1.91 – 0.30	0.15
VAS neck pain, 12-month change	-0.90	-2.03 – 0.24	0.12
VAS Neck Pain Improvement at 12 months	1.02 (OR)	0.89 – 1.18	0.76
VAS-NP pain-free at 12 months	1.04 (OR)	0.90 – 1.21	0.57
MCID VAS-NP at 12 months	1.12 (OR)	0.90 – 1.39	0.30
Secondary Outcomes			
VAS arm pain, 12 months	-1.20	-2.34 - -0.06	0.04
VAS arm pain, 12-month change	-1.27	-2.64 – 0.11	0.07
mJOA, 12 months	1.78	0.54 – 3.03	0.006**
mJOA, 12-month change	1.49	0.22 – 2.75	0.02**
NDI, 12 months	-8.64	-16.10 - -1.18	0.02**
NDI, 12-month change	-10.60	-18.10 - -3.06	0.006**
EQ-VAS, 12 months	3.34	-5.23 – 11.90	0.44
EQ-VAS, 12-month change	-1.71	-12.10 – 8.66	0.74
EQ-5D, 12 months	0.07	-0.003 – 0.15	0.06
EQ-5D, 12-month change	0.05	-0.03 – 0.14	0.23
NASS[1], 12 months	0.45 (OR)	0.20-0.98	0.046**
Return to work, 12 months	1.01 (OR)	0.87 – 1.16	0.93
Return to baseline activities, 12 months	1.20 (OR)	1.00 – 1.43	0.045**

Abbreviations: CI: confidence interval; **OR**: odds ratio; **mJOA**: modified Japanese Orthopaedic Association; **VAS**: visual analog scale; **NDI**: neck disability index; **EQ-VAS**: EuroQol-Visual Analog Scale; **EQ-5D**: EuroQol-5D; **NASS**: North American Spine Society
** denotes a significant difference with p-value < 0.05.
[1] OR < 1 denotes superior satisfaction for ACDF, compared to PCF

Multivariate comparison of clinical outcomes at 12 months (ref=PCF)

57. The Antero-Posterior Positionning of Visco-Elastic Cervical Disc Prosthesis Does Not Alter the Outcomes

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Summary
The comparison of the clinical and radiological outcomes regarding the antero-posterior positioning of a visco-elastic cervical disc prosthesis in a series of 30 consecutive patients suggests this generation of implants tolerate greater variability in its technique of implantation.

Hypothesis
Since the center of rotation in visco-elastic cervical disc prostheses is free, our hypothesis was to check if the antero-posterior positioning of the implants may influence the clinical outcomes at follow-up.

Design
Data has been compiled from 30 consecutive patients with single-level cervical total dis replacement using the Visco-Elastic Cervical Disc Prosthesis. There were 16 women and 14 men, aged 28 to 73 years-old. The average follow-up was 25.9 months (15 to 38). The population was retrospectively split in two halves: the 15 most anteriorly / the 15 most posteriorly placed implants.

Introduction
Second generation visco-elastic disc prostheses are of most interest today for cervical reconstruction after discectomy. The biomechanical concept of one-piece implants combines

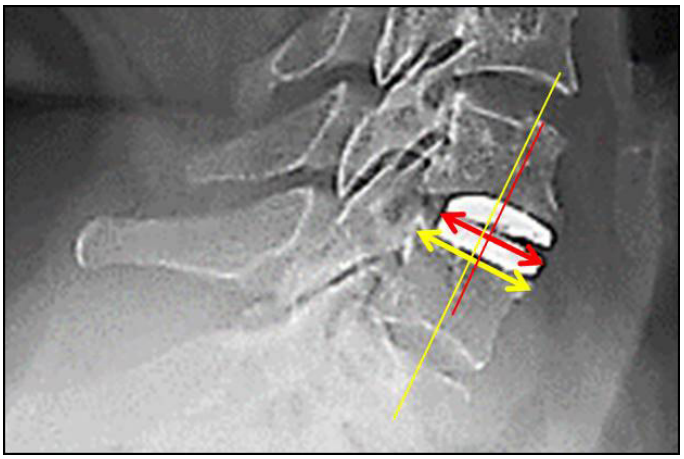
intervertebral cohesion, elastic return, full-6 degrees of freedom, and free center of rotation. While first generation articulated disc prostheses had an ideal positioning schematically as posterior as possible, because of their geometrically determined center of rotation, the dogma may change for visco-elastic implants, whose center of rotation is free.

Methods
The assessment of the antero-posterior positioning was based on the relative position of the middle of the prosthesis to the middle of the inferior endplate on the lateral radiograph. Recorded outcomes were clinical and radiological : Neck Disability Index (NDI), visual analog scale for neck and radicular pain (VASn and VASr), flexion-extension range of motion (ROM). All outcomes at last follow-up (LFU) were correlated to the groups.

Results
The median of the anteroposterior positioning of the prostheses was 44%. The average NDI was 33.1% preop, dropping to 12.3% at LFU. The average VASn and VASr were 8.6 and 7.3 preop, dropping to 3.2 and 2.5 at LFU. The average flexion / extension ROM at LFU was 14.0°. No significant difference was observed between the anterior and the posterior groups.

Conclusion
The antero-posterior positioning of viscoelastic dis replacement do not significantly influence the clinical or radiological outcomes.

Take Home Message
Since their center of rotation is free, visco-elastic implants seem to be more permissive in term of antero-posterior placement.



Assessment of the antero-post. positioning of the prosthesis

58. Clinical & Radiological Outcomes Following the Use of Triangular Sacro-Iliac Joint Cages in Addition to S2AI Screws (Bedrock Technique) to Enhance Spinopelvic Fixation

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Summary
Biomechanical studies have demonstrated that triangular SIJ implants can substantially reduce movement across the SIJ, reinforcing fixation and protecting S2AI screws from complications. We prospectively investigated the clinical and radiological outcomes of our series of patients undergoing this Bedrock technique using PROMS and CT scans. We found significant improvement in pain and function and satisfactory fusion and implant positioning one year post surgery. The described technique could potentially lower the risk of mechanical failure and pseudoarthrosis.

Hypothesis
Triangular SIJ cages in addition to S2AI screws (Bedrock Technique) is associated with good clinical & radiological outcomes

Design
Prospective observational

Introduction
The pelvis is an important caudal anchor point for long construct spinal fusions. S2AI screws have shown less complications than traditional iliac bolts and allow easier rod insertion. However as the SIJ is not fused, there are potential problems with toggling, loosening and breakage. About 12% of patients also complain of SIJ pain. The Bedrock technique adds triangular titanium implants across the SIJ from a medial to lateral trajectory above the S2AI screws. We assessed the clinical and radiological outcomes of this technique

Methods
Pre-operative EQ5D, EQ5D VAS, ODI and VAS scores were obtained in all patients who underwent this technique. Enhanced spinopelvic fixations using the Bedrock technique were performed in a single tertiary specialist centre by two senior surgeons. All implants were inserted using computer navigation. We prospectively reviewed PROMS at six months and one-year following surgery. CT scans were performed at 12 months to assess fusion rates. All patients had a minimum 12 months follow up and were assessed for SIJ pain

Results
Of our 15 patients, 10 had adult degenerative scoliosis, two had spondylolisthesis and positive sagittal balance and three had revision surgery for flat back fusions and metalwork failure. Follow-up ranged from 12-30 months. At 1 year, EQ5D improved from 0.3 to 0.7, EQ5D VAS from 44.5 to 76.8, ODI from 58.8 to 26.3, VAS leg from 6.7 to 1.4 and VAS back from 7.3 to 2. No patients complained of SIJ pain. All patients had CT scans at exactly one year post op, showing good evidence of fusion at one year with bone growing

through the SIJ cages and there were no cases of distal implant failure or evidence of screw loosening

Conclusion
The clinical and radiological results of our study reveal that the use of triangular SIJ cages in addition to S2AI screws (Bedrock Technique) in long construct adult deformity surgery yields good outcomes with no mechanical failure of the spinopelvic fixation

Take Home Message
The Bedrock technique is associated with good clinical and radiological outcomes. It can enhance spinopelvic fixations and lower the risk of mechanical failure and pseudoarthrosis at the caudal anchor point

59. Cost-Effectiveness of Sacroiliac Joint Stabilization in Patients Undergoing Multiple-Segment Lumbar Fusion to the Sacrum

David W. Polly Jr., MD; Stacey J. Ackerman, PhD; Gurvinder S. Deol, MD

Summary
Among patients with high body mass index and high pelvic incidence, stabilizing the sacroiliac joint (SIJ) when performing multiple-segment lumbar fusion to the sacrum (MLF) can reduce the incidence of post-operative SIJ pain, currently estimated at 30%. Our economic analysis demonstrated that MLF + SIJ fusion (SIJF) at five years postoperatively was cost-effective from a societal perspective.

Hypothesis
Stabilizing the SIJ in high-risk patients undergoing MLF (2-4 levels) improves health quality at an acceptable cost from a societal perspective.

Design
Markov process cost-utility model.

Introduction
MLF can lead to increased angular motion and stress across the SIJ and risk of SIJ pain. SIJF using porous, 3D printed titanium, triangular-shaped implants placed posteriorly across the SIJ can reduce range of motion and screw stresses, thereby potentially avoiding revisions. To our knowledge, the cost-effectiveness of SIJF in high-risk patients undergoing MLF has not been investigated.

Methods
Cumulative 5-year costs and quality-adjusted life-years (QALY) of MLF compared to MLF + SIJF were evaluated from a societal perspective using data from the published literature; costs from Medicare claims data analyses and health state utility values (derived from EQ-5D) informed by two prospective, multicenter, clinical trials (INSITE and SIFI). The base case assumed a postoperative SIJ pain relative risk reduction of 67% (from 30% to 10%). Costs and utilities were discounted 3% annually. The incremental cost-effectiveness ratio (ICER) is reported in 2020 US dollars.

Results
With an assumed 30% incidence of SIJ pain after MLF, stabilizing with SIJF was associated with an additional cost of $2,421 and a gain of 0.14 QALYs, resulting in an ICER of $17,293 per QALY gained (similar to hip arthroplasty and more favorable than laminectomy for lumbar stenosis). Assuming 40% and 50% incidence of SIJ pain after MLF resulted in cost neutrality and cost-savings, respectively. In our model, the ICER was less than $50,000 per QALY (a commonly accepted threshold) provided that the incidence of SIJ pain after MLF was at least 22%. ICERs were most sensitive to success rates for each treatment, SIJF implant costs, and utility of severe SIJ pain (Figure).

Conclusion
Among high-risk patients undergoing MLF, stabilizing with SIJ fusion is a cost-effective strategy, and, depending on the current practice-specific incidence of SIJ pain after MLF, a cost-neutral or cost-saving strategy.

Take Home Message
Stabilizing the SIJ in high-risk patients undergoing MLF appears to provide value-based healthcare when the incidence of SIJ pain after MLF exceeds approximately 25%.

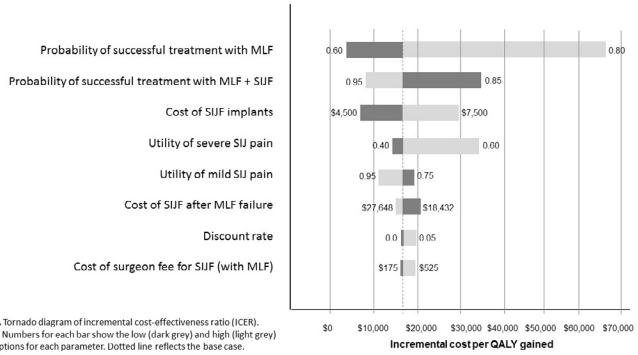

Figure. Tornado diagram of incremental cost-effectiveness ratio (ICER).
Notes: Numbers for each bar show the low (dark grey) and high (light grey) assumptions for each parameter. Dotted line reflects the base case.

60. Galveston Iliac Screw Technique with Modified Lateral Connectors: Results of 335 Consecutive Patients in Adult Deformity Surgery

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Summary
Lumbopelvic fixation has been analysed in the context of Adult Spinal Deformity (ASD) correction and found to have a high variability in its failure rate. Iliac screws have been used traditionally, however S2AI screws were proposed with the expectation of lower revision rates due to its lower profile. But the scientific literature still shows very high failure rates in spino-pelvic fixation. Our series of 335 consecutive cases with traditional iliac screws (IS) have shown a low revision rate.

Hypothesis
N/A

Design
Retrospective review of multi-centre, single surgeon ASD database

Introduction
Pelvic fixation is often found to be necessary to support the Sacral screw for long spinal fixations involving more than three motion segments. This was traditionally done with Iliac screws (IS) but S2-Alar-Iliac (S2AI) screws have been used more often recently due to hardware related issues like use of connector, prominence of Iliac screws etc. This study will demonstrate our experience of pelvic fixation with traditional Iliac screws in adult spinal deformity.

Methods
A retrospective review of database was done for all patients who underwent spinopelvic fixation procedure with IS performed by the senior author (BH) between 2010 and 2020. All patients aged >18 years, 1-year minimum follow-up were included in the study. Screws were inserted by the Galveston technique with the screw-head counter-sunk adequately and a modified lateral connector with an "end-stop" was used to allow the shortest connector to be used.

Results
Three hundred and thirty five patients met the study inclusion criteria. Average patient age was 69.5 years. Surgical indications were degenerative scoliosis, degenerative disc disease and spinal stenosis. Fusion levels ranged from C2-pelvis to L4-pelvis, T10-pelvis being the largest category with 247 patients followed by T3-pelvis with 33 patients. Only 6/335 patients required a revision/removal of IS due to persistent symptoms. All six patients required revision or removal due to persistent symptoms due to screw head prominence.

Conclusion
This series is one of the largest single surgeon consecutive case series reported in the current literature and it shows one of the lowest revision rates for iliac screws. The consistent technique to counter-sink the screw head and the use of modified lateral connector minimised screw head prominence and, therefore, symptoms resulting from the prominent hardware, which is one the major reason for revision in iliac screws.

Take Home Message
Traditional Iliac screws performed with proper technique has very good outcome contrary to the reported literature.

61. Where Do Patients with Degenerative Lumbar Pathology Lose Lordosis?

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Summary
This study aims to quantify how much lordosis is lost in the proximal and distal lumbar spine in patients with 1-2 levels of degenerative disease, when stratified by pelvic incidence (PI) - LL mismatch. Data demonstrates that pts with 1-2 levels of degenerative disease lose significantly more lordosis at L1-L4 compared to L4-S1. It's observed that patients with mild PI-LL mismatch lose lordosis proximally while moderate mismatch lose significant lordosis at L1-L4 and L4-S1.

Hypothesis
Loss of lordosis occurs mainly at the distal levels

Design
Retrospective analysis of single-institution data

Introduction
Quantification of how and where LL is lost in degenerative pts with progressively worsening sagittal alignment remains to be explored This study aims to quantify how much lordosis is lost in the proximal and distal lumbar spine in pts with 1-2 levels of degenerative disease

Methods
A cohort of 50 patients undergoing MIS procedures for degenerative lumbar pathology was retrospectively reviewed. Global and regional lordosis were compared to age- and PI-adjusted norms. After stratification by degree of PI-LL mismatch, the same comparisons were made. Paired-sample t tests were used to compare measurements at a significance level of 0.05

Results
The cohort (67.2yo, 50% male) presented with PI 57.2 ± 12.0°, LL 44.7 ± 17.1°, PT 22.5 ± 8.5°, and C7 SVA 6.1 ± 4.6 cm; on average 68.6% of LL came from L4-S1. Compared to age and PI adjusted norms, there was 4.3° loss of lordosis across L4-S1 ($p = 0.02$), and 8.6° across L1-L4 ($p < 0.001$). L1-L4 lordosis averaged 61.5% of the norm, which was significantly less than L4-S1 lordosis which averaged 86% of the norm ($p = 0.02$). After stratification by PI-LL, pts with mild mismatch (PI-LL =13.6 ± 4.6°) had a significant decrease in L1-L4 relative to the norm (-10.7°, 47% reduction; $p = 0.001$) but no significant difference at L4-S1. The moderate mismatch group (PI-LL=29.1 ± 6.3°) had a significant decrease in L1-L4 lordosis of 15.7° (72% reduction; $p = 0.001$) and L4-S1 lordosis of 13.6° (42% reduction; $p = 0.001$).

Conclusion
Pts with 1-2 levels of degenerative disease lose significantly more

relative lordosis at L1-L4 compared to L4-S1. Those without a PI-LL mismatch are younger and have no differences in regional alignment when compared to age-and PI-adjusted norms. Those with a mild mismatch lose all of their lordosis proximally, while those with a moderate mismatch have significant loss of lordosis at both L1-L4 and L4-S1. These findings suggest that the distribution of regional lordosis in patients with degenerative lumbar pathology should be an area of future investigation.

Take Home Message
Patients with 1-2 levels of degenerative disease with mild PI-LL mismatch lose lordosis proximally while moderate mismatch lose significant lordosis at L1-L4 and L4-S1.

62. Resolution of Radiculopathy Following Indirect vs. Direct Decompression in Single Level Lumbar Fusion

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Summary
Patients with radiculopathy often undergo decompressive procedures to ameliorate radiculopathic symptoms. This study demonstrates direct decompression improved radiculopathy-related outcomes in patients to a significant degree relative to indirect decompression. These results serve to underscore the importance of targeted intervention in patients with radiculopathy.

Hypothesis
Rates of radiculopathy resolution in patients undergoing direct vs. indirect decompression in single level lumbar spine surgery are similar.

Design
Retrospective review at a single institution.

Introduction
Indirect or direct decompressions are often used to correct stenosis, or reduce nervous irritation and radiculopathy.

Methods
Patients ≥ 18 years of age diagnosed with pre-op radiculopathy undergoing single-level lumbar fusion with minimum 1-year follow-up were included. Patients were grouped by indirect and direct decompression. Direct decompression (DD) group included TLIF with or without DD procedure as well as ALIF and LLIF with DD procedure. Indirect decompression group included ALIF and LLIF without DD procedure. DD procedure defined as any decompressive procedure: laminectomy, laminotomy, or foraminotomy. Outcome measures: VAS scores at Balesine, 3, 6, and 12 months, resolution of radiculopathy symptoms at 3, 6, and 12 months post-op, and perioperative complications. Statistical analysis included independent t-tests and chi-square analyses with significance set at $p<0.05$.

Results
195 direct and 58 indirect decompressions between 2012 and 2021 were included; age significant between bothg roups. Propensity score matching for age, resulted in 116 patients: direct decompression (N=58; 67.2% female, mean age 53.9±12.897, mean BMI 30.275±5.896) and indirect decompression (N=58; 61.4% female, mean age 54.60±12.606 mean BMI 30.045±6.259). There was significantly more estimated blood loss in the DD group vs. indirect group (p=.007). A significantly greater proportion of the DD group had full resolution of radiculopathy at 3 months post op relative to the indirect decompression group (p=.002). DD also had a significantly larger reduction in VAS score 6 months post-op (indirect: -.897 v direct: -2.889, p=.044) (Table 1).

Conclusion
After matching groups by age, the difference in radiculopathy resolution between direct and indirect decompression groups was significant, with DD experiencing greater resolution sooner. These results warrant further investigation and underscore the importance and efficacy of targeted intervention in patients with radiculopathy.

Take Home Message
Patients undergoing direct decompression had increased rates of radiculopathy resolution at 3 months post-op and greater reduction in VAS scores at 6 months post-op compared to those with indirect decompression.

Table 1. Comparison of demographics, surgical characteristics, and radiculopathic results between indirect and direct decompression radiculopathy patients.

Demographics		Indirect Decompression (N=58)	Direct Decompression (N=58)	p-value
Age (years)		54.60 ± 12.606	53.90 ± 12.897	0.766
Gender (Percentage Female)		35 (61.4%)	39 (67.2%)	0.513
BMI (kg/m²)		30.045 ± 6.259	30.275 ± 5.896	0.839
Estimated Blood Loss (mL)		171.79 ± 143.962	242.41 ± 128.466	**0.007**
Length of Stay (days)		3.421 ± 1.634	3.188 ± 1.538	0.434
Charlson Comorbidity Index (CCI)		2.09 ± 2.029	1.97 ± 2.008	0.748
Surgical Characteristics		**Indirect Decompression (N=58)**	**Direct Decompression (N=58)**	**p-value**
Operative Time (min)		247.76 ± 87.720	219.38 ± 72.997	0.061
Durotomy		0 (0%)	0 (0%)	N/A
Intraoperative complications		1 (1.7%)	1 (1.7%)	1
Post-Operative Outcomes		**Indirect Decompression (N=58)**	**Direct Decompression (N=58)**	**p-value**
30 Day return to OR		3 (5.2%)	1 (1.7%)	0.309
90 Day return to OR		2 (3.4%)	3 (1.7%)	0.559
Radiculopathy Resolution		**Indirect Decompression**	**Direct Decompression**	**p-value**
Radiculopathy 3 months	No Resolution	n=2 (3.92%),	n=1 (3.1%)	**.002**
	Partial Resolution	n=42 (82.35%)	n=14 (43.8%)	**.002**
	Full Resolution	n=7 (13.73%)	n=17 (53.1%)	**.002**
Radiculopathy 6 months	No Resolution	n=0 (0%)	n=1 (3.1%)	.062
	Partial Resolution	n=26 (70.3%),	n=14 (43.8%),	.062
	Full Resolution	n=11 (29.7%)	n=17 (53.1%)	.062
Radiculopathy 12 months	No Resolution	n=1 (3.7%)	n=2 (7.1%)	.455
	Partial Resolution	n=17 (63.0%)	n=13 (46.4%)	.455
	Full Resolution	n=9 (33.3%)	n=13 (46.4%)	.455
VAS Score		**Indirect Decompression**	**Direct Decompression**	**p-value**
Baseline VAS		5.56 ± 3.386 (n=52)	6.59 ± 2.592 (n=56)	0.08
3 month VAS		3.97 ± 3.023 (n=37)	3.68 ± 2.868 (n=31)	0.682
6 month VAS		5.13 ± 3.063 (n=31)	3.44 ± 2.549 (n=18)	0.055
12 month VAS		4.00 ± 3.753 (n=24)	3.74 ± 3.160 (n=19)	0.808
3 month VAS change (from baseline)		-2.222 ± 3.743 (n=36)	-2.484 ± 3.677 (n=31)	0.775
6 month VAS change (from baseline)		-.897± 4.286 (n=29)	-2.889 ± 2.271 (n=18)	**0.044**
12 month VAS change (from baseline)		-1.773 ± 4.535 (n=22)	-2.525 ± 3.007 (n=19)	0.541

63. Static vs. Expandable Interbody Fusion Devices: A Comparison of 1-year Clinical and Radiographic Outcomes in Minimally Invasive Transforaminal Lumbar Interbody Fusion

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Summary
This is a retrospective study which compares the radiographic and clinical outcomes of transforaminal lumbar interbody fusion using minimally invasive surgery (MIS-TLIF) performed using either a static or expandable cage. Expandable devices offered greater improvements in radiographic parameters at 1-year, though no significant differences in patient reported outcome measures and post-operative complications compared to static devices were observed.

Hypothesis
Expandable interbody devices provide greater improvements in radiographic measures with no significant differences in patient reported outcomes or post-operative complications compared to static cages.

Design
Retrospective review of a single-institution experience.

Introduction
Expandable interbody spacers allow for potentially greater improvements in radiographic parameters and clinical outcomes following MIS-TLIF compared to static spacers, though at a higher cost and increased rates of subsidence. This study compares the radiographic and clinical outcomes of static and expandable cages used in MIS-TLIF.

Methods
A retrospective review of 1- and 2-level MIS-TLIFs with static and expandable cages performed was performed. Radiographic measurements were performed on radiographs taken pre-operatively, at 6-weeks follow-up, and 1-year follow-up. Postoperative complications such as 90-day readmission and revision surgery were compared between groups. Clinical outcomes were evaluated by comparing Oswestry Disability Index, visual analogue scale for back, and visual analogue scale for leg at 3-months and 1-year follow-up.

Results
Expandable cages provided significantly greater anterior (11.4 mm static vs. 13.1 mm expandable, $p < 0.001$) and posterior (7.2 static vs. 8.7 expandable, $p < 0.001$) disc height at 1-year follow-up. Expandable devices offered similar improvements in segmental lordosis at 6-weeks (7.3 deg static vs. 8.3 deg expandable, $p = 0.76$) which was better maintained in the expandable group at 1 year (6.3 deg static vs. 79 deg expandable, $p = 0.03$). No significant differences in cage subsidence rates were noted between static (17.8%) and expandable (25.7%) devices at 1 year (OR = 1.61, $p = 0.13$). No significant differences were noted in 1-year patient reported outcomes and post-operative complications between static and expandable groups.

Conclusion
Expandable devices offer greater improvements in radiographic measures compared to static devices. No significant differences in subsidence rate, 1-year patient reported outcomes, and post-operative complications between groups were observed.

Take Home Message
Expandable interbody fusion devices provided significantly greater improvements in radiographic parameters with no significant differences in 1-year patient reported outcomes or complication rates compared to static cages.

64. Which Components of the Global Alignment Proportionality Score Have the Greatest Impact on Outcomes in Adult Spinal Deformity Corrective Surgery?

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Summary
The global alignment and proportionality (GAP) score has been discussed in literature as a potential criteria for alignment targets, in order to minimize mechanical complications. In this study, it was found that certain components of GAP had a significantly greater impact on mechanical complication rates, as well as, patient reported outcome measures.

Hypothesis
To investigate the impact of GAP components on patient outcomes.

Design
Retrospective cohort study of prospective, multicenter ASD database

Introduction
Our goal was to study individual GAP components to determine predictive value with patient outcomes.

Methods
Operative ASD patients (scoliosis >20, SVA>5cm, PT>25, or TK>60) with a fusion at L1 or higher and available baseline (BL) and 2-year (2Y) radiographic and HRQL data. Proportioned alignment (PA) in 4 parameters: PV (Pelvic Version- based on sacral slope), LL (Lumbar Lordosis), LDI (Lumbar Lordosis Index), and SP (Spinopelvic) was used for a linear regression analysis. Controlling for the others, this determined how individual PA correlated with HRQLs (SRS, ODI, SF36, back and leg pain) and complications. Conditional inference tree (CIT) modeling was then used to rank components hierarchically to determine which components were most impactful.

Results
674 ASD patients met inclusion criteria (59.9yrs±14.0, 79%F, BMI: 27.7 kg/m2 ±6.0, CCI: 1.8 ±1.7). PA in GAP SP was associated with meeting MCID for SRS and ODI, and a higher SRS-Activity, SRS-Satisfaction, and NSR Leg pain at 2Y. CIT ranking revealed that PA in GAP SP was most predictive of achieving a higher SRS-Total score, higher SRS-Appearance and lower ODI, followed by GAP LL and GAP LDI. PA in GAP SP patients developed less PJK 0.42[.26-.7] and PJF .27[.1-.7] by 2Y. With a malalignment in GAP SP, PA in GAP LL was correlated with a lower risk of PJK at 2Y .47[.27-.780]. With malalignment in GAP LDI, PA in GAP SP correlated with increased incidence of` PJK 2[1.02-4], while GAP LL lowered incidence .5[.3-.9]. (All $p<0.05$).

Conclusion
The spino-pelvic component of the GAP score, provides an accurate overall picture of alignment. Among the parameters, GAP SP alignment correlated with ODI, all SRS, leg pain and development of PJK/PJF. Although literature shows overall GAP score was developed for mechanical complications, GAP SP individually was found to be a strong predictor of both mechanical complications and patient reported outcome measures.

Take Home Message
Although literature shows overall GAP score was developed for mechanical complications, GAP SP individually was found to be a strong predictor of both mechanical complications and patient reported outcome measures.

65. The Incremental Benefit of Adding Layers of Complexity to the Planning and Execution of Adult Spinal Deformity Corrective Surgery

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Summary
For surgical adult spinal deformity (ASD) patients, determining optimal restoration of alignment and spinal shape have been increasingly studied. Temporally, the SRS-Schwab classification system was the first severity categorization system. Next, the age-adjusted alignment was proposed, followed by Roussouly classification, and then Global Alignment and Proportion (GAP) Score. These additional layers of complexity add to an already technically challenging and high risk case. Multiple schemas may assist in optimizing outcomes following spinal realignment surgery.

Hypothesis
Outcomes will be affected by incremental addition of ASD surgical corrective measures.

Design
Retrospective

Introduction
What hasn't been determined is the incremental benefit of added alignment schemas in ASD postop outcomes.

Methods
ASD patients with baseline and 2-year data included. Patients were classified by four corrective alignment measures: SRS-Schwab: PT, SVA and PI-LL(0, +, and ++); Age-Adjusted: PT, PI-LL, and SVA-adjusted ideal; Roussouly Type: 'Match' theoretical type; GAP Score: disproportion score out of 13. Alignment improvement: SRS-Schwab 0 or severity decrease, Age-Adjusted match, Roussouly

Match, and decrease GAP. To assess the incremental layers of complexity: first layer(1st) solely improving in SRS-Schwab at 2Y, 2nd Schwab and matching Age-Adjusted, 3rd as the two prior with matching Roussouly, and 4th with addition of GAP. Comparison was accomplished with means comparison and chi-squared analyses.

Results

732 ASD patients (57.5yrs, 82.4%F) included. Descriptives of the layers are in Table 1. Comparing 2nd to 1st layer, complications and HRQLs were similar($p>0.05$). 3rd demonstrated less mechanical complications (16.1% vs. 22.58%, $p=0.027$) and PJK occurrence (48.3% vs. 59.4%, $p<0.001$) than the 2nd. 3rd met MCID for PCS and SRS-Mental less then 2nd, $p<0.005$. 4th compared to the 3rd, met MCID for ODI (44.2% vs. 3rd: 28.3%, $p=0.011$) and SRS-Appearance (70.6% vs. 44.8%, $p<0.001$) more. PI, PT, PI-LL and SVA were smallest in the 3rd group($p<0.020$). Operative time, EBL and LOS were similar between complexity groups($p>0.050$). Mechanical complications and PJK occurred to a greater extent in the 1st and 2nd complexity groups($p=0.024$). According to HRQL follow-up, the 4th layer met MCID more than all other complexity groups for SRS-22 Appearance($p=0.002$) and ODI($p=0.085$). Invasiveness was the greatest in the 4th layer ($p<0.001$).

Conclusion

Utilizing age-adjusted ideal in addition to SRS-Schwab assessment does not lead to better radiographic outcomes. The addition of Roussouly predicts decrease in mechanical failure and PJK. Finally, adding the GAP score provides an increased likelihood of MCID for ODI and SRS.

Take Home Message

Multiple clarification and treatment schemas may assist in optimizing outcomes following spinal realignment surgery.

SRS-Schwab	
PI-LL Improved 2-Year	74.3%
SVA Improved 2-Year	71%
PT Improved 2-Year	54.9%
Age-Adjusted	
PT Ideal Match 2-Year	28%
PI-LL Ideal Match 2-Year	18.8%
SVA Ideal Match 2-Year	31.3%
Roussouly	
Matched Type 2-Year	44.7%
GAP	
Improved in 2-Year	30.8%
Layer Of Complexity Groups	
1st	640 (87.4%)
2nd	517 (70.6%)
3rd	176 (24%)
4th	55 (7.5%)

Descriptives of the incremental layers of complexity.

66. Optimal Realignment Outweighs Increased Perioperative Risk in ASD Surgery

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Summary

Recent emphasis on perioperative outcomes have become the focus of healthcare because of their tie to reimbursement by Medicare and Medicaid. However, it is unknown whether these perioperative complications have any effect on achieving a successful outcome. Our study demonstrated the perioperative risk of increased invasiveness and correction needed to achieve optimal realignment is warranted to obtain long-term, durable outcomes during ASD surgery.

Hypothesis

The superiority in achieving optimal realignment on long-term outcomes despite the increased risk of transient perioperative complications.

Design

Retrospective cohort

Introduction
An increased risk of perioperative complications comes with increasing complexity. However, some patients persevere through short-term complications and manage to still achieve optimal, long-term outcomes.

Methods
Operative ASD patients with baseline (BL) & 1-year (1Y) data were included. Patients were stratified based on meeting 1Y optimal outcome. Optimal outcome: improvement in all three age-aligned SRS-Schwab modifiers, proportioned (P) in GAP, and a 2Y-ODI score of less than 25. Multivariate analysis was used to determine significance for complications. Published methods converted ODI to SF-6D. Cost was calculated using the PearlDiver database and CMS.gov definitions.

Results
469 ASD patients included. 63% of patients underwent a posterior approach, 37% combined. 52% underwent decompression, 66% underwent an osteotomy. BL radiographics: SVA:63.3±70.7 mm, PI-LL:14.4±21.2,PT:23.49±11.1. Patients grouped as follows: 105 "optimal" (O), 364 "not optimal" (NO). Comparison revealed differences in age, BMI, and FI. NO group had less levels fused and osteotomies, but significantly higher EBL and decompressions. Controlling for age and frailty, the O group had more perioperative complications (58.1%vsNO:52.8%), significantly more GI complications(p=.027) and overall medical complications (10.5%vsNO:8.5%). NO group had more reoperations (p=.004), major complications(p=.024), instrumentation failures(p=.079), and higher rate of PJK/PJF. Groups were significantly different in utility gained, 2-year QALYs, and overall cost (O:$74,371.08 vs. NO:$87,945.87,p=.008).

Conclusion
Despite undergoing more invasive procedures and sustaining more perioperative complications, patients meeting optimal outcome experienced less major/mechanical complications, fewer reoperations, and lower rates of PJK/PJF. Accordingly, a higher, transient perioperative complication profile should not preclude surgical correction in ASD patients who demonstrate baseline characteristics suggestive of successful long-term outcomes.

Take Home Message
Higher perioperative complications should not preclude the spinal deformity surgeon from correcting to optimal realignment to achieve long-term durable outcomes in ASD surgery.

Table 3. Group Differences in Perioperative and Long-Term Complications

Complication within 90 days	Did Not Improve	Improved	p-value
Adverse Event	0.146	.114	.414
Reoperation	0.256	0.124	.004
Minor Complication	0.357	0.362	.929
Major Complication	0.302	0.191	.024
Any Perioperative Complication	0.528	0.581	.334
Medical Complication	0.085	0.105	.537
MSK Complication	0.033	0.000	.060
Cardiac	0.022	0.010	.228
GI	0.047	0.105	.027
Infection	0.036	0.010	.165
Neuro	0.066	0.019	.065
Pulmonary	0.055	0.048	.769
Renal	0.003	0.000	.592
Implant Failure	0.214	0.143	.087
Instrumentation Failure	0.159	0.076	.031
X-ray Imbalance	0.044	0.029	.106
PJK at 6W	0.536	0.514	.699
PJK at 2Y	0.566	0.476	.104
PJF by 2Y	0.220	0.152	.132

67. Have We Made Advancements in Optimizing Surgical Outcomes and Ameliorating Recovery for High Risk Adult Spinal Deformity Patients over Time

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Summary
Surgical correction of adult spinal deformity (ASD) has high rates of complication. However, patients often derive significant benefits in functional status and quality of life from surgical intervention despite being deemed as high risk for complications. This study found that over a 10-year span, spine surgeons have both increased and optimized operating on high risk patients, while minimizing the

occurrence of poor clinical outcomes and reducing complication rates.

Hypothesis
Spine surgeons are improving surgery for high risk patients and minimizing poor outcomes.

Design
Retrospective Cohort

Introduction
It has yet to be investigated whether spine surgeons are improving surgery for high risk patients and minimizing poor outcomes.

Methods
Operative ASD patients ≥18yrs with complete pre-(BL) and 2-year (2Y) postop radiographic/HRQL data were obtained from a dataset spanning the years 2009 to 2018. Patients were categorized as having undergone surgery from 2009 to 2013 [Early] or from 2014 to 2018 [Late]. High risk [HR] patients were defined as meeting ≥2 of the following: 1) ++ BL PI-LL or SVA by SRS-Schwab criteria, 2) being elderly, 3) severe BL frailty, 4) high Charlson comorbidity index, 5) undergoing three column osteotomy, and 6) fusion of >12 levels, or >7 levels for elderly patients. Differences in demographics, clinical outcomes, alignment targets, and complication rates were assessed by time-period for high-risk patients.

Results
725 ASD pts met inclusion criteria. 52% of patients (n=377) were identified as high risk [HR]. Overall, 47% of patients (n=338) had surgery prior to 2014[Early], and 53% (n=387) in 2014 or later [Late]. There was a higher proportion of HR patients in the Late group (56% vs. 48%, p=0.028). Analysis of HR by Early/Late status showed no significant differences in radiographic improvement, matching age-adjusted alignment goals, or improving in GAP proportionality by 2Y (all p>0.05). Late/HR patients were less likely to have a poor clinical outcome using SRS and ODI (both p<0.01). Late/HR patients had lower rates of overall complications (63% vs. 74%, p=0.025), reoperations (17% vs. 30%, p=0.002), and surgical infection (p=0.031). Late/HR patients had lower rates of early PJK (by 6M postop; 10% vs. 17%, p=0.041) and PJF (11% vs. 22%, p=0.003).

Conclusion
Our findings indicate substantive improvements in outcomes for high-risk patients over the course of the last decade. Despite operating on more high-risk patients from 2014-18, spine surgeons effectively reduced the rate of complications, mechanical failures and reoperations, while simultaneously improving HRQL.

Take Home Message
Over time in our data set, spine surgeons have both increased and optimized operating on high risk patients, while minimizing the occurrence of poor clinical outcomes and reducing complication rates.

68. Natural History of Adult Spinal Deformity: How Do Patients with Less Than Optimal Surgical Outcomes Fare Relative to Non-Operative Counterparts?

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Summary
While treatment of adult spinal deformity (ASD) increasingly favors operative intervention, incidence of complications and reoperations remains high. Yet, these suboptimal surgical outcomes may not necessarily lead to worse patient reported outcomes compared to natural history of ASD. When compared to patients that declined surgical intervention, ASD patients with suboptimal surgical outcomes still have superior HRQL outcomes relative to their non-op "natural history" counterparts.

Hypothesis
Operative adult spinal deformity (ASD) patients (pts) with suboptimal surgical outcomes have superior HRQL outcomes relative to the natural history of the disease.

Design
Retrospective analysis of prospectively enrolled ASD patients from a single center database.

Introduction
As treatment of ASD increasingly favors operative intervention, incidence of complications and reoperations remains high. While non-operative treatments have varying rates of efficacy, these pts presumably approximate the natural history of ASD.

Methods
Pts >18 years old with BL & 1-year (1Y) data were included. All pts met BL radiographic parameters for ASD & while all pts were offered operative intervention, for Non-Op pts, the decision to forego surgery was made by the pt. Operative pts were selected for "suboptimal outcomes," defined as any reoperation, major complication, or >2 severe SRS-Schwab modifiers at Y1. Pts were separated into suboptimal operative (SOp) & natural history (i.e. non-operative) (NH) groups. SOp & NH pts were then propensity score matched (PSM) by BL age, deformity, ODI, & CCI. Means comparison tests analyzed differences between groups in outcomes.

Results
370 pts met inclusion (284 SOp, 86 NH). After PSM, 67 SOp & 67 NH pts remained. Groups were not significantly different in BL demographics or deformity (Table 1). BL ODI, SRS-Total, & SRS-pain were not significantly different between groups. At 1Y, significantly more SOp pts reached MCID in ODI (39.7% SOp vs. NH 2.9%, p<.001). At 1Y, SOp pts had more improvement in SRS-Pain & SRS-Total (all p-values <.05). Finally, more SOp pts reached MCID in SRS-Activity (40.7%) & SRS-Pain (57.6 %) compared to NH, 17.1% & 31.4% respectively (both p<.02).

Conclusion
Compared to the natural history of ASD patients, operative pts with suboptimal outcomes still experience significantly greater improvements in HRQLs after surgical intervention. Such divergent outcomes seen at 1Y, highlight the stagnation & deterioration in HRQLs associated with the natural history of ASD. Surgeons and patients should consider such outcomes when weighting risk & benefits of operative intervention for ASD.

Take Home Message
Compared to the natural history of ASD patients, operative pts with suboptimal outcomes still experience significantly greater improvements in HRQLs after surgical intervention.

Table 1: Baseline Demographics	NH	SOp	Cohort	*p* value
Age (years)	58.28±13.8	57.05±15.13	57.67±14.44	>.05
Gender (% Female)	91.05%	82.09%	85.67%	>.05
BMI (kg/m^2)	26.02±5.61	26.08±5.02	26.05±5.27	>.05
CCI	1.40±1.43	1.42±1.61	1.41±1.51	>.05
Baseline HRQLs	NH	SOp	Cohort	*p* value
ODI	31.06±15.56	31.67±14.76	31.36±15.11	>.05
SRS Activity	3.6±0.75	3.31±0.87	3.45±0.82	0.043
SRS Pain	2.95±0.89	2.9±0.91	2.92±0.89	>.05
SRS Total	3.29±0.61	3.16±0.58	3.23±0.60	>.05
Baseline Radiographic Characteristics	NH	SOp	Cohort	*p* value
BL PT (°)	21.54±10.02	22.95±11.28	22.26±10.66	>.05
BL SVA (mm)	37.40±61.70	40.93±57.28	39.16±59.33	>.05
BL PI-LL (°)	9.11±17.86	11.27±20.64	10.22 ±19.29	>.05
Severe (++) PT Modifier (%)	17.5	23.9	20.6	>.05
Severe (++) SVA Modifier (%)	13.4	17.9	15.7	>.05
Severe (++) PI-LL Modifier (%)	26.6	37.3	32.1	>.05
1Y HRQLs	NH	SOp	Cohort	*p* value
ODI	26.63±13.47	21.26±18.46	23.28±16.88	>.05
ODI Difference from BL	-0.51±8.14	-9.16±17.71	-5.91±15.38	0.002
Gained > 1 MCID for ODI (%)	29	39.7	25.8	$X^2(1)=15.437, p<.001$
SRS-22 Activity	3.63±0.79	3.51±0.84	3.55±0.82	>.05
SRS-22 Pain	3.20±0.89	3.55±0.95	3.42±0.94	0.075
SRS-22 Total	3.44±0.71	3.71±0.70	3.61±0.71	0.073
SRS-22 Activity - Difference from BL	-0.15±0.49	0.13±0.83	0.46±0.88	0.01
SRS-22 Pain - Difference from BL	0.24±0.77	0.56±0.90	0.92±0.97	<.001
SRS-22 Satisfaction - Difference from BL	0.34±1.00	1.72±1.25	1.52±1.32	<.001
SRS-22 Total - Difference from BL	0.05±0.44	0.49±0.63	0.74±0.73	<.001
Gained > 1 MCID for SRS-22 Activity (%)	17.1	40.7	31.9	$X^2(1)=5.600, p=.018$
Gained > 1 MCID for SRS-22 Pain (%)	31.4	57.6	47.9	$X^2(1)=6.042, p=.014$
1Y Radiographic Characteristics	NH	SOp	Cohort	*p* value
PT (°)	20.82± 9.03	20.12± 10.94	20.35±10.30	>.05
SVA (mm)	16.14±43.61	20.17±58.31	18.83±53.63	>.05
PI-LL (°)	5.99±14.80	1.77±16.98	3.17±16.32	>.05
PT Difference from BL (°)	0.21±2.74	-3.09±7.36	-1.99±6.39	0.003
SVA Difference from BL (mm)	2.56±34.69	-22.07±59.54	-13.86±53.65	0.017
PI-LL Difference from BL (°)	2.01±6.64	-10.04±19.38	-6.02±17.20	<.001
Severe (++) PT Modifier (%)	13.8	20.7	18.4	$X^2(2)=3.230, p>.05$
Severe (++) SVA Modifier (%)	6.9	13.8	11.5	$X^2(2)=1.034, p>.05$
Severe (++) PI-LL Modifier (%)	13.8	13.8	13.8	$X^2(2)=1.163, p>.05$

69. Operation Timing of Adult Spinal Deformity Surgeries: Does the Wait Matter?

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Summary
We sought to evaluate the effects of case start time and day of the week on 90-day complication, readmission, and revision rates after adult spinal deformity surgery. We found that late start cases had higher rates of 90-day readmission (10.5% vs. 6.0%, p=0.02), reoperation (11.9% vs. 6.6%, p=0.008), and neurologic injury (5.2% vs. 2.1%, 0.019). Sub-analysis of neurologic complications demonstrated that there was a higher rate of postoperative radiculopathy (p=0.007), and residual stenosis (p=0.029) in late start cases.

Hypothesis
The impact of surgery start time and the day of the week surgeries are performed may be modifiable factors that can affect postoperative length of stay and postoperative complications.

Design
Retrospective review of prospectively collected database.

Introduction
Adult spinal deformity surgery can entail complex reconstructive procedures. To date, there are no ASD studies that have examined the impact of case start time on postoperative complications. In this regard, the purpose of this study was to evaluate the effects of surgery start time and day of the week on 90-day complication, readmission and revision rates after ASD surgery.

Methods
This is a retrospective study of 1040 ASD patients from a single institution. We collected start times and day of the week for cases from 2011-2018. Early start was designated as any case starting at 7:30 AM; late start was designated as any case starting 11 AM or later. Outcome measures include 90-day complication, revision, and readmission rates.

Results
1040 ASD patients (Age: 46 ± 23; BMI 25 ± 7, ASA 2.5 ± 0.6, Levels fused 10 ± 4, 3CO: 13%) were included. There was no association between day of the week and length of stay, 90-day complication, readmission, or reoperation rates in the adjusted analyses. Late start cases had higher rates of 90-day readmission (10.5% vs. 6.0%, p=0.02), reoperation (11.9% vs. 6.6%, p=0.008), and neurologic injury (5.2% vs. 2.1%, 0.019). Sub-analysis of neurologic complications demonstrated that there was a higher rate of postoperative radiculopathy (p=0.007), and residual central or foraminal stenosis (p=0.029) in late start cases. A late start time was predictive of increased risk for 90-day readmission (OR 1.8, p=0.02), unplanned reoperation (OR 1.9, p=0.009), and neurologic complication (OR 2.1, p=0.046).

Conclusion
A late OR start time was predictive of increased risk for neurologic complication, 90-day readmission, and unplanned reoperation. Well-established protocols for first start OR times for elective ASD surgery may decrease outcome risk and reduce variability in complication rates.

Take Home Message
A late case start time for ASD surgeries is a risk factor for 90-day readmission, unplanned reoperations, and neurologic complications.

70. Revision Free Loss of Sagittal Correction >3 years After Adult Spinal Deformity Surgery: Who and Why?

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Summary
In this retrospective cohort analysis of 420 surgical adult deformity patients who were revision-free for a minimum of 3 years, patients who lost the initial improvement in PI-LL were compared to those who maintained correction. Approximately one-third of patients lost more than 5° with an average of 10° loss? in PI-LL between 6-weeks and 3-years postop. After excluding those with hardware failures, the lack of supplemental rods, longer fusions, and negative PI-LL were associated with loss of correction

Hypothesis
Compared to those who maintain correction, patients who lose a portion of the original correction after surgery exhibit different surgical and radiographic characteristics.

Design
Retrospective cohort study

Introduction
The sustainability of adult deformity (ASD) surgery remains a health care challenge. This study aims to investigate the maintenance of long-term correction within the instrumented lumbar spine following ASD surgery

Methods
394 patients who underwent fusion of the lumbar spine (≥5 levels, LIV S1/ilium) with a revision-free follow-up ≥3 years were identified from a multi-institutional ASD database. Patients were stratified by the change in PI-LL from 6 wks to 3 yrs postop: increase > 5° (PI-LL Loss) and change ±5° (PI-LL Maintain). Those with a loss due to hardware failure (broken rod, screw pullout, etc.) were excluded before comparisons. Demographics, surgical data, and radiographic alignment were compared.

Results
Mean age 64±10 yrs, BMI 28±6 kg/m2, 81% female. Baseline alignment mean PI-LL 21±19°, T1PA 26±12°, corrected to PI-LL 4±14°, T1PA 19±11° at 3 yrs (mean FU: 42m±10). 117 (27.9%) of patients lost >5° of PI-LL correction (mean loss 10±5°). After excluding the 36 (9%) with hardware failure, 277 (77%) were classified as Maintain (mean 1±3° increase in PI-LL) and 81 (23%) as Loss (mean 9±3° increase in PI-LL, representing a median loss of 37% of the initial correction). Demographics, surgical data, ODI, and SRS were similar between the cohorts (Table 1). However, the Loss cohort had longer fusions and less frequent use of a supplemental rod (Table 1). Preoperatively and at 6 weeks, the Loss cohort had a larger coronal deformity and lower PI-LL and T1PA (Table 1). Multivariate logistic regression showed that lack of a supplemental rod (OR 4.0, p=0.005), fusion length (OR 2.2, p=0.004), and a negative postop PI-LL (OR 1.03, p=0.014) were independent risk factors for loss of correction

Conclusion
Approximately a third of ASD patients lose an average of 10°of their 6-week correction by 3 years, especially those undergoing fusion ≥13 levels. The use of supplemental rods and avoiding sagittal overcorrection may help mitigate this loss

Take Home Message
Approximately one-third of ASD patients do not maintain their initial improvement in postoperative PI-LL. Supplemental rods and appropriate alignment goals may help mitigate this loss.

Table 1. Comparison of factors between patients who lose or maintain initial surgical correction at 3-year follow up.

	PI-LL Maintain (277)		PI-LL Loss (81)		
Demographics	**Mean/N**	**SD/%**	**Mean/N**	**SD/%**	**p-value**
Age, yrs	64.0	9.8	61.7	10.5	0.069
Female	222	80.4%	70	86.4%	0.220
BMI, kg/m2	28.5	6.0	26.7	5.0	0.736
Preop alignment					
PI-LL (°)	21.3	18.4	15.5	19.6	0.015
C7 SVA (mm)	81.2	66.9	62.9	69.5	0.036
T1PA (°)	25.8	11.7	22.7	13.0	0.048
Max Coronal Cobb (°)	36.7	20.1	46.0	21.7	<0.001
6-week alignment					
PI-LL (°)	1.2	12.9	-2.6	15.4	0.028
C7 SVA (mm)	27.8	46.3	15.2	54.3	0.039
T1PA (°)	16.0	9.3	13.4	10.6	0.035
Max Coronal Cobb (°)	17.3	12.4	24.0	17.3	0.003
Surgical factors					
Revision	163	59.3%	44	54.3%	0.427
Fusion ≥13 levels	89	32.1%	42	51.9%	<0.001
LLIF*	30	15.7%	13	21.7%	0.285
TLIF*	90	47.1%	24	40.0%	0.334
ALIF*	84	44.0%	29	48.3%	0.554
3CO	60	21.7%	15	18.5%	0.541
Use of BMP	240	86.6%	68	84.0%	0.539
Use of supplemental rod	61	22.0%	7	8.6%	0.007
Rod diameter (mm)					0.170
5.5	186	67.1%	48	60.0%	
6.0	20	7.2%	11	13.8%	
6.35	71	25.6%	21	26.2%	
Rod material					0.143
Cobalt chrome	166	60.8%	53	66.2%	
Titanium	59	21.6%	9	11.2%	
Stainless steel	46	16.8&	18	22.5%	

**% calculated out of the 191 patients who had interbodies*

71. What is the Incidence, Mechanism, and Protective Strategies for 2 Year Pelvic Fixation Failure after Adult Spinal Deformity Surgery with A Minimum 6 Level Fusion

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Summary

Prior literature suggests high rates of pelvic fixation failure (PFF) after adult spinal deformity (ASD) surgery. However, few report on potential protective strategies to mitigate this risk of failure. Our single center study of 253 patients (pts) demonstrates at rate of 4.3% within 2 years after surgery (0.4% within 6 months). The most influential protective factors included a higher number (no.) of rods across the lumbosacral junction, accessory rod(s) LIV to S2 or ilium and lower residual coronal malalignment.

Hypothesis

There are potential modifiable risk factors for PFF

Design

Single-Center, Retrospective Cohort

Introduction

Protective factors for PFF after ASD is not well understood, and none propose an optimal rod strategy.

Methods

ASD pts and pelvic fixation with min. 2 yr f/u were consecutively collected (2015-2019). Pts with prior pelvic fixation were excluded. PFF was defined as broken rod across the lumbosacral junction, broken pelvic screw, pseudarthrosis across the lumbo-sacral junction requiring revision to pelvic screws, loose pelvic screw, sacral/iliac fracture, set cap loosening or dislodgement. Pt, operative, screw, rod, rod pattern, and pre- and post-radiographic parameters were collected. All rods across the lumbosacral junction were cobalt-chrome. All iliac and S2AI screws were closed-headed.

Results

Of 253 patients (means of age=58.9years, TIL=13.6,3CO=11.3%,L5-S1 interbody=53.5%,length and diameter of pelvic screws were 86.9mm and 8.6mm), the 2 year failure rate was 4.3% (N=11). The mechanism of failure included broken rod across the lumbo-sacral junction (N=4), pseudarthrosis across the lumbosacral junction requiring revision to pelvic screws (N=3), broken pelvic screw (N=1), loose pelvic screw (N=1), sacral/iliac fracture (N=1), set cap loosening/dislodgement (N=1). A higher no. of rods crossing the lumbopelvic junction (No Failure=3.8 vs. Failure=2.9), and accessory rod(s) LIV to S2/ilium (No Failure=54.2% vs. Failure=18.2%) were protective for failure. Multivariate logistic regression demonstrated that accessory rod LIV to S2/ilium vs. S1 (OR 0.2) and number of rods crossing the lumbar to pelvis (OR 0.15) were protective, while worse postoperative CVA (OR 1.5) was predictive for failure.

Conclusion

The 2 yr failure rate is low relative to what is reported in literature, despite pts undergoing long fusion constructs for ASD. No. of rods crossing the lumbo-pelvic junction and accessory rod(s) LIV to S2/ilium relative to S1 alone is likely to increase construct stiffness. Residual postoperative coronal malalignment should be avoided to reduce pelvic fixation failure.

Take Home Message

The 2 year failure rate is low. Number of rods, accessory rod LIV, and residual coronal imbalance are important factors to consider.

Multivariate Logistic Regression Results				
	Odds Ratio	**95% Confidence Interval**		**P-Value**
Accessory Rod LIV Does Not Include Either S1 or S2 vs. S1	10.4	1.6	68.1	**0.002**
Accessory Rod LIV is S2 vs. S1	0.2	0.04	1.3	**0.004**
Number of Rods Crossing Lumbar to Pelvis	0.15	0.04	0.5	**0.002**
Postoperative CVA	1.5	1.1	2.2	**0.028**
Interbody Fusion L5-S1	10.3	0.8	127	0.070

MLR Results

72. Identification of Optimal Frailty and Deformity Ranges at Presentation to Achieve Maximum Improvement from Adult Spinal Deformity Corrective Surgery

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Summary
Given both severe frailty and deformity can be limiting factors in a patient's ability to improve after adult spinal deformity corrective surgery, the present study utilized polynomial fitting to find ranges at which maximum improvement in ODI is reached regarding frailty and radiographic measures. Within these ranges, patients experienced increased improvement and a combination of reaching both frailty and radiographic ideal ranges resulted in a cohort with reduced complication rates.

Hypothesis
Ability to improve Health-Related Quality of Life measures reaches a maximum according to frailty and radiographic severity

Design
Retrospective

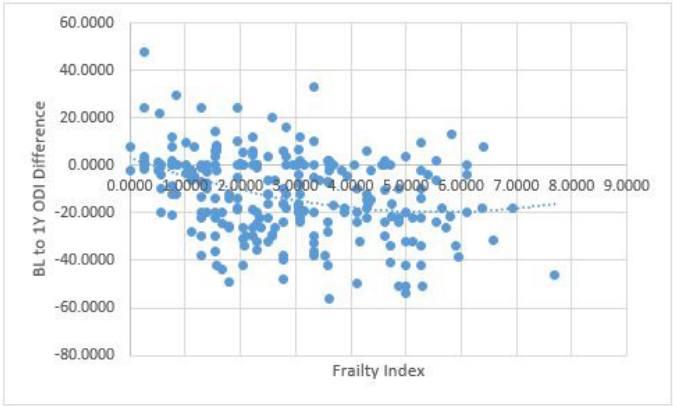
Introduction
Improvement capability increases with frailty and deformity severity to a certain point. The present study aimed to identify the range in which a patient would benefit from intervention and what the upper limit for reduced improvement would be due to severe frailty or deformity.

Methods
Surgically eligible ASD patients with baseline (BL) and up to 2-year (2Y) ODI were included. Difference between BL and 1Y ODI was calculated, graphed alongside Frailty Index and radiographic measures (Sacral Slope, Pelvic Incidence, PI-LL, Thoracic Kyphosis), and fitted to a polynomial, the vertex representing the value at which patients most improved. "Optimal Ranges" (OR) for these criteria were determined to be within a range of the vertex value. ANCOVA established estimated marginal means while adjusting for covariates including age, sex, and surgical invasiveness.

Results
Overall, 250 patients were included. BL Frailty value for vertex of polynomial between BL to 1Y ODI improvement and BL Frailty (R2=0.1199): 5.0. Frailty OR patients (between 4.0 and 5.2) had the highest improvement in ODI at 1Y (-20.44) compared to under the OR (-10.33) and over (-17.37, p=0.001). ODI improvement at 2Y: OR=-20.84; under=-12.32; over=-19.31, (p=0.006). Frailty OR had more improved SRS-22 Total Scores at 1Y (1.12; 0.73; 0.98; p=0.001) and 2Y (1.09; 0.77; 1.02; p=0.013). Radiographic vertices: SS=12.14; PI=53.2; PI-LL=53.1; TK=1.36. Patients who were within ±5 (OR) had greater improvement in 1Y ODI (-15.68) compared to no ORs (-11.27; p=0.125). ORs for both frailty and at least one radiographic had greatest improvement in ODI by 1Y (p=0.017) and 2Y (p=0.068) and lowest rates of major complications (p=0.086).

Conclusion
Patients above the determined thresholds have reduced improvement in patient-reported outcomes despite having more "room to improve," indicating that although capacity to improve is present, frailty or deformity inhibits the ability to do so.

Take Home Message
Degree of frailty and deformity can both enhance and limit a patient's ability to improve by patient-reported outcome measures depending on severity.



73. Comparison of Complications, Outcomes, and Cost in Frail vs. Non-Frail ASD Surgery Patients

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Summary
Frailty is a dynamic measure of physiological age. Overall, frail patients had more invasive surgeries, and experienced more complications postoperatively. Although initial costs of surgery are higher for frail patients, the quality of life gained is higher for not frail patients resulting in a comparable overall cost-utility of corrective surgery.

Hypothesis
To investigate impact of frailty on operative course, clinical outcomes, and cost utility.

Design
Retrospective cohort study of prospective, multicenter ASD database

Introduction
The impact of frailty on ideal sagittal alignment targets remains to be studied in literature.

Methods
Operative ASD patients (scoliosis >20, SVA>5cm, PT>25, or TK>60) with available baseline (BL) and 2-year (2Y) radiographic and HRQL data were included. The miller frailty index was used to stratify patients into 2 categories: Not Frail (NF) (<.3), and Frail (F) (>.3). Univariate and multivariate analysis assessed differences in radiographic, surgical, and clinical factors. Published methods to convert ODI to SF-6D obtained Quality Adjusted Life Years (QALY). QALYs utilized a 3% discount rate for residual decline to life expectancy (78.7 years). Direct costs calculated using the PearlDiver database incorporating complications, LOS, and associated healthcare costs.

Results
245 ASD patients met inclusion criteria (57yrs±15.0, 82%F, BMI: 26.3 kg/m2 ±6.0, ASD-FI: 2.9±1.6, CCI: 1.55 ±1.7). Frailty breakdown was: 138 (55%) NF, and 107 (45%) F patients. BL radiographic and perioperative parameters in Table 1. F patients had more overall complications (86% vs. 78%, p=.094), more major complications (41% vs. 24%, p=.003), and more reoperations (24% vs. 18%, p=.314). Controlling for age and deformity, F patients were more likely to experience major complications (1.9[1.04-3.5],p=.03). Improvement in ODI was greater for frail patients (-19 vs. -12), however, at 2Y ODI remained significantly higher (32 vs. 15, both p<0.05). In a cost analysis, 2Y cost of F patients was higher ($90,967 vs. $81,479), however, due to a greater gain in QALY, cost was comparable to NF patients ($71,600 vs. $75,191).

Conclusion
Frail patients experienced a longer LOS, and higher EBL, possibly due to the increased invasiveness used to treat a more severe deformity with a worse preoperative physiological state. Although frail patients experienced more complications, the higher overall improvement in ODI contributed to a comparable cost utility despite a higher initial cost.

Take Home Message
Despite higher initial surgical cost in frail patients, quality of life improvement in this population led to a similar cost utility of corrective surgery when compared to not frail patients.

	Not Frail	Frail	
PT	20°	26 °	p=.001
PI-LL	6.5°	20°	p=.001
SVA C7-S1	80mm	34mm	p=.001
BL ODI	27	52	p=.001
Invasiveness	88	100	p=.012
EBL	1550ml	2050ml	P=.008
LOS	7 days	8.8 days	P=.001

Baseline and perioperative differences between F and NF patients.

74. The At-HOME Score: A Novel Scoring System Predicting Discharge Disposition following ASD Surgery

Khaled M. Kebaish, MD; *Brian J. Neuman, MD*

Summary
Adult spinal deformity (ASD) surgery often results in non-routine discharge. The aim of this study was to develop and validate a novel scoring tool used for predicting non-home discharge after deformity surgery. We present the At-HOME score, which is composed of 5 preoperative variables: assigning points for low SRS Activity, Hypothyroidism, ODI ≥ 42, Motor weakness, and Elderly. Compared to a 4% risk of non-home discharge with a score of 0, scores ≥8 had an 86% risk of non-home discharge.

Hypothesis
Non-routine discharge can be predicted using a score-based risk stratification system

Design
Retrospective review of a single-center surgical registry

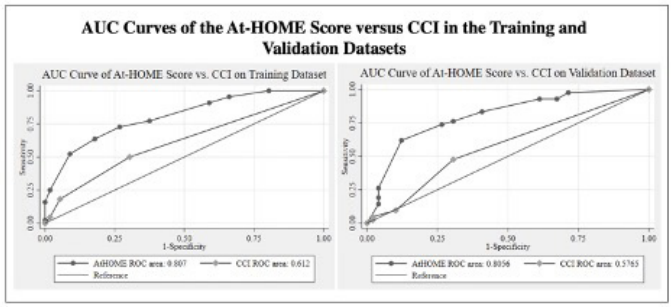
Introduction
ASD surgery requires an extended recovery period and often a non-routine discharge (DC). The aim of this study was to develop and validate a novel score-based risk stratification system to preoperatively identify patients most likely to require non-home DC.

Methods
The cohort included 195 adult ASD patients who underwent spine fusion ≥5 levels. We split this cohort, 50% for training the model and 50% for validation. Patient demographics, comorbidities, surgical parameters, ODI, SRS and Charlson Comorbidity Index (CCI) were collected. The primary outcome was home vs. non-home DC. Multivariable logistic regression was performed on the training set to identify preoperative risk factors for non-home DC. The risk factors were weighted based on nomogram analysis and aggregated into the 11-point At-HOME model. Using area under curve (AUC) analysis, we validated the At-HOME score by applying it to the validation set comparing it to CCI. Optimal cutoffs for the scoring system were determined using stratum-specific likelihood ratio (SSLR) analysis.

Results
Mean age at surgery was 60±13 yrs. 45% (88) had a non-home DC. Points in the At-HOME Score were assigned as follows: +1 for preoperative SRS Activity <3 (OR=2.4), +1 for Hypothyroidism (OR=2.8), +2 for preoperative ODI ≥42 (OR=2.7), +3 for preoperative Motor weakness (OR=2.8), +4 for Elderly age >65 (OR=5.6) (p<0.05 for all). The At-HOME score had an AUC of 0.81 in both the training and validation set, which was higher than the AUC of CCI (p<0.001). SSLR analysis produced 4 categories based on risk of non-home DC: 4% for score 0, 31% for score 1-5, 65% for score 6-7, 86% for score 8+. Relative to a score of 0, scores of 1-5, 6-7, and 8+ had 11x, 46x, and 150x greater odds of non-home DC (p<0.05 for all).

Conclusion
By using a robust combination of baseline demographics, objective clinical criteria, and patient reported outcomes, the At-HOME score was highly predictive of non-routine DC following ASD surgery. This tool was shown to be more predictive than CCI.

Take Home Message
The At-HOME score can be used by surgeons, perioperative teams, and policy-makers to efficiently predict non-routine DC in ASD patients



75. Health Related Quality of Life Measures in Adult Spinal Deformity: Can We Replace the SRS-22 with PROMIS?

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Summary
The Scoliosis Research Society 22-item questionnaire is commonly used to assess function, pain, self/image, and mental health in adult spinal deformity (ASD). The Patient Reported Outcome Measurement Information System (PROMIS) is a newer patient-reported metric that involves computer adaptive testing for each individual patient. This study determined the internal consistency, test-retest reliability, validity, responsiveness of PROMIS physical domains (Physical Function [PF], Pain Intensity[PI], Pain Interference[Int]) in comparison to the SRS-22r (Function, Pain, Self/Image, Mental Health).

Hypothesis
Responsiveness of the PROMIS domains will be comparable to the SRS-22 in operative ASD patients.

Design
Retrospective

Introduction
The validity and responsiveness of PROMIS vs. SRS-22r has yet to be investigated in ASD patients.

Methods
Surgical ASD patients ≥18yrs, ≥4 levels fused included. All patients had complete baseline (BL) PROMIS and SRS-22r data. Internal consistency (Cronbach's alpha), test-retest reliability (intraclass correlation coefficient; ICC), convergent and known groups validity, and sensitivity to change (standard response means) were compared. Cronbach's alpha and ICC values ≥0.70 were predefined as satisfactory. Convergent validity was tested by estimating Spearman's correlations (<0.40 weak, 0.40-0.60 moderate, >0.60 strong). Responsiveness was assessed via paired samples t-tests with Cohen's d to assess measure of effect (baseline-3 months)

Results
110 pts (59.2yrs, 69.3%F, 28.1 kg/m2) included. Mean baseline SRS-22 and PROMIS domains can be seen in Table 1. Cronbach's alpha and ICC were not satisfactory for any of the SRS-22 and PROMIS domains. Specifically, SRS-22 Function and PROMIS-PF demonstrated a Cronbach's alpha of 0.167, and an ICC of 0.091, while PROMIS-PI and SRS-22 Pain were 0.164 and 0.076, respectively. PROMIS-Int reliability was low for all SRS-22 domains (0.037-0.225). Convergent validity demonstrated strong correlation between PROMIS-PI and SRS-22r(-0.61), SRS-22 Function(-0.781), and SRS-22 Pain(-0.735). PROMIS-PF had strong correlation with SRS-22 Function (0.643), while PROMIS-Int had a moderate negative correlation with SRS-22 Pain(-0.507). SRS-22r and Self Image changed pre- to post-operatively($p<0.050$), but Function, Pain, and Mental Health did not (all $p>0.1$). PROMIS-PI and Int changed at follow up($p<0.050$), but PF did not($p=0.327$). Effect size via Cohen's d, showed that PROMIS PF and Int had greater effect across all domains except for Self Image [Table 1].

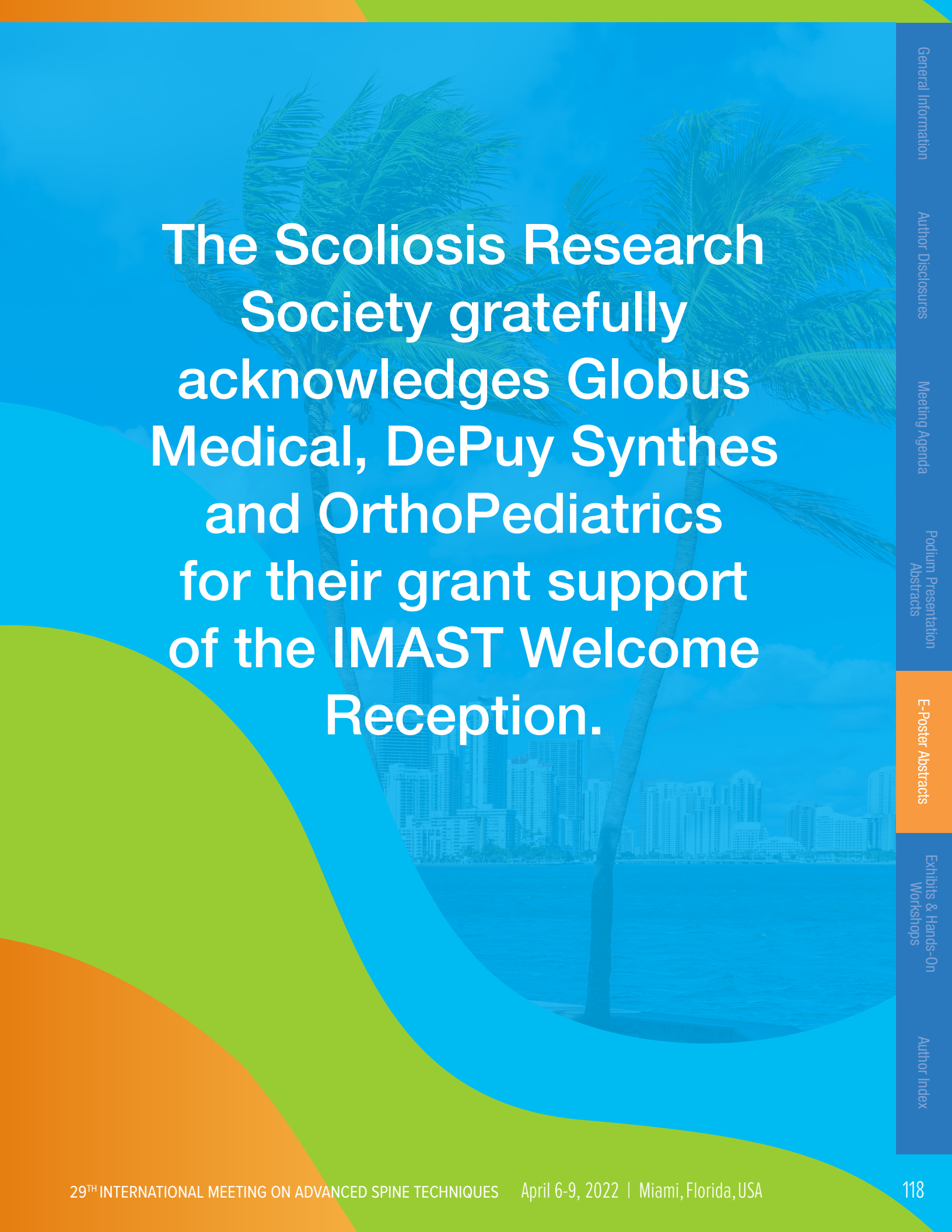
Conclusion
PROMIS is a valid measure compared to the SRS-22r in terms of convergent validity, as well as has greater measure of effect in terms of responsiveness, but failed in reliability and internal consistency.

Take Home Message
Surgeons should consider the lack of reliability and internal consistency (despite validity and responsiveness) of the PROMIS to SRS-22r before replacing the traditional questionnaire with the computer-adaptive testing.

SRS-22r		
Overall	2.6	
Function	2.6	
Pain	2.5	
Self/Image	2.2	
Mental Health	3	
PROMIS		
Physical Function	12.4	
Pain Intensity	91.7	
Pain Interference	55.9	
Responsiveness		
	Cohen's d	Effect
SRS-22r	0.37	Medium
SRS-22 Function	0.04	-
SRS-22 Pain	0.23	Small
SRS-22 Self/Image	0.91	Large
SRS-22 Mental Health	0.04	-
PROMIS Physical Function	0.58	Large
PROMIS Pain Intensity	0.17	Small
PROMIS Pain Interference	0.66	Large

Mean baseline SRS-22r and PROMIS scores for all domains, and responsiveness of each of the HRQLs based on Cohen's d and each effect

E-Poster Abstracts



The Scoliosis Research Society gratefully acknowledges Globus Medical, DePuy Synthes and OrthoPediatrics for their grant support of the IMAST Welcome Reception.

101. Results of Posterior Spinal Fusion (PSF) After Failed Anterior Vertebral Body Tethering (aVBT)

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Summary
The exact role of aVBT continues to evolve. Several studies provide support; however, this is tempered by a reported high revision rate (~20-30%). Some patients will require PSF after failed aVBT. On average, this occurs ~4yrs after the index procedure. Excellent radiographic correction is obtained with similar implant density and percent correction but is technically more challenging with significant increases in EBL and OR time. This supports aVBT as an alternative but this must be counterbalanced with risk of reoperation.

Hypothesis
Fusion after aVBT will provide inferior outcomes compared to patients undergoing primary fusion without a previous aVBT.

Design
Single Center Retrospective Review

Introduction
In a subset of patients undergoing aVBT, some will require PSF. Limited data exists on the results of fusion after tethering, with regards to clinical and radiographic outcomes. The purpose of this study was to compare this cohort to patients undergoing fusion without a previous VBT.

Methods
Under IRB approval, a dataset of 490 patients were analyzed who underwent aVBT. 20 patients (4.1%) subsequently underwent conversion to posterior spinal fusion. A matched control group was collected of primary fusions (no previous VBT) closely matched for comparison. Clinical and radiographic data were collected across multiple time points and compared using paired t-tests.

Results
There is a significant increase in estimated blood loss (EBL) (p=0.012), operative time (p=0.034) in VBT conversion group compared to primary fusion. An increased amount of radiation exposure (mGy) was noted in the conversion group but did not show a significant difference (p=0.13). There was no difference in the number of levels fused (p=0.38), implant density (p=0.13), blood transfusions, and intraoperative neuromonitoring events. There is no significant difference between both the thoracic and lumbar percent correction of the major cobb from preop to latest follow up (Thoracic p=0.507, Lumbar p=0.952). The average time to conversion was ~ 4 years (46.8 ± 16.4 months).

Conclusion
A subset of aVBT patients will require conversion to posterior spinal fusion. These failures typically occur 3-5 years post index procedure. Although technically it may make the revision surgery challenging, it can be safely performed with similar clinical and radiographic outcomes. This supports feasibility of aVBT as a growth modulating technique that does not lose its ability to convert to a traditional fusion.

Take Home Message
Fusion can be performed safely with similar results to those without a previous tether. Operative challenges are encountered but outcomes remain the same as primary fusion.

Table #1

	Tether to Fusion Conversion (n= 20)	Fusion Control (n=40)	p-Value
EBL	607.25 ± 308.20	445.3 ± 251.4	0.0125
Transfusion (Y/N)	4	5	
Transfusion Amounts (mL)	66.25 ± 136.76	41.88 ± 112.72	
Total Length of surgery (minutes)	332.60 ± 63.2	288.58 ± 66.37	0.0343
Radiation exposure (mGy)	23.90 ± 14.47	17.94 ± 9.73	0.1277
Levels Fused	11.25 ± 1.12	10.5 ± 1.63	0.3841
Total Length of Stay: Total/(ICU)	4.90 ± 0.97/(1.90 ± 0.97)	4.1 ± 1.03/(1.48 ± 0.78)	0.036
Number IONM Events	1 Case No Post Op neuro deficit	1 Case No Post Op neuro deficit	
Implant Density	1.91 ± 0.10	1.96 ± 0.06	0.1331
Thoracic Percent Correction (PreOp to Latest)	80.3 ± 31.27%	83.84 ± 15.66%	0.5065
Lumbar Percent Correction (PreOp to Latest	70.09 ± 14.91%	69.90 ± 20.31%	0.952

VBT Conversion Clinical Data Table

102. Trying To Find The Sweet Spot: Results of Significant vs. Limited Growth with Anterior Vertebral Body Tethering

Amer F. Samdani, MD; Joshua M. Pahys, MD; Firoz Miyanji, MD; Baron S. Lonner, MD; Solomon Samuel, D. Eng.; Alejandro Quinonez, BS; Evan Yarnall, BS; Steven W. Hwang, MD

Summary
Timing of surgical intervention with anterior vertebral body tethering (VBT) remains unclear. We analyzed 189 patients who underwent VBT at a single institution and stratified them by those with significant growth vs. limited growth remaining. At last visit, patients with significant growth demonstrated smaller Cobb angles but also more reoperations than those with limited growth. VBT relies on growth, but surgeons must tailor their surgical strategy according to growth potential to optimize outcomes.

Hypothesis
Patients with significant growth remaining will have better outcomes than those with limited growth after VBT.

Design
Single center retrospective review

Introduction
Anterior VBT is intended for skeletally immature patients. It remains unclear how the amount of growth remaining affects outcomes.

Methods
From a dataset of 203 patients with thoracic curves and minimum 2-year follow-up, we identified 189 who had preoperative hand x-rays to assess remaining growth. Patients were divided into those with significant growth remaining (S=Sanders 1-3) and those with limited growth potential (L=Sanders 4-6). Radiographic and clinical outcomes were analyzed and compared using Student t tests.

Results
139 patients comprised the S group and 50 the L group. At last visit, 83% in the S group and 90% in the L group were skeletally mature (Risser 4 and 5). Both groups were similar with respect to major Cobb (S= 52 ± 10.5°, L= 52 ± 9°, p= 0.9), flexibility (% correction S= 54.3 ± 20.0%, L= 56.5 ± 21.1%, p= 0.6), and number of levels tethered (S= 8.3 ± 1.3, L= 8.4 ± 1.3, p= 0.57). The S group had a higher percentage of premenarche (S= 75.6%, L= 41.3%) and patients with open triradiates (S= 42.5%, L= 0%). The change in height from pre-op to most recent was greater in the S group (S=10.7 ± 6.3 cm, L= 4.5 ± 2 cm, p< 0.01). At last visit, those with significant growth remaining had smaller Cobb angles (S=21.7 + 11.1°, L=27 + 10.9°, p<.01). Reoperations occurred in 32 patients (23.0%) in the S group, most often for overcorrection (71.9%), whereas only 2 patients in the L group underwent a reoperation.

Conclusion
Patients with significant growth who undergo VBT demonstrate improved Cobb angles but also more reoperations than those with limited growth. A customized surgical strategy in which less intraoperative correction is attained for those with significant growth may reduce the risk of overcorrection. Conversely, aggressive correction in those with limited growth potential may still provide adequate radiographic outcomes at skeletal maturity.

Take Home Message
Patients with significant growth after VBT demonstrate smaller Cobb angles but also more reoperations than those with limited growth. Surgeons may need to customize intraoperative correction accordingly to optimize results.

	Sanders 1-3	Sanders 4-6	P
Age at operation (years)	12.4 ± 1.3	13.3 ± 1.0	**<.01**
% female	89	92	NS
% premenarchal	76	41	**<.01**
% triradiates open	43	0	**<.01**
Average follow-up (months)	42.7 ± 17.7	35.4 ± 12.6	**<.01**
Pre-op thoracic Cobb	52 ± 10.5	52 ± 9	NS
Pre-op lumbar Cobb	32.8 ± 11.2	31.5 ± 10.9	NS
Flexibility percent correction	54.3 ± 20.0	56.5 ± 21.1	NS
T5-T12 kyphosis	20.7 ± 11.2	20 ± 8.9	NS
T12-L5 lordosis	46.9 ± 13.6	45.7 ± 12.8	NS
Number of levels tethered	8.3 ± 1.3	8.4 ± 1.3	NS
Mean OR time (minutes)	238.8 ± 102.9	236.1 ± 104.9	NS
Mean estimated blood loss (mL)	127.8 ± 142.2	115.7 ± 122.1	NS
Last visit thoracic Cobb	21.7 ± 11.1	27 ± 10.9	**<.01**
Last visit lumbar Cobb	18.2 ± 9.3	19.8 ± 9.7	NS
Last visit T5-T12 kyphosis	23.7 ± 12.7	26.2 ± 11.2	NS
Last visit T12-L5 lordosis	47.4 ± 14.4	48.2 ± 14.1	NS
Last Risser score	4.2 ± 1.1	4.4 ± 0.6	NS
Change in height (pre-op to last visit) (cm)	10.7 ± 6.3	4.5 ± 2.6	**<.01**

103. Difference Between Radiographically Suspected and Intra-Operatively Confirmed Tether Breakages After Vertebral Body Tethering (VBT) for Idiopathic Scoliosis

Per D. Trobisch, MD; Alice Baroncini, MD; Stephanie Da Paz, MD

Summary
Tether breakages were evaluated intraoperatively in patients who have had anterior revision after failed vertebral body tethering. 36 / 80 segments were found to have a tether breakage. Only 20 of these 36 breakages were suspected pre-operatively by using the ">5° rule". This study shows that tether breakage after VBT may be under diagnosed but also that tether breakages often do not lead to relevant segmental loss of correction.

Hypothesis
We hypothesize that the real incidence of tether breakages after VBT is much higher than the incidence that is calculated by using the radiographic ">5° rule".

Design
Retrospective data analysis, consecutive case series.

Introduction
Vertebral Body Tethering (VBT) has shown promising results but also a high tether breakage rate, which has been reported in up to 48% of patients. Tether breakages can lead to loss of correction and the most used definition for tether breakage is a loss of segmental correction of >5°. However, there may also be some breakages that do not have a negative influence on curve correction. Analyzing the real breakage rate was the aim of this study.

Methods
All patients who underwent anterior revision surgery after VBT were included in this retrospective study. Real (intraoperatively confirmed) tether breakages were compared to pre-operatively suspected tether breakages. The definition for a suspected tether breakage was an angular change of more than 5° between any early and the latest radiograph.

Results
10 patients who received 11 revision surgeries with a total of 15 revised curves were analyzed. Of the 80 analyzed segments, 36 were found to have breakage. Of these 36 segments, 20 were suspected to be broken pre-operatively. 16 breakages were not identified on pre-operative radiographs (44%). 1 suspected broken tether was intraoperatively found to be intact.

Conclusion
By using the >5° rule, only 56% of the tether breakages could be diagnosed. On the other hand, many tether breakages will not result in a loss of correction.

Take Home Message
Tether breakage rate after VBT is much higher than suspected but many tether breakages will not have a relevant negative effect on curve behavior.

104. Spontaneous Lumbar Curve Correction Following Vertebral Body Tethering of Main Thoracic Curves

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Summary
Growth modulation through vertebral body tethering (VBT) has emerged as a fusionless option for progressive thoracic scoliosis. While VBT directly corrects the main thoracic curve, the compensatory lumbar curve must correct indirectly to maintain coronal balance. At 2 years post-thoracic VBT, spontaneous lumbar curve correction was 31%, 26%, and 24% for lumbar modifiers A, B, and C, respectively.

Hypothesis
The uninstrumented lumbar curve after VBT will demonstrate initial spontaneous lumbar curve correction (SLCC) and continued correction over time.

Design
Retrospective, multicenter

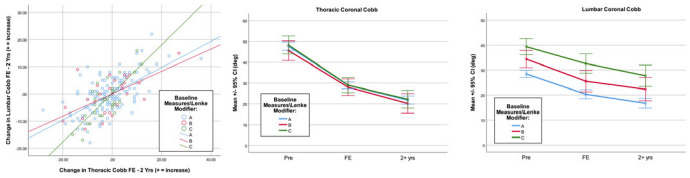
Introduction
Growth modulation through VBT has emerged as a fusionless option for progressive thoracic scoliosis. Little is known about the response of the uninstrumented compensatory curves after initial implantation and during subsequent period of growth modulation.

Methods
A review of patients that had VBT of their main thoracic scoliosis and minimum 2 years of follow-up was performed. Cobb angles for the main thoracic and compensatory lumbar curves were recorded at preop, first erect (FE) postop, and at 2 years postop. Lumbar curves were further stratified based on their lumbar modifier (A, B or C). Repeated measures ANOVA and ANOVA was performed to compare correction rates and Pearson's coefficient to determine the correlation between the tethered thoracic curve and uninstrumented lumbar curve Cobb angles.

Results
218 patients (155 lumbar modifier A, 32 B, and 31 C) were included. Thoracic curve (48±9°) correction was 40% at FE (29±8°), and 43% at 2 years (27±11°), (p=0.04). The SLCC at FE was 30%, 26%, and 18% for lumbar modifiers A, B, and C, respectively (p <0.001). After 2 years, SLCC was similar: 31%, 26% and 24% respectively. Further analysis of the 218 patients demonstrated that only 118 (54%) had thoracic curve improvement (growth modulation) from FE to 2 years. In this subgroup, thoracic curves improved 39% at FE and 55% at 2 years. SLCC at FE was 30%, 25%, and 16% for lumbar modifiers A, B, C, respectively with additional improvement to 42%, 35%, and 31% at 2 years. The FE to 2 year changes in thoracic and lumbar curves were highly correlated (r=0.641, p<0.001).

Conclusion
There is immediate SLCC following VBT correction of a main thoracic curve. Further improvement of the thoracic curve through growth modulation was present in only half the case. For those with additional growth modulation, the 2 year SLCC was 31-42%. As indications for VBT are further refined, this data will provide insight into the response of the lumbar curve after thoracic VBT.

Take Home Message
The spontaneous lumbar curve correction 2 years following vertebral body tethering of main thoracic curves was 31%, 26%, and 24% for lumbar modifiers A, B, and C, respectively.



105. Management of AIS with Double Major Curves with Hybrid Technique. Combination of Posterior Pedicle Screw Fixation-Fusion for Thoracic and Vertebral Body Tethering for Thoracolumbar/Lumbar Curves

Meric Enercan, MD; Hamisi M. Mraja, MD; Halil Gok, MD; Ugur Tasci, MD; Ayhan Mutlu, MD; Tunay Sanli, MA; Selhan Karadereler, MD; Azmi Hamzaoglu, MD

Summary
Hybrid technique including posterior pedicle screw fixation-fusion for thoracic curve with hypokyphosis/lordosis(HK/L) and Vertebral Body Tethering(VBT) with double screw double cord(DS-DC) fixation for thorocalumbar/lumbar(TL/L) curve provided satisfactory corrections on both planes. Thoracic kyphosis was restored with posterior surgery with or without Ponte ostetotomy. The cervical sagittal alignment improved following restoration of TK in pts with preop hypokyphosis/lordosis. VBT with DS-DC fixation preserved spinal flexibility and lumbar spine motion without any cord rupture at the end of 2 years f/up.

Hypothesis
VBT is not powerful enough to restore ideal thoracic sagittal alignment in pts with thoracic hypokyphosis/lordosis. We planned posterior surgery for thoracic scoliosis with HK/L & VBT with DS-DC to correct TL/L deformity, preserve spinal flexibility & motion of the lumbar spine.

Design
Retrospective

Introduction
We combined two techniques for management of the double major

curves. Posterior surgery was performed to correct thoracic coronal and sagittal deformity & VBT with DS-DC fixation was performed for TL/L deformity. The aim of this study to evaluate the results of hybrid technique for the surgical treatment of AIS with double major curves

Methods
42(32F,10M) pts, mean age 14(11-18)years were included. Indication for posterior surgery was presence of thoracic HK/L or upper trunk shift/shoulder asymmetry occurred following TL/L curve correction with VBT. Coronal and sagittal parameters were measured on preop, first erect & f/up x-rays. Preop & f/up lumbar ranges of motion were compared. SRS-22r was used for clinical assessment

Results
Mean f/up was 28 (24-62) months. Mean MT curve 48° was corrected to 8° at f/up (84%). Mean TL/L curve of 52° was corrected to 8,5° at f/up (83,5%).In 18 pts, thoracic hypokyphosis of 9,1° restored to 29° with posterior surgery using only reduction screws without osteotomy. Multi-level Ponte osteotomies were performed in 13 pts with lordoscoliosis. Thoracic lordosis of -8° restored to 32° with Ponte osteotomy. Preop cervical kyphosis of 9.6° improved to 7° lordosis following TK restoration. According to TL/L sagittal alignment, anterior or posterior cord was tightened first to restore TL/L alignment.12 pts with TL kyphosis of 14.4°was restored to 2.3°.There was no cord rupture. Preop lumbar ROM was preserved at f/up.

Conclusion
Posterior surgery w/o Ponte osteotomy enables restoration of TK in pts with thoracic hypokyphosis/lordosis. The sagittal cervical alignment improved following TK restoration. VBT with DS-DC fixation provided TL/L deformity correction, restored ideal TL/L alignment, preserved spinal flexibility and motion of lumbar spine.

Take Home Message
Hybrid technique, including posterior surgery w/o Ponte osteotomy for thoracic curve with hypokyphosis/lordosis & VBT with Double Screw-Double Cord fixation for thorocalumbar/lumbar deformity provided satisfactory corrections without any cord rupture

108. Neurologic Dysfunction in Adolescent Idiopathic Scoliosis Patients Treated with Thoracoabdominal Vertebral Body Tethering

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Summary
In adolescent idiopathic scoliosis (AIS) treatment, Vertebral body tethering (VBT) is an emerging technique which can be utilized for thoracolumbar curve correction through an anterior-to-the-psoas approach. In investigating neurologic complications and the safety of neuromonitoring, 10% of patients experienced iliopsoas (IP) irritation and 50% experienced transient numbness. A change in the Quadricep MEP from baseline during surgery was associated with transient numbness in the Obturator nerve distribution. All patients with numbness improved without intervention.

Hypothesis
Neurologic monitoring, clinical and surgical characteristics can be used to predict transient sensory changes in the medial thigh following anterior-to-the-psoas approach for VBT of AIS patients.

Design
Retrospective analysis of AIS patients who underwent anterior-to-the-psoas approach for VBT at a single academic medical center from 2020 through 2021.

Introduction
Vertebral body tethering (VBT) for adolescent idiopathic scoliosis (AIS) utilizes a retroperitoneal approach to achieve tether placement for thoracolumbar curves. Major neurologic complications are uncommon; however, paresthesia and/or numbness on the medial thigh can occur due to the anatomy of the psoas muscle. To date, no description of the frequency or risk factors for these sensory changes has been published.

Methods
Demographic and clinical characteristics were obtained. Neurologic monitoring and clinical variables were assessed for all patients who underwent anterior-to-the-psoas approach for VBT. Differences in variables were assessed via T-test and chi-square square.

Results
30 patients were included. 10% of patients experienced IP irritation and 50% experienced transient numbness in the thigh. Sensory change was significantly associated with a change in Quadriceps MEP from baseline during surgery. No other factors were significant. No patients developed a motor deficit. All sensory changes resolved without intervention with full resolution of symptoms averaging 6 days.

Conclusion
Anterior-to-the-psoas approaches for VBT are safe and effective. An anterior-to-the-psoas approach decreases complication risks, which is further supported by the absence of post-op motor deficits for the study cohort. Despite a significant difference in Quadricep MEP between those with and without sensory symptoms, no clinical presentation correlated to this difference. Other neuromonitoring and clinical characteristics were not predictive in this study. Sensory changes resolved without intervention within several weeks.

Take Home Message
Absence of major or persistent deficits underlines the reliability of anterior-to-the-psoas approaches in VBT. Change in Quadricep MEPs may be associated with sensory symptoms and would benefit from additional inquiry.

Table 1: Demographic, clinical and neuromonitoring data from 30 AIS patients following thoracolumbar VBT.

			No Post-op Paresthesia (n=15)	Post-op Paresthesia Present (n=15)	p value
Demographics	Age		15.13±3.87	13.53±1.81	0.158
	Gender (%F)		86.70%	86.70%	1
	BMI		20.84±2.69	21.92±2.88	0.94
	Risser		3.03±1.88	2.67±1.95	0.604
	Sanders		5.70±2.21	4.54±2.73	0.286
	Charlson Comorbidity Index (CCI)		0	0	
Radiographic Parameters	Starting Lumbar Cobb Angle (°)		50.69±12.23	43.76±8.53	0.098
	Post-op Lumbar Cobb Angle (°)		24.42±11.71	20.79±8.89	0.454
	Change in Cobb Angle (°)		-23.61±7.01	-25.03±16.06	0.810
Surgical Characteristics	Op time (min)		493.53±119.96	473.20±120.16	0.646
	EBL (mL)		373.33±211.18	303.33±89.58	0.247
	Fluro dose (mGy)		119.71±119.08	91.74±68.68	0.437
	Levels Corrected		8.67±2.53	8.40±2.44	0.771
	LIV		22.80±0.68	22.93±0.26	0.485
	Double Staple at LIV		80.00%	93.30%	0.283
	Double Curve		53.30%	46.70%	0.715
	Left Retroperitoneal Approach		69.20%	90.00%	0.231
	Retroperitoneal First Approach		60.00%	73.30%	0.439
Sensory Evoked Potentials	Change in SEP Morphology	*stable*	23.10%	40.00%	0.339
		variable	61.50%	60.00%	0.934
		absent	15.40%	0.00%	0.115
	Loss of SEP	*no loss*	66.70%	73.30%	0.706
		partial loss	25.00%	26.70%	0.922
		loss	8.30%	0.00%	0.255
Motor Evoked Potentials	Baseline Iliopsoas MEP	*present*	100.00%	91.70%	0.350
		variable	0.00%	8.30%	0.350
		absent	0.00%	0.00%	
	Change in Iliopsoas MEP	*no change*	70.00%	44.40%	0.260
		decreased	30.00%	55.60%	0.260
		absent	0.00%	0.00%	
	Baseline Adductor MEP	*present*	84.60%	85.70%	0.936
		variable	0.00%	7.10%	0.326
		absent	15.40%	7.10%	0.496
	Change in Adductor MEP	*no change*	63.60%	40.00%	0.279
		decreased	27.30%	50.00%	0.284
		absent	9.10%	10.00%	0.943
	Baseline Quadriceps MEP	*present*	100.00%	85.70%	0.157
		variable	0.00%	0.00%	
		absent	0.00%	14.30%	0.157
	Change in Quadriceps MEP	*no change*	84.60%	45.50%	0.043
		decreased	15.40%	45.50%	0.106
		absent	0.00%	9.10%	0.267

Table 1: Demographic, clinical and neuromonitoring data from 30 AIS patients following thoracolumbar VBT.

109. High Volume Surgeons Have Better Surgical Outcomes and Lower Costs

Vishal Sarwahi, MD, MBBS; Sayyida Hasan, BS; Jesse M. Galina, BS; Terry D. Amaral, MD

Summary
High volume surgeons have better intraoperative outcomes and lower costs than low-volume surgeons.

Hypothesis
High volume surgeons will have lower costs than low-volume surgeons.

Design
Retrospective Review

Introduction
Increased surgical volume has been associated with improved perioperative outcomes after spinal deformity correction. However, there is a lack of information on how this may affect hospital costs.

Methods
A retrospective study of adolescent idiopathic scoliosis (AIS) patients undergoing PSF from 2013 – 2019 was performed. Demographic, XR, chart review and hospital costs were collected and compared between high-volume (HV) surgeons (>50 AIS cases/yr) and low-volume (LV) surgeons (≤50/yr). Comparative analyses were computed using Wilcoxon Rank-Sum, Kruskal-Wallis, and Fisher's exact tests. Median values with corresponding IQRs were reported.

Results
A total of 335 patients (HV: 198, LV: 137) operated by 4 surgeons (1 HV, 3 LV). Radiographic parameters were similar between the groups. HV surgeons had significantly lower EBL (325v600 mL, $p<0.001$), fewer intraoperative transfusions (9.1% vs. 17.5%, $p<0.022$), and shorter surgery time (232min vs. 304min, $p<0.001$), radiation from intraoperative fluoroscopy (2.81mGy vs. 1.64mGy, $p<0.001$). HV patients were more likely to be extubated in the OR (98.5% vs. 86.1%, $p<0.001$) and perioperative complications (within 30 days) (0.5% vs. 5.8%, $p = 0.004$). HV surgeons had significantly lower total costs ($63,793.50 vs. $59,480.30, $p<0.001$). This included lower transfusion costs ($p = 0.022$), OR costs ($14,779.80 vs. $11,205.60, $p<0.001$), and costs associated with a 30-day emergency department (ED) return ($p=0.019$). Postoperative hospital stay ($34,400 vs. $34,400, $p=0.600$) and screw costs ($14,720 vs. $14,080, $p= 0.491$) were similar.

Conclusion
High Volume surgeons had lower transfusion rates, shorter surgery time and were more likely to be extubated in the OR than their low volume counterparts. In addition, high volume surgeons had lower overall costs compared to low volume surgeons.

Take Home Message
High volume surgeons have better surgical outcomes and lower costs than low volume surgeons.

110. Risk Factors for Early Tether Breakage After VBT

Alice Baroncini, MD; Stephanie Da Paz, MD; Per D. Trobisch, MD

Summary
Tether breakage is a common mechanical complication after VBT. Breakages happens more frequently after lumbar instrumentation. Age or skeletal maturity do not influence the breakage rate. Coronal imbalance represents a risk factor for tether breakage both for thoracic and lumbar curves, along with a low postoperative thoracic kyphosis for thoracic curves and high preoperative flexibility along with a high amount of correction for lumbar curves.

Hypothesis
We hypothesized that some perioperative demographic or

radiographic parameters may represent risk factors for an early tether breakage (within 12 months from surgery).

Design
Retrospective study of prospectively collected data

Introduction
Tether breakage represents the most frequent mechanical complication of VBT. Aim of this study was to identify possible perioperative risk factors for an early rupture to improve patients' care and informed consent.

Methods
Perioperative radiographic and demographic data of all consecutive patients who underwent VBT and had a FU of 1 year were collected (age, Risser, Sanders, curve magnitude and flexibility, coronal imbalance, sagittal parameters before VBT and at the 1st standing x-ray). The data of the curves that showed an early rupture where compared with those who didn't with a T-Test.

Results
Data from 105 patients and 153 instrumented curves (85 thoracic, 68 lumbar) were obtained. A breakage was observed in 20% of thoracic curves and 53% of lumbar ones. Age and skeletal maturity did not represent a risk factor (RF) for tether breakage. In thoracic curves, only a high preoperative coronal imbalance ($p = 0.02$) and a lower values of postoperative thoracic kyphosis ($p = 0.03$) were highlighted as RF. In lumbar curves, a high preoperative flexibility ($p = 0.0002$) and coronal imbalance ($p = 0.005$) were observed to be RF, along with a smaller curve magnitude ($p = 0.003$) and a higher amount of curve correction ($p = 0.0002$).

Conclusion
Lumbar curves present a higher rupture rate than thoracic ones. Age and skeletal maturity do not represent RF for early rupture, while a high preoperative coronal imbalance is a RF for both thoracic and lumbar curves. In lumbar curves, high preoperative flexibility along with a high amount of correction also represent RF for tether breakage, along with postoperative thoracic kyphosis for thoracic curves. Further techniques such as double tether may be used in patients who present these RF to minimize the risk of early rupture.

Take Home Message
Coronal imbalance represents a risk factor for rupture in all curves, with low postoperative TK for thoracic curves and high preoperative flexibility and high amount of correction for lumbar curves.

111. Impact of Skeletal Maturity on Radiographic Outcomes After Vertebral Body Tethering in Adolescent Idiopathic Scoliosis

Theodor Di Pauli von Treuheim, B. Eng; Lily Q. Eaker, BA; Dhruv S. Shankar, BS; Jonathan Markowitz, MD; James Meyers, BA; *Baron S. Lonner, MD*

Summary
Despite less curve correction, more skeletally mature patients still experience comparable clinically successful outcomes to immature patients at 2 year follow-up post VBT surgery for correction of AIS.

Hypothesis
More skeletally mature patients experience less percent curve correction but still have clinically successful correction as compared to immature patients.

Design
Retrospective; Single Center

Introduction
Vertebral body tethering (VBT) is a non-fusion scoliosis correction approach that uses remaining skeletal growth to impart curve correction in patients with Adolescent Idiopathic Scoliosis (AIS). Our aim was to assess whether satisfactory outcomes can be achieved in patients with little or no remaining growth.

Methods
Patients with single thoracic curves 40–70°, age<18, and >2-year follow-up were included. Patients were grouped by skeletal maturity: Immature (IM), Risser 0–2 (n=16) vs. Mature (M), Risser 3–5 (n=19). Radiographic measures were collected preoperatively (PR), at first erect (FE), and at two-year follow-up (YR2) using Mann-Whitney U-test ($p<0.05$).

Results
There was no difference between groups in thoracic curve correction at FE, but at YR2 the IM group yielded a lower residual curve [15° (-16°–38°) vs. 29° (12°–42°), p=0.008]. The compensatory thoracolumbar/lumbar curves corrected similarly in both groups at FE and YR2 and there was no difference in sagittal curve behavior at two years. Clinically successful correction (residual curve<35º) was similar at two years [15 (94%) vs. 15 (79%), p=0.58]. Two overcorrections occurred, both in IM patients. The instrumented segment vertical height increased significantly between time intervals only in immature patients. No revisions or conversions to spinal fusion were needed.

Conclusion
Both skeletally immature and mature patients yield clinically successful radiographic outcomes at two years. Skeletally immature patients benefit from greater post-operative curve correction but are at the risk of overcorrection. Further follow up is needed to assess if satisfactory correction is maintained in mature patients seeking to avoid fusion.

Take Home Message
Although controversial, we show less but still clinically successful correction with VBT in more skeletally mature AIS patients at 2 year follow-up.

TABLE	Radiographic Parameters Comparing Immature and Mature Patients		
Variable Risser	Skeletally immature 0 – 2	Skeletally mature 3 – 5	*p-value*
Instrumented major thoracic curve, degree, median (range)			
Preoperative	51 (36 – 69)	49 (40 – 69)	0.77
First erect	23.5 (4 – 36) *	29 (13 – 46) *	0.27
Two-year follow up	15 (-16 – 38) *‡	29 (12 – 42) *	0.008
Percent correction, % degree, median (range)			
First erect	55.5 (31 – 92)	44 (33 – 73)	0.37
Total	69 (28 – 132)	53 (13 – 76)	0.008
Follow up	15 (-75 – 500)	0 (-61 – 30)	0.09
Non-instrumented TL/L curve, degree, median (range)			
Preoperative	32.5 (17 – 52)	31.5 (9 – 47)	0.77
First erect	13 (-6 – 29) *	13 (3 – 33) *	0.72
Two-year follow up	13.5 (-17 – 27) *	15 (0 – 31) *	0.77
Percent correction, % degree, median (range)			
First erect	42.5 (8 – 119)	57.5 (-22 – 83)	0.18
Total	51 (-14 – 153)	55.5 (-33 – 100)	0.85
Follow up	4 (-183 – 214)	0 (-300 – 100)	0.64
T5–T12 Kyphosis, degree, median (range)			
Preoperative	23.5 (12 – 38)	19 (4 – 38)	0.51
First erect	21.5 (10 – 37)	17 (4 – 35)	0.10
Two-year follow up	23.5 (15 – 41)	20 (1 – 45)	0.14
Change in T5–T12 Kyphosis, degree, median (range)			
First erect	-5 (-12 – 9)	-5 (-13 – 16)	0.82
Total	1.5 (-12 – 9)	3 (-18 – 15)	0.61
Follow up	4 (-7 – 10)	2.5 (-20 – 19)	0.94
UIV–LIV vertical height, cm, median (range)			
Preoperative	15 (13 – 20)	20 (14 – 25)	<0.001
First erect	18 (13 – 20) *	21 (15 – 26)	<0.001
Two-year follow up	19.5 (14 – 24) *‡	22 (16 – 26)	0.12

*: within group difference compared to preoperative, Bonferroni-corrected p<0.05
‡: within group difference compared to first erect, Bonferroni-corrected p<0.05
Follow up refers to the change that occurred between first erect and the two-year mark

112. Can We Stop Distally at LSTV-1 for Adolescent Idiopathic Scoliosis with Lenke 1A/2A Curves?

Xiaodong Qin, PhD; Yong Qiu, MD; Bin Wang, MD; Bangping Qian, MD; Zhen Liu, MD; Zezhang Zhu, MD

Summary
Selecting one level proximal to last substantially touching vertebra (LSTV-1) as lowest instrumented vertebra (LIV) could yield good outcomes in nearly 50% adolescent idiopathic scoliosis (AIS) with Lenke 1A and 2A curves. However, for skeletally immature patients with long thoracic curve, preoperative coronal imbalance, large rotation and deviation of LSTV-1, distal fusion level should extend to LSTV to avoid distal adding-on.

Hypothesis
In some cases, selecting LSTV-1 as LIV could achieve similar outcomes to LSTV.

Design
Retrospective study

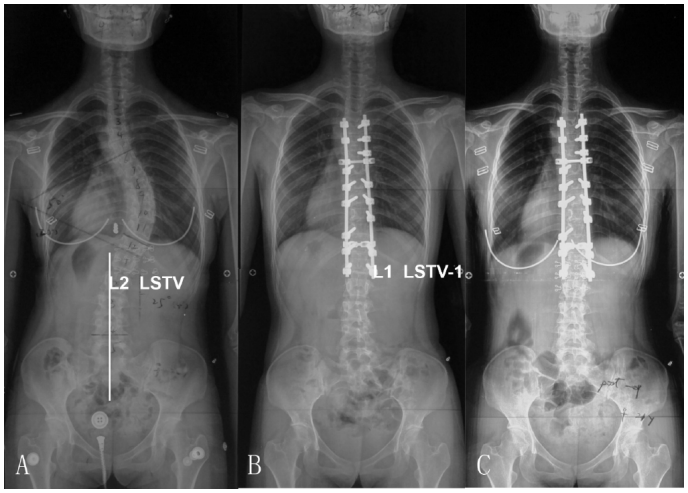
Introduction
Posterior thoracic fusion to save more lumbar mobile segments has become the mainstay of operative treatment for AIS with Lenke 1A/2A curves. Although previous studies have recommended selecting the LSTV as LIV, good outcomes could still be achieved in some cases when LSTV-1 was selected as LIV. The purpose of the study is to determine in which case LSTV-1 could be a valid LIV, in which case distal fusion should extend to LSTV, and to identify risk factors for distal adding-on.

Methods
Ninety-four patients were included in the study with a minimum of 2-year follow-up after posterior thoracic instrumentation, in which LSTV-1 was selected as LIV. Patients were identified with distal adding-on between first erect radiographs and 2-year follow-up based on previously defined parameters. Factors associated with the incidence of adding-on were analyzed.

Results
The mean follow-up duration was 37.7±15.8 months. Forty patients (42.6%) with LSTV-1 selected as LIV achieved good outcomes at the last follow-up. Several preoperative risk factors significantly associated with distal adding-on were identified, including lower Risser (p=0.001), longer thoracic curve length (p=0.005), larger rotation and deviation of LSTV-1 (p<0.001) and preoperative coronal imbalance (p=0.013).

Conclusion
Skeletally immature patients with long thoracic curve, preoperative coronal imbalance, large rotation and deviation of LSTV-1 are at increased risk of distal adding-on when selecting LSTV-1 as LIV. Under this condition, distal fusion level should extend to LSTV; While in other case, LSTV-1 could be a valid LIV.

Take Home Message
In nearly 50% AIS patients with Lenke 1A and 2A curves, selecting LSTV-1 as LIV could achieve similar outcomes to LSTV.



(A)A 18-year-old girl with Lenke 1A curve. L2 was LSTV, Risser grade was 5, CSVL-C7PL distance was 9mm. (B)First erect radiograph postoperatively with fusion to LSTV-1. (C)3-year postoperative radiograph showed good corrective outcome remained without distal adding-on.

114. Congenital Scoliosis Patients Can Attain Similar Curve Correction and Perioperative Outcomes to AIS Patients without the Need for Hemivertebra Excision

Vishal Sarwahi, MD, MBBS; Sayyida Hasan, BS; Terry D. Amaral, MD

Summary
Patients with congenital scoliosis, in most cases, can avoid

hemivertebra excision, while obtaining similar curve correction and perioperative outcomes to AIS patients.

Hypothesis
Correction of congenital scoliosis can be achieved through the use of pedicle screws and a posterior-only approach without the need for hemivertebra excision in most cases.

Design
A retrospective case-controlled matched study.

Introduction
Hemivertebra excision is a technically challenging procedure and complications can include spinal cord injury, nerve root injury and CSF leak. We have utilized a hemivertebra-sparing approach in these patients alongside multi-level Ponte osteotomies and all pedicle screw constructs.

Methods
24 patients with congenital scoliosis and associated hemivertebra were included. These 24 patients were compared with the most recent 54 AIS correction surgeries with 2-year follow up. An additional analysis was done to match hemivertebra patients from a database of 330 AIS patients. Patients were matched based on gender, age, BMI, and preoperative Cobb. 12 pairs (24 patients) were matched and analyzed to compare the surgeries. Wilcoxon signed-rank tests were used.

Results
When comparing hemivertebra to the most recent AIS patients, age ($p=0.81$), BMI ($p=0.24$) and preoperative Cobb ($p=0.06$) were similar. Postoperative Cobb ($p=0.048$) was significantly larger for AIS patients ($p=0.048$), however, overall Cobb correction was similar between the groups (% correction) ($p=0.297$). Estimated blood loss was similar ($p=0.095$) while surgical time ($p<0.001$) and length of stay ($p<0.001$) were significantly longer for hemivertebra patients. Postoperative Cobb (1.0) and overall correction ($p=0.966$) were similar. Patients had a similar number of levels fused ($p=0.227$) and a similar number of fixation points ($p=0.23$). Surgical time ($p=0.413$) and blood loss ($p=0.954$) were similar. Hemivertebra patients had longer hospital stay ($p=0.001$).

Conclusion
Patients with hemivertebra can benefit from hemivertebra sparing approach which has similar or better curve correction. Choosing fusion levels on similar principles akin to AIS leads to avoidance of hemivertebra excision in most case including lumbosacral hemivertebra cases. The correction likely results at disc levels above and below the hemivertebra.

Take Home Message
Surgeons treating congenital scoliosis can avoid hemivertebra excision when using all pedicle screw constructs and judicious use of Ponte type osteotomies.

115. Identifying Delays to Adult Spinal Deformity Surgery in the Setting of a Multidisciplinary Approach

Lisa Depledge, BS; Caroline Drolet, PhD; Jesse Shen, MD; Venu M. Nemani, MD, PhD; Jean-Christophe A. Leveque, MD; Rajiv K. Sethi, MD; Philip K. Louie, MD

Summary
At a single, multidisciplinary spine surgery center, 193 patients underwent complex spine surgery for adult spinal deformity over a 44-month period. Of these, 35 (18.1%) experienced at least one delay in their proposed surgery date. The most common cause for delay was the need for additional preoperative medical optimization in order to meet protocol requirements.

Hypothesis
At a single institution where surgical optimization is accomplished by a multidisciplinary team with a defined perioperative protocol, this optimization requirements lead to a delay in surgery date for a subset of patients.

Design
Retrospective case series.

Introduction
Adult spinal deformity surgery is associated with high rates of perioperative adverse events (AE). To minimize the risk of AEs, our institution requires patients to undergo a rigorous pre-operative evaluation and optimization. The decrease in AEs brought out by this optimization may come at the cost of an increase in delay to surgery date. We aimed to determine the origin of any delay so that our team and those with similar systems might better anticipate and address these delays.

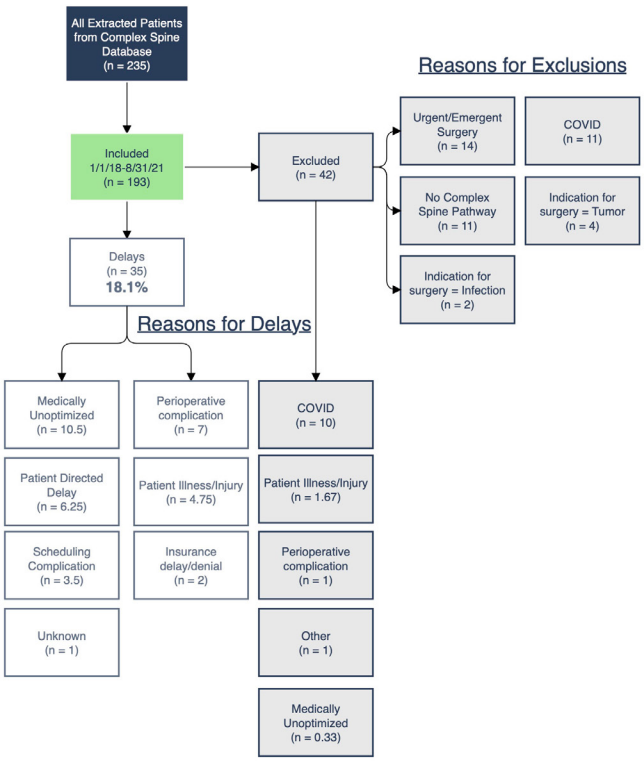
Methods
Complex spine procedures for treatment of adult spinal deformity from 1/1/18 to 8/31/21 were identified. Procedures for infection, tumor, and urgent/emergent cases were excluded. Surgeries that were delayed due to COVID, or those that deviated from the established care pathway were also excluded. The electronic health record was used to identify the duration and cause of preoperative scheduling delays.

Results
Of 235 patients scheduled for complex spine surgery, 193 met criteria. Of these patients, 35 had a surgical delay. The reasons for delay from most to least prevalent were medically unoptimized (n=10.5, 5.4%), pre-operative medical complication (n=7, 3.6%), patient directed delay (n=6.25, 3.2%), patient illness/injury (n=4.75, 2.5%), scheduling complication (n=3.5, 1.8%), insurance delay/denial (n=2, 1.0%), and unknown (n = 1, 0.5%).

Conclusion
At a single multidisciplinary complex spine center, we identified a variety of reasons for surgical delays. Of the identified delays, over a third were inevitable (patient directed delays, patient illness/injury, and insurance denials (n=13, 6.7%)). For delays that were not

inevitable, we suspect that the preoperative protocol might increase delays for unoptimized patients, as the protocol is intended to ensure patients receive surgery only when they are medically ready. Further research is needed to determine the economic and system impact of delay.

Take Home Message
At a single institution with a multidisciplinary preoperative protocol, 18.1% of patients undergoing complex spine surgery for adult spinal deformity will experience at least one delay in their scheduled surgery.



Each patient with a surgical delay is counted as n = 1. If their surgery was delayed more than once (x > 1), each reason is counted as n = 1/x.

116. Efficacy of Fracture Risk Assessment Tool (FRAX) Criteria in Identifying Osteoporosis and Osteopenia in an Adult Spinal Deformity Population

Josephine R. Coury, MD; Yong Shen, BA; Meghan Cerpa, MPH; Nathan J. Lee, MD; Mark Weidenbaum, MD; Zeeshan M. Sardar, MD; Lawrence G. Lenke, MD

Summary
Osteoporosis is frequently underdiagnosed and undertreated in adult spinal deformity (ASD). In this study, we analyzed the effectiveness of the Fracture Risk Assessment Tool (FRAX) in an ASD population and found it to be an ineffective screening tool. More effective bone health screening tools are needed for ASD patients.

Hypothesis
The FRAX tool is ineffective in evaluating fracture risk in ASD patients.

Design
Retrospective consecutive cohort

Introduction
Osteoporosis (OPO) and osteopenia (OPE) can cause significant complications in adult spinal deformity (ASD) surgery. Studies have demonstrated that OPO is frequently underdiagnosed in ASD patients. The Fracture Risk Assessment Tool (FRAX) is a validated tool to identify patients at risk for osteoporotic fracture with or without the bone mineral density scores (BMD) based on their individual risk factors. The goal of this study was to analyze the efficacy of the FRAX tool without BMD in identifying ASD patients with osteoporosis.

Methods
A retrospective review was performed of all patients seen by 2 spinal deformity physicians at a single institution within two years. 354 ASD patients over age 30 who underwent instrumented fusion were identified. Data extracted included demographics, medical comorbidities, medications, and bone density testing. FRAX score without BMD was calculated and analyzed for the 211 patients with a preoperative DXA scan.

Results
52.6% (n=111) of patients had OPE, 23.2% (n=49) OPO, and only 24.17% (n=51) normal bone health. According to the FRAX calculator, 15% (32/211) of patients had a 10-year probability of a hip fracture ≥3% or major osteoporosis-related fracture ≥20%. It did not identify 73% (36/49) of patients with OPO based on DXA scan. Comparing FRAX 10-year probability of a hip fracture ≥3% or major osteoporosis-related fracture ≥20% to DXA as the gold standard, FRAX had a 26.53% sensitivity and 88.27% specificity for detecting patients at risk for osteoporotic fracture.

Conclusion
The prevalence of OPO or OPE is high (76%) in patients undergoing ASD surgery. FRAX without BMD in an ASD patient population is an ineffective screening tool for osteoporosis with a low sensitivity of 26.53%, misdiagnosing 73% of patients with an OPO diagnosis as low fracture risk. Alternate screening tools for ASD patients need to be developed to identify patients at risk for osteoporosis complications.

Take Home Message
The FRAX tool is ineffective in screening for OPO. Given the high prevalence of OPO/OPE in the ASD population, a more effective screening tool for bone health is needed.

Demographic	% With Preop DXA	% Diagnosed with OPO or OPE
Previous personal fracture	79.7%	64.1%
Current smoker	60%	20%
Chronic Glucocorticoid	73.7%	57.9%
Rheumatoid arthritis	100%	100%
Secondary osteoporosis	80%	70%
>3 or more alcohol units daily	80%	80%

Patients with preoperative DXA diagnosed with OPO or OPE based on FRAX risk factors.

117. Complication Rate Evolution Across 10-year Enrollment Period of a Prospective Multicenter Database

Renaud Lafage, MS; Eric O. Klineberg, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Han Jo Kim, MD; Jonathan Elysee, MS; Gregory M. Mundis Jr., MD; Peter G. Passias, MD; Munish C. Gupta, MD; Richard Hostin, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

Summary
Across a 10-year enrollment prospective database, patient profiles changed significantly. Patients have become, older, sicker, more disabled, with larger sagittal malalignment. Surgical strategy changed and evolved to shorter surgery, less 3CO but more ACR, more supplemental rods, and BMP use. While complication rates did not significantly change, major complication leading to revision decreased by 10%, especially implants and radiographic failures. Rate of major complication without revision remained stable but the distribution changed (operative decreased while radiographic increased).

Hypothesis
Complication rates change over the enrollment period of a prospective ASD database.

Design
Retrospective review of prospective multicenter database

Introduction
Surgical treatment of ASD can lead to great outcomes despite high rate of complications. This study aims to investigate the evolution of the complication profiles across a single prospective multicenter database.

Methods
Surgical ASD with min. 2-year FU were included and stratified into 3 groups by date of surgery. Pre-operative data, surgical information, and complications were compared across time using a moving average of 316 patients to delineate those enrolled at the beginning of the study (E) from the most recent (L)

Results
947/1260 (67%) pts met inclusion criteria. Compared to the E phase (Oct2008-Nov2012), L patients (Jan2016-Jan-2018) were older (56.7±15yo vs. 64.3±12.3), sicker (CCI: 1.46±1.6 vs. 2.08±1.78), more disabled (ODI: 42.6±19.4 vs. 45.7±15.3), with larger sagittal deformity. There was an increase use of IBF (61% vs. 69.9%), more ACR/3CO (21% vs. 37%), less 3CO (21% vs. 12%), shorter fusion (11.2±4 vs. 9.8±5), more suppl. rods (0.3% vs. 26.9%) and BMP use (64.1% vs. 80.1%) (all $p<0.05$), but no difference in invasiveness (91.2±37.1 vs. 86.0±36.9 $p=0.06$). LOS decrease by a day, EBL by 500cc and rate of ICU stay decrease from 71% to 53% (all $p<0.01$) Complication rates were similar (73% vs. 67.4% $p=0.14$) despite a decrease in major complications associated with reoperations (27.6% vs. 17.4% $p<0.01$), and a decrease in implant (8.3% vs. 4.1% $p=0.03$) and radiographic failures (12.7% vs. 5.7% $p<0.01$). Rate of major operative complication decreased (11.8% vs. 6.7% $p=0.02$) while the rate of major radiographic complication increased (0.6% vs. 5.7% $p<0.01$). The moving average revealed a steady decrease in major complications associated with reoperation (from 28% to 17%, Figure). The lowest peak of major complications (21%), and overall complications both occurred around 2015.

Conclusion
Despite an increase in patient complexity, complication rates did not increase and the rate of complications requiring surgery decreased over time. These findings likely reflect evolutions in practice improvement.

Take Home Message
Across a 10-year enrollment period, despite patients becoming more complex and susceptible to experience complications, changes in surgical strategy allow to maintain and/or reduce complication rates.

118. Pseudarthrosis in Minimally Invasive Multilevel Lateral Lumbar Interbody Fusion with Posterior Column Osteotomy for Adult Spinal Deformity

Jung-Hee Lee, MD, PhD; Ki Young Lee, MD; Sang-Kyu Im, MD; Tae Su Jang, MD; *Jae Ho Kim, MD*; Won Young Lee, MD; Sun Hwan Choi, MD

Summary
We conducted a retrospective study of pseudarthrosis for patients with adult spinal deformity (ASD) who were surgically treated by pedicle subtraction osteotomy (PSO) or lateral lumbar interbody fusion (LLIF). As a result, applications of additional rod technique can be beneficial for reducing pseudarthrosis, and in order to prevent several complications that are induced by PSO, multilevel LLIF with posterior column osteotomy (PCO) using additional rod technique will be promising methods for reducing pseudarthrosis in surgically treated ASD.

Hypothesis
Minimally invasive multilevel LLIF with PCO using additional rod technique can reduce pseudarthrosis in surgically treated ASD.

Design
A retrospective study.

Introduction
PSO is highly effective as a sagittal correction approach in patients with ASD, but surgical complexity and long-term complications limit its applicability. Recently, minimally invasive multilevel LLIF surgery with PCO has been reported to be promising method for reducing complications for ASD. However, in patients with multilevel LLIF with PCO, pseudarthrosis can occur even when solid bone union is confirmed. Therefore, we applied additional rod technique with minimally invasive multilevel LLIF, and evaluated the effect of reducing pseudarthrosis in ASD patients.

Methods
We retrospectively selected 251 consecutive patients with ASD (mean age 70.8 years) who underwent deformity correction with a minimum 2-year follow up. Subjects were classified into PSO group (n=96) and LLIF group (n=155). PSO group was subdivided into 2-rod group (n=40) and 4-rod group (n=56), and LLIF group was subdivided into 2-rod group (n=106) and 4-rod group (n=49). The incidence of pseudarthrosis and radiographic parameters were evaluated and compared between each group.

Results
The overall pseudarthrosis rate was 17.5% (44/251 cases); 28.1% (27/96 cases) of PSO group and 11% (17/155 cases) of LLIF group ($p < 0.05$). In PSO groups, pseudarthrosis rate of 2-rod group was 60% (24/40 cases) and that of 4-rod group was 5.4% (3/56 cases, $p < 0.05$). In LLIF group, pseudarthrosis rate of 2-rod group was 16% (17/106 cases) and that of 4-rod group was 0% (0/49 cases, $p < 0.05$). Radiographic parameters did not show significant differences between each group.

Conclusion
Applications of additional rod technique are effective methods for reducing pseudarthrosis in surgically treated ASD. Therefore, in order to prevent several complications that are induced by PSO, multilevel LLIF with PCO using additional rod technique will be promising methods and can give better results in ASD patients.

Take Home Message
Minimally invasive multilevel LLIF with PCO using additional rod technique can reduce pseudarthrosis in surgically treated ASD, and it will be an effective guideline for spine reconstruction surgeries.

119. Modified Sequential Correction Technique Combined 3-Column Osteotomy: A Safe and Efficient Surgical Strategy for Severe Kyphoscoliosis

Chen Ling, MD; Zongshan Hu, PhD; Zhen Liu, MD; Yanjie Xu, MD; Zhikai Qian, MD; Ziyang Tang, MD; Zezhang Zhu, MD; Yong Qiu, MD

Summary
To investigate the feasibility and effect of modified sequential correction technique combined 3-column osteotomy. It is a safe and reliable surgical technique, which can effectively avoid the dislocation of osteotomy surface and massive bleeding that may be caused by three-column osteotomy, and has few intraoperative complications. The placement of the rods in the peri-osteotomy area is preferred to participate in correction and also disperses the stress, thereby reducing the incidence of internal fixation failure.

Hypothesis
Modified sequential correction technique combined 3-column osteotomy is a safe and efficient surgical strategy for severe kyphoscoliosis.

Design
A retrospective analysis was performed on the 18 patients (7 males

and 11 females) with severe kyphoscoliosis who received modified sequential correction technique combined 3-column osteotomy in our hospital from June 2019 to April 2020.

Introduction
Modified sequential correction technique combined 3-column osteotomy was performed in our hospital for severe ASD.

Methods
Preoperative, postoperative, and final follow-up clinical and imaging data were evaluated.

Results
The mean follow-up time was 12.7±2.3 months. The preoperative Cobb Angle of the main curve was 65.0°±16.4° and the preoperative global kyphosis was 65.5°±20.8°.The surgical outcome was satisfactory and there was no significant correction loss at the last follow-up. In this group, the average fixed segment was (11.2±3.8), the average operative time was (401.9±68.9) min and the average intraoperative blood loss was (2418.8±736.9) ml. No alters of SEP and MEP were observed during operation. There were no complications of screw and rod breakage during the follow-up period.

Conclusion
Using modified sequential correction technique combined 3-column osteotomy can obtain good local correction in severe kyphosis, and there is no significant loss of correction in long-term follow-up. It is a safe and reliable surgical technique, which can effectively avoid the dislocation of osteotomy surface and massive bleeding that may be caused by three-column osteotomy, and has few intraoperative complications. The placement of the rods in the peri-osteotomy area is preferred to participate in correction and also disperses the stress, thereby reducing the incidence of internal fixation failure.

Take Home Message
Modified sequential correction technique combined 3-column osteotomy is a safe and efficient surgical strategy for severe kyphoscoliosis

120. The Impact of Upper Instrumented Vertebra Orientation on Proximal Junctional Kyphosis - A Noble Parameter for Prediction of Proximal Junctional Kyphosis

Sang-Kyu Im, MD; Ki Young Lee, MD; *Jae Ho Kim, MD*; Tae Su Jang, MD; Jung-Hee Lee, MD, PhD; Sun Hwan Choi, MD; Won Young Lee, MD

Summary
Upper instrumented vertebra (UIV) pelvic angle is a fixed parameter for the relationship between pelvis and UIV which is not changed by position. Decreasing UIV pelvic angle act as a risk factor of proximal junctional kyphosis (PJK) and it can be adjusted by pelvic incidence (PI) – lumbar lordosis (LL) and lordosis distribution index (LDI).

Hypothesis
UIV orientation affect the occurrence of PJK.

Design
Retrospective study

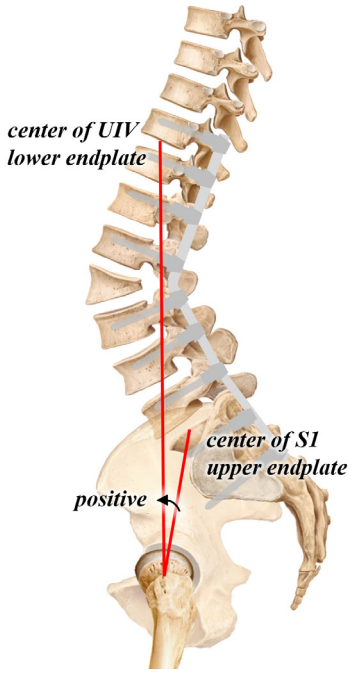
Introduction
PJK is a challenging complication after adult spinal deformity (ASD) surgery. Some study proposed UIV orientation act as a risk factor of PJK, but there remain debates because UIV orientation is changed by position. Therefore, we investigated the relationship between UIV pelvic angle, a novel parameter for the relationship between UIV and pelvis which did not changed by position, and PJK.

Methods
ASD patients underwent long-segment fusion to pelvis and followed-up for more than 2 years were included. Comparative analysis was performed on spinopelvic parameters including UIV orientation parameters (UIV slope angle and UIV pelvic angle) between PJK and non-PJK group. Binary regression analysis was conducted to find out the risk factors for PJK. And correlation analysis was conducted to find out the parameters that affect UIV pelvic angle.

Results
A total of 190 patients were included. PJK incidence was 13.2% (25/190). PJK group showed significantly greater postoperative UIV slope (21.3° vs. 18.8°, p=0.041) and significantly lesser postoperative UIV pelvic angle (-0.9° vs. 4.5°, p<0.001). In binary regression analysis, only UIV pelvic angle act as a risk factor of PJK (odds ratio=0.920, p=0.004). UIV pelvic angle has strong positive correlation with PI–LL (r=0.666, p<0.001) and negative correlation with LDI (r=-0.228, p=0.004).

Conclusion
UIV pelvic angle is a fixed parameter which is not dependent on position. A reduction of the UIV pelvic angle increases the risk for PJK. UIV pelvic angle can be adjusted through PI–LL and LDI. Thus, surgeons should increase UIV pelvic angle by adjusting the PI–LL and LDI during ASD surgery to prevent PJK.

Take Home Message
Decreasing UIV pelvic angle act as a risk factor of PJK and it can be adjusted by PI – LL and LDI.



Measurement of the UIV pelvic angle. UIV pelvic angle was defined as the angle between the lower endplate and sacral endplate with reference to the midpoint of the bicoxofemoral axis.

121. COVID-19 Pandemic Impacted Surgical Outcomes After Single-Level Thoracolumbar Fusions

Sai S. Chilakapati, MS; Syed Khalid, MD; Owoicho Adogwa, MD

Summary
During COVID-19 pandemic, surgeons rapidly adapted patient care while conserving hospital resources and limiting COVID exposure. The aim of this study was to describe impact of COVID-19 pandemic on patient care following single-level thoracolumbar fusions by comparing hospital length of stay (LOS), readmission rates and post-operative complication rates to surgical patients prior to COVID-19. Our results show that during COVID-19 there was increased length of stay, 30-day readmission rates, and risk for deep vein thrombosis postoperatively.

Hypothesis
Patients during the pandemic have similar LOS, readmission rates, and complication profile after single-level thoracolumbar fusions.

Design
Retrospective Review

Introduction
The COVID-19 pandemic had a significant impact on surgical care, with over 28 million surgeries cancelled worldwide. Hospital systems have had to rapidly adapt surgical care to meet patient needs. To date, no studies have characterized the impact of the COVID-19 pandemic on patient outcomes following single-level thoracolumbar fusions.

Methods
This was a retrospective analysis using the Mariner-53 database (administrative database containing 53 million participants) to compare patients (age > 18) who underwent thoracolumbar fusions during COVID-19 pandemic (4/1/2020 - 11/1/2020) to patients who underwent surgery prior to COVID-19 pandemic during a similar time frame in 2018 and 2019, based on ICD-10 diagnostic codes. A total of 47,885 patients were identified, and exact 1:1 matching was performed based on baseline demographics and comorbidities to create two groups with identical covariates: COVID-19 group (n = 14,968), pre-COVID-19 group (n = 14,968). The rates of 30-day major complications, readmission, and LOS were compared between the groups.

Results
Patients who had thoracolumbar fusions during the COVID-19 pandemic had increased LOS compared to patients who underwent surgery prior to the COVID-19 pandemic (4.19 vs. 4.12 days, p = 0.03), although not clinically relevant. There was an increase in deep vein thrombosis (OR:1.31, 95%CI: 1.03 – 1.66) and an increase in readmission rate within 30-days (OR 1.09, 95% CI:1.003 – 1.185) compared to patients who had surgery prior to COVID-19 pandemic. There were no differences in rates of other 30-day major postoperative complications.

Conclusion
Following single-level thoracolumbar fusions, patients who underwent surgery during the COVID-19 pandemic had increased 30-day hospital readmissions and odds for deep vein thrombosis compared to patients who underwent surgery prior to the COVID-19 pandemic. LOS was slightly increased, although not clinically relevant. Further studies are needed to characterize the drivers of hospital readmission.

Take Home Message
During COVID-19 pandemic, patients undergoing single-level thoracolumbar fusions had increased postoperative 30-day readmission and increased odds for developing deep vein thrombosis compared to matched surgical patients prior to the pandemic.

122. Lumbar Lordosis is Primarily Lost in the Upper Lumbar Spine in ASD Patients with Sagittal Deformities

Renaud Lafage, MS; Alex Soroceanu, MPH; Justin S. Smith, MD, PhD; Peter G. Passias, MD; Han Jo Kim, MD; Gregory M. Mundis Jr., MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Eric O. Klineberg, MD; Munish C. Gupta, MD; Douglas C. Burton, MD; Shay Bess, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

Summary
This study aims to investigate the location of lumbar lordosis loss in a cohort of primary ASD patients prior to surgical intervention. Actual sagittal alignment was compared to predicted normative alignment, based on the degree on PI-LL mismatch. Contrary to common belief, the loss of lumbar lordosis mainly affects the proximal segments of the lumbar spine for patients with mild PI-LL mismatch. As the malalignment worsens, the loss of lordosis spreads distally, but to a lesser extent.

Hypothesis
Loss of lumbar lordosis is homogeneous across the lumbar segments for ASD.

Design
Retrospective review of prospective databases.

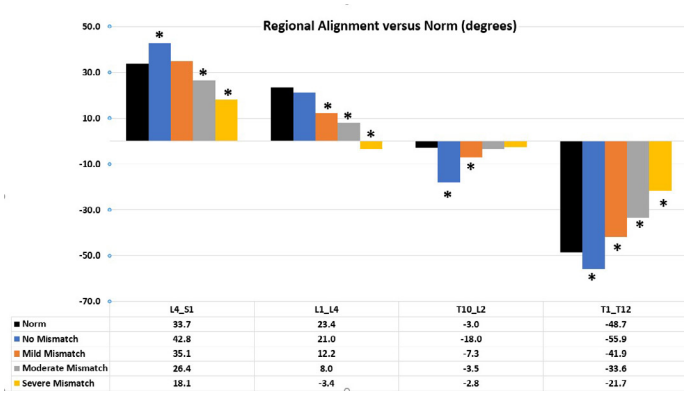
Introduction
In asymptomatic adults, 2/3 of LL comes from L4-S1, therefore it is possible that LL lost in ASD also occurs in the L4-S1 region. This study investigates the location of LL loss in ASD patients with no history of spine surgery.

Methods
Asymptomatic volunteers were used to build age and PI adjusted models of PI-LL, L1-L4 lordosis, L4-S1 lordosis, TL kyphosis (TKL), and thoracic kyphosis. The study cohort was identified from a prospective, database of ASD patients with no history of spine surgery, nor coronal deformity (SRS ASD Classification Type=N). The formulas developed in the asymptomatic population were applied to the ASD group to calculate normative values. The ASD population was divided into four groups of PI-LL deficit from the norm: no, mild, moderate, and severe PI-LL mismatch. Regional alignment was compared with the calculated normative values.

Results
The 119 normative volunteers (50.7yo±17, PI: 52°±11.4) had the following regional alignment: L4-S1=34°, L1-L4=23°, TKL=3°, and TK=49°. The study cohort included 357 ASD patients (64.6yo, 58.5%F). The PI-LL of the 4 quartiles were -10°, 10°, 20°, and 40°. There were no significant differences in PI or in any of the coronal Cobb angles, but numerous differences in regional alignment when compared to the Norm (Figure). The analysis by percentage of actual alignment vs. the calculated age and PI matched normative values permitted to identify the driver(s) of the sagittal malalignment. The "no mismatch" had an excess of TLK (+510%) compensated by an excess in L4-S1 (+27%). The "mild mismatch" had a loss of L1-L4 (-48%) with a normal L4-S1, and the "moderate mismatch" had mainly a deficit in L1-L4 (-66%) associated to a 22% loss on L4-S1. The "severe-mismatch" presented a kyphotic L1-L4 (-115% vs. norm) with a 46% deficit in L4-S1.

Conclusion
The majority of LL lost for ASD patients is attributable to the degenerative kyphosing of the proximal lumbar segments. As sagittal deformity worsens, the loss of lordosis spreads to the distal lumbar segments.

Take Home Message
Contrary to common belief, loss of LL in ASD patients mainly affects the proximal lumbar segments, then extends distally for moderate and severe sagittal deformities.



	L4_S1	L1_L4	T10_L2	T1_T12
Norm	33.7	23.4	-3.0	-48.7
No Mismatch	42.8	21.0	-18.0	-55.9
Mild Mismatch	35.1	12.2	-7.3	-41.9
Moderate Mismatch	26.4	8.0	-3.5	-33.6
Severe Mismatch	18.1	-3.4	-2.8	-21.7

123. The Effect of Overcorrection on Proximal Junctional Kyphosis (PJK) in Adult Spinal Deformity (ASD): Analysis by Age-Adjusted Ideal Sagittal Alignment

Jae Hwan Cho, MD, PhD; Chang Ju Hwang, MD, PhD; Dong-Ho Lee, MD, PhD; Choon Sung Lee, MD, PhD; *Sang Yun Seok, MD*

Summary
Overcorrected patients had a significantly higher PJK rate in the age-adjusted analysis. The degree of postoperative LL correction relative to the PI is a risk factor for the development of PJK (11.4° for PJK vs. 0.2° for non-PJK, P=0.033). In addition, inferior clinical outcomes (back VAS and ODI) were found in patients with PJK. So, to reduce the risk of PJK, surgeons should take age-adjusted parameters into account and exercise caution not to overcorrect patients with low PI.

Hypothesis
Overcorrection considering age-adjusted sagittal alignment goal leads to PJK.

Design
A retrospective comparative study

Introduction
The effect of the degree of lumbar lordosis (LL) correction on PJK has not been analyzed by considering age-adjusted sagittal

alignment goal. The purpose of this study is to determine the effect of sagittal correction on the incidence of PJK after an age-adjusted analysis in patients with ASD.

Methods
This study included 78 ASD patients who underwent deformity correction and were followed-up more than 2 years. Patients were grouped according to the degree of LL correction relative to pelvic incidence (PI) by adjusting for age using the following formula: (age-adjusted ideal PI - LL) - (postoperative PI - LL). These were group U (undercorrection; <–10°, N = 15), group I (ideal correction; –10°–10°, N = 34), and group O (overcorrection, >10°, N = 29). Various clinical and radiological parameters were compared among groups. The risk factors for PJK were also evaluated.

Results
The overall incidence of PJK was 32.1% (25/78), with significantly higher PJK rate in group O (48.3%) compared with groups U (13.3%) and I (26.5%) (P = 0.041). The degree of postoperative LL correction relative to the PI by adjusting for age was a risk factor for the development of PJK (11.4° for PJK vs. 0.2° for non-PJK, P = 0.033). In addition, 2-year postoperative VAS (7.0 vs. 3.4, P < 0.001) and ODI (28.9 vs. 24.8, P = 0.040) scores were significantly higher in the PJK group than in the non-PJK group. A small PI (PI < 45°) was associated with a tendency of overcorrection (73.3%, P < 0.001) and thereby with the high incidence of PJK (53.3%, P = 0.005).

Conclusion
Overcorrection of LL relative to PI considering age-adjusted ideal sagittal alignment tends to increase the incidence of PJK. The incidence of PJK is expected to be high in patients with low PI (<45°) because of the tendency of overcorrection. To reduce the risk of PJK, surgeons should take age-adjusted parameters into account and exercise caution not to overcorrect patients with low PI, since this can result in suboptimal clinical outcomes.

Take Home Message
To reduce the risk of PJK, surgeons should take age-adjusted parameters into account and exercise caution not to overcorrect patients with low PI.

124. Global Alignment and Proportion (GAP) Score in Asymptomatic Subjects: Is It Universal?

Hongru Ma, MD; Yong Qiu, MD; Zezhang Zhu, MD; Zhen Liu, MD; Zongshan Hu, PhD

Summary
This study demonstrated that the GAP score might not be a reliable method in evaluating the sagittal spinopelvic alignment of Chinese population. The "ideal" sagittal alignment defined in GAP score was significantly different from the model we established using the data collected from a prospective cohort of asymptomatic Chinese subjects.

Hypothesis
The Global Alignment and Proportion (GAP) score, established based on Euro-American population database, might not be suitable for Chinese population due to ethnicity-related alignment difference.

Design
A prospective cross-sectional radiographic study

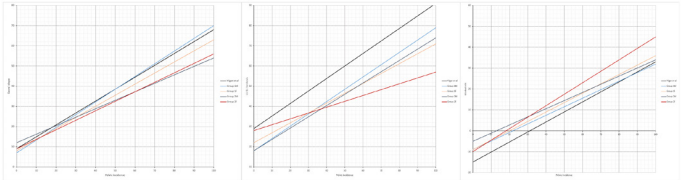
Introduction
The GAP score was established based on American and European subjects, which might limit its feasibility in Chinese population due to ethnicity-related difference of sagittal alignment.

Methods
Four hundred and ninety asymptomatic Chinese adults aged between 20 and 79 were prospectively recruited and divided into 4 groups: Group 1M: male subjects < 60 years old; Group 1F: female subjects < 60 years old; Group 2M: male subjects > 60 years old and Group 2F: female subjects > 60 years old. The GAP scores and categories were determined and compared between groups. The distribution of GAP categories in our cohort was compared with the results of asymptomatic American subjects in a previous study. Univariate linear regression analysis was carried out between pelvic incidence (PI) and sacral slope (SS), lumbar lordosis (LL) and global tilt (GT) in each group.

Results
The distribution of GAP categories in our study was statistically different from American population. Significantly different distribution of GAP categories was observed between Group 1M and Group 2M, Group 1F and Group 2F, and Group 1M and Group 1F. Radiographic measurements and GAP parameters were significantly different between Group 1M and Group 2M, and Group 1F and Group 2F. Gender-related difference of parameters was more prominent between Group 1M and Group 1F. Linear relationship of PI with SS, LL and GT were different from the regression models of "ideal" sagittal alignment in GAP score.

Conclusion
The GAP score might be inappropriate in Chinese population due to ethnicity-related alignment difference. Worse feasibility of GAP score was observed in female and old subjects.

Take Home Message
Ethnicity-related alignment difference might limit the ability of GAP score as an appropriate method to evaluate sagittal alignment in Chinese population.



Univariate linear regression correlations between PI with SS, L1-S1

lordosis and GT in each group compared with the "ideal" correlation in GAP score.

126. Novel Use of 360 Virtual Reality Technology for Pre-operative Correction Planning in Adult Spinal Deformity

Juan M. Valdivia, MD

Summary
Using Virtual Reality for pre-operative spino-pelvic measurements in correction and approach planning.

Hypothesis
Converting 2D standing x-ray measurements to a 360 degree virtual reality model of the CT scan allows for immersive pre-operative planning.

Design
Reviewing a case using virtual reality in adult spinal deformity to combine the 2D x-ray measurements and planned surgical approach with the patients 360-degree CT reconstruction.

Introduction
The patient specific virtual model embedded with the spinopelvic measurements is manipulated per vertebral level as you see the correction happening before surgery.

Methods
Preoperatively the patient received a standing x-ray and a CT angiogram of the lumbar spine. From the x-ray we found the spinopelvic measurements, such as: Sacral Slope, Pelvic Incidence, Pelvic Tilt and True Vertical. The standing x-ray measurements were then correlated onto the CT scan starting with the the Sacral Slope. Using the Sacral Slope we adjusted the CT model to become upright. With the virtual reality headset, the vertebral levels were individualized from the lowest level working up. There were 4 "polygon objects" created, L5-T10, L4-T10, L3-T10, and L2-T10. Next, we adjusted the roll and pitch of each vertebral polygon object based off of the planned surgical cages. Once all planned cages were counted for, we viewed the offset of the virtual correction from the True Vertical and the current CT scan from the axial plane.

Results
The technology allows us to fuse the post-operative CT scan with the pre-operative CT scan. The two scans were fused in 360 degrees using the pelvic bones. The post-operative result was reviewed with the planned polygon objects and the pre-operative scan. The ability to view the planned correction of the spine from the top view using the true vertical obtained from the standing x-ray gave us a novel preoperative view, named "Top view translation".

Conclusion
Adding certain AI calculations to correlate the 2D measurements will enhance the technology. In conclusion virtual reality, a noninvasive tool, is useful for pre-operatively planning adult spinal deformity correction.

Take Home Message
The 360 patient specific virtual reality tool is useful for combining 2D Spinopelvic parameters with the CT scan to see the surgical plans impact before surgery.

127. Postoperative Evolution of Sagittal Parameters Over Time Does Not Differ by Upper Instrumented Vertebra

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Summary
While research has focused on sagittal alignment targets, less is known about how parameters evolve over time and whether these changes vary by choice of UIV. Here we show that small changes in thoracic kyphosis (TK)/T1 pelvic angle (TPA) with compensatory changes in pelvic tilt (PT) occur up to 6 months postoperatively. These changes do not vary by UIV, suggesting that one approach may not be superior to another and that UIV decision should be made on a case-by-case basis.

Hypothesis
Evolution of postoperative sagittal parameters will vary by upper instrumented vertebra (UIV)

Design
Retrospective cohort

Introduction
Recent literature in adult spinal deformity (ASD) has focused on achieving specific sagittal alignment goals. Less is known about how sagittal parameters evolve over time and whether these changes differ by choice of UIV.

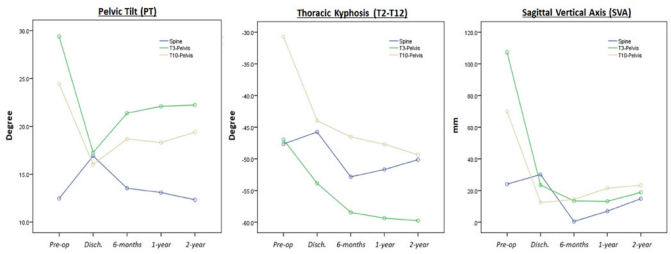
Methods
This was a retrospective review of ASD patients. Routine 36" sagittal x-rays were obtained preoperatively, prior to hospital discharge, and at 6 months, 1 yr, and 2 yrs and sagittal parameters were measured. Patients with UIV above T7 were classified as upper thoracic (UT) and below T7 as lower thoracic (LT). Patients without fusion to pelvis were classified as spine (S).

Results
A total of 118 patients with mean age 62.4 yrs (±13.2) were included in the analysis (49 UT, 53 LT, 16 S). The UT and LT groups differed significantly in preoperative alignment, including TLK (-24.6° vs. -13.1°) and the TK (-47.0° vs. -30.7°)($p<0.05$). Despite these differences, the UT/LT groups experienced similar changes postoperatively. PT demonstrated significant improvement with surgery, increasing 3.3° ($p<0.001$) by 6 months but remaining stable thereafter. Both UT/LT groups demonstrated significantly greater TK from preoperatively to discharge to 6 months ($p<0.05$), stabilizing at that time point out to 2 years. TPA demonstrated improvement

with surgery and subsequently showed a steady increase of 3.5° between discharge and 2Y for both groups. Regarding global alignment, there was significant improvement in sagittal vertical axis (SVA) after surgery, which was maintained out to 2 years of follow-up (p>0.05).

Conclusion
Patients demonstrate a small increase in TK up to 6 months after surgery, resulting in a rise of TPA. PT increases as a compensatory mechanism, enabling patients to maintain correction of their global SVA up to two years. These changes are similar and do not vary by UT/LT UIV, suggesting that one approach may not be superior to another and that UIV decision should be made on a case by case basis.

Take Home Message
Regardless of UIV, ASD patients experience a small increase in TK/TPA with compensatory changes in PT to 6 months postoperatively, resulting in maintenance of global sagittal correction.



128. The Effects of Global Alignment and Proportionality Scores on Post-Operative Outcomes Following Adult Spinal Deformity Correction

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Summary
Since the introduction of the Global Alignment and Proportionality (GAP), literature has been inconclusive on the utility of the GAP score in clinical practice. Our study shows that the GAP score had strong predictive potential for proximal junctional kyphosis (PJK), specifically, in patients with severe baseline sagittal malalignment and/or those 65 and older, and may have less utility in younger patients, or those with history of a previous fusion.

Hypothesis
To investigate if the GAP score has value in predicting complications.

Design
Retrospective cohort study of prospective, multicenter ASD database.

Introduction
The GAP score has gained attention for predicting complications, our purpose is to investigate predictive value overall and in certain cohorts.

Methods
Operative ASD patients (scoliosis >20°, SVA>5cm, PT>25°, or TK>60 °,) with a fusion at L1 or higher with available baseline (BL) and 2-year (2Y) radiographic and HRQL data were included. Multivariate analysis (MVA) controlling for age and CCI was used to find correlations between complications and GAP categories: Moderately Disproportioned (MD) (GAP >2 and <7) and Severely Disproportioned (SD) (GAP >7). Severe sagittal deformity was defined by a ++ in SRS-Schwab for SVA, or PILL. “Mechanical complications” excluded PJK.

Results
227 ASD patients met the inclusion criteria (59.9yrs±14.0, 79%F, BMI: 27.7 kg/m2 ±6.0, ASD-FI: 3.3±1.6, CCI: 1.8 ±1.7). MVA showed no association of GAP MD or SD patients with PJF, or mechanical complications, (p>0.05) but MD patients showed a positive correlation with development of PJK [OR: 2, 95% CI: 1-3.7, p<0.05]. GAP MD and GAP SD were predictive of 2Y PJK in patients with severe sagittal deformity (MD (4.2[1.3-13.4]), SD (3.3[1.06-10]), and in patients 65 y/o and older (MD (5[1.4-18]), SD (3.6[1-12]), all p<0.05, with no association with PJF or mechanical complications. In patients with a history of prior fusion, or patients less than 65 years of age, there was no correlation of GAP MD/GAP SD with PJK, PJF, or mechanical complications. The continuous 6W GAP score, as well as the GAP categories, did now show significant correlations with patient reported outcomes at 2 years

Conclusion
Our study shows that the GAP score had strong predictive potential for proximal junctional kyphosis specifically, in patients with severe baseline sagittal malalignment and/or those 65 and older, and, may have less utility in younger patients, or those with a previous fusion. Additionally, the GAP score showed no correlation with patient reported outcome measures.

Take Home Message
GAP criteria was predictive for proximal junctional kyphosis, specifically, in patients with severe baseline sagittal malalignment and/or those 65 and older and less so in younger or prior fusion patients.

129. Changes in Cytokine Expression Robustly Predict Risk for Delirium Following Complex Spine Surgery

Sai S. Chilakapati, MS; Owoicho Adogwa, MD; Michael Burton, PhD

Summary
We sought to correlate postoperative inflammation and delirium by characterizing the principal immune changes in the plasma by analyzing pro-inflammatory (IL-4, IL-6, IL-8, TNF- α) and anti-inflammatory (IL-10, IL-22) cytokine levels following spine surgery. As a pilot study with 15 patients, we found a strong correlation with an increase in plasma pro-inflammatory cytokines (IL-8 and TNF-α) and risk for postoperative delirium.

Hypothesis
Increase in plasma pro-inflammatory cytokine levels are associated with risk for delirium postoperatively.

Design
Prospective, single-center cohort

Introduction
Postoperative delirium is a common complication among adults following spine surgery. Older age, pre-existing cognitive decline, and duration of surgery are important clinical risk factors. However, the underlying physiological mechanisms of delirium following spine surgery are unclear. Understanding the robust inflammatory response after spine surgery may elucidate any mechanistic links to developing postoperative delirium.

Methods
15 patients undergoing complex spine surgery for adult spinal deformity were enrolled in this study. Whole blood samples were collected at three timepoints: preoperatively (Pre-Op), postoperative day 0 (POD 0), then at postoperative day 3 (POD 3). Plasma was isolated using Ficoll density centrifugation. Plasma IL-4, IL-6, IL-8, IL-10, IL-22, TNF-α were measured using a Quanterix Multi-Plex cytokine assay. Pearson correlation and linear regression models were used to assess the association between cytokine profile and postoperative delirium.

Results
Three of fifteen patients (20%) developed delirium postoperatively. Patients with delirium had higher levels of IL-8 on POD3 and higher levels of TNF-α on both POD0 and POD3 ($P<0.05$). On linear regression, POD0 and POD3 TNF-α levels accounted for over 70% of the variance in predicting delirium and remained statistically significant after controlling for age, sex, BMI, and comorbidities. Patients with delirium also had increased IL-6 on both POD0 and POD3, however the difference was not statistically significant. Changes in anti-inflammatory cytokines were not correlated with delirium.

Conclusion
Following spine surgery, patients with delirium exhibited an increase in the pro-inflammatory cytokines IL-8 and TNF-α. These findings suggest an underlying persistent inflammatory response in patients who develop delirium postoperatively. Further biochemical and ex-vivo studies are needed to fully characterize changes to the immune response after surgery in patients with delirium.

Take Home Message
In this exploratory analysis, increased plasma pro-inflammatory cytokines were associated with the presence of delirium following complex spine surgery for adult spinal deformity.

130. Predicting Osteoporosis Using Machine Learning in Patients Undergoing Spinal Reconstruction Surgery

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Summary
Although poor bone health negatively impacts spinal deformity surgery outcomes, many patients are not routinely screened. Spine surgeons lack the tools to risk stratify patients preoperatively to determine who should undergo bone health screening. We developed a machine learning algorithm to predict the bone health status of adult patients undergoing instrumented spine surgery, and discovered predictors of bone health that are understudied in the spine patient population.

Hypothesis
Machine learning (ML) algorithms can predict the bone health status of adult spinal deformity patients preoperatively.

Design
Retrospective cohort.

Introduction
Poor bone health negatively impacts deformity surgery outcomes. Dual-density X-ray absorptiometry (DEXA) scans, which assess bone health, are not routinely performed for many patients. We aimed to develop an ML algorithm to predict patients at risk for poor bone health based on electronic health record (EHR) data and identify patients who should undergo DEXA scans.

Methods
211 subjects over the age of 30 with DEXA scans, who underwent instrumented spinal surgery were reviewed. Data was collected by manual and automated collection from the EHRs. The Weka software was used to develop ML models for classification of healthy, osteopenia (OPE), and osteoporosis (OPO) bone status. Bone status was labeled according to the WHO criteria using DEXA T-scores. The sensitivity, specificity, and area under the receiver-operating-curve (AUC) were calculated. The model was evaluated on a test set of unseen data for generalizability. Paired T-test was used to perform statistical testing, with significant p-value set to < 0.05.

Results
The prevalence of OPO was 23.22% and OPE was 52.61%. The random forest model achieved optimal performance with averaged sensitivity of 0.81, specificity of 0.95, and AUC of 0.96 on the training set. The model yielded an averaged sensitivity of 0.64, specificity of 0.78, and AUC of 0.69 on the test set. Numerous patient features exhibited predictive value, such as BMI, language (English, Spanish, or Other), insurance type, serum sodium level, history of bariatric surgery, and the use of medications such as selective serotonin reuptake inhibitors.

Conclusion
ML algorithms can discriminate the bone health status of patients

preoperatively. ML models identified several understudied predictors for poor bone health in the spine patient population. Surgeons can use ML models to inform surgical planning and investigate predictive factors for poor bone health.

Take Home Message
Machine learning algorithms can predict the bone health status of patients undergoing instrumented spinal surgery and detect understudied predictors for poor bone health in the spine patient population.

131. The T4-L1-Hip Axis: Defining a Normal Sagittal Spinal Alignment

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Summary
We analyzed an international sample of spines without degeneration or deformity to precisely define a normal thoracic and lumbar sagittal alignment using 4 measures that are fixed or directly modifiable in surgery: L1-S1 lordosis, L1 pelvic angle, T4 pelvic angle, and pelvic incidence. We found the L1 and T4 pelvic angle to be nearly equivalent in normal spines (r = 0.9), resulting in an aligned T4-L1-hip axis.

Hypothesis
Analysis of non-degenerated spines will offer more precise sagittal alignment targets relative to prior analysis.

Design
International Cross-Sectional Study

Introduction
Currently accepted sagittal alignment targets were developed using correlations in spinal deformity patients, rather than disease-free samples. We analyzed a disease-free sample to report establish a method for defining a normal lumbar and thoracic sagittal alignment using measures that are either fixed or directly modifiable in surgery, and mechanistically related to sagittal balance.

Methods
Asymptomatic volunteers over 18 years with no signs of disc degeneration or deformity were included. Sagittal balance was defined using vertebral body tilt and spinopelvic alignment was defined as the vertebral pelvic angles from C2 to L5. Associations with pelvic incidence were assessed using linear regression. Multivariable linear regression was used to estimate a normal L1-S1 lordosis, adjusting for pelvic incidence and the L1 pelvic angle. Correlation between the L1 and T4 pelvic angles was used to define a normal thoracic alignment relative to the lumbar spine.

Results
Among 320 volunteers from 4 continents, median age was 37 and 60% were female. Pelvic tilt was significantly associated with vertebral pelvic angles (r2 = 0.82 for T4 pelvic angle). Pelvic incidence was inadequate for estimating a normal L1-S1 lordosis (r2 = 0.3), but was strongly associated with the L1 pelvic angle (r2 = 0.58. Defining lumbar lordosis as a function of pelvic incidence and L1 pelvic angle resulted in high explained variance (R2 = 0.74). The T4 pelvic angle had a near perfect positive correlation with the L1 pelvic angle (r = 0.9; Fig 1).

Conclusion
We defined normal sagittal balance and spinopelvic alignment in a disease-free international volunteer cohort. We report four parameters that are either fixed or directly modifiable in surgery to describe a normal thoracic and lumbar alignment: L1-S1 lordosis, L1 pelvic angle, T4 pelvic angle, and pelvic incidence. The L1-S1 lordosis is defined as a function of pelvic incidence and the L1 pelvic angle and the T4 pelvic angle is nearly equivalent to the L1 pelvic angle, aligning the T4-L1-hip axis.

Take Home Message
Defining normal sagittal alignment using L1-S1 lordosis, L1 pelvic angle, T4 pelvic angle and pelvic incidence offers precise thoracic and lumbar targets that mirror normal alignment.

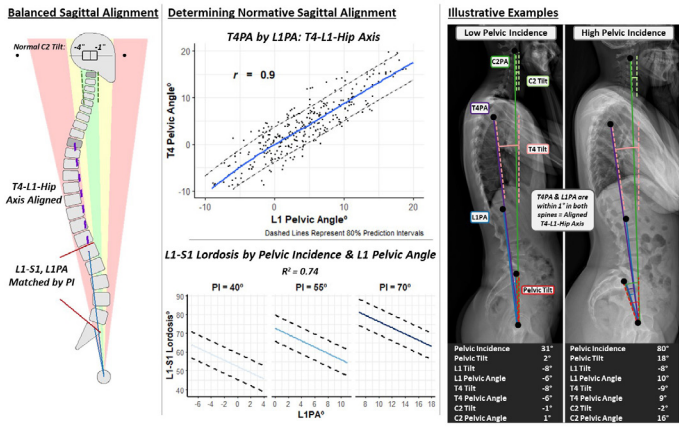

Figure 1.

132. Two- and Three-Year Outcomes of Minimally Invasive and Hybrid Correction of Adult Spinal Deformity

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Summary
In a comparison of less invasive surgical approaches for adult

spinal deformity (ASD), hybrid procedures were associated with a greater CC improvement compared to circumferentially MIS (cMIS) techniques. cMIS was associated with superior ODI and back pain at 2 years, but this difference was no longer evident at 3 years. However, cMIS was associated with superior leg pain at 3 years. There were fewer complications following cMIS, with the exception of pseudarthrosis.

Hypothesis

There are no differences in 2- and 3-year outcomes of cMIS and hybrid correction of ASD.

Design

Retrospective review of multicenter ASD database

Introduction

Previous studies have demonstrated the short-term benefits of cMIS and hybrid (i.e., minimally invasive anterior/lateral interbody fusion with an open posterior approach) techniques to correct ASD. It is not known if these benefits are maintained over time.

Methods

The database was reviewed for patients undergoing cMIS or hybrid surgery for ASD (defined as coronal cobb(CC)>=20°, sagittal vertical axis (SVA)>5 cm, pelvic incidence–lumbar lordosis (PI-LL)>=10°, or pelvic tilt (PT)>20°). Radiographic parameters were evaluated at latest follow-up. Clinical outcomes were compared at 2 and 3 years.

Results

Overall, 197 (108 cMIS;89 hybrid) patients were included with 187 (99 cMIS;88 hybrid) and 111 (60 cMIS;51 hybrid) evaluated at 2 and 3 years. Mean follow-up for cMIS (39.0±13.3 months; range 22-74 months) and hybrid (39.9±16.8 months; range 22-94 months) was similar. Hybrid corrected the CC greater than cMIS (adjusted p=0.022). Postoperative SVA, PI-LL, PT, and sacral slope were similar. At 2 years, cMIS had lower Oswestry Disability Index (ODI) scores (adjusted p<0.001), greater ODI change as a percentage of baseline (adjusted p=0.006), less visual analog scale (VAS) back pain (adjusted p=0.006), and greater VAS back pain change as a percentage of baseline (adjusted p=0.001) compared to hybrid. These differences were no longer significant at 3 years. At 3 years, but not 2 years, VAS leg pain was lower for cMIS compared to hybrid (adjusted p=0.032). cMIS had fewer complications compared to hybrid (adjusted p=0.006), but a higher odds of pseudarthrosis (adjusted p=0.039).

Conclusion

In a comparison of less invasive surgical approaches for ASD, hybrid procedures were associated with a greater CC improvement compared to cMIS techniques. Circumferential MIS was associated with superior ODI and back pain at 2 years, but this difference was no longer evident at 3 years. However, cMIS was associated with superior leg pain at 3 years. There were fewer complications following cMIS, with the exception of pseudarthrosis.

Take Home Message

Compared to cMIS, hybrid was associated with a greater CC improvement but more complications. cMIS was associated with superior ODI and back pain at 2 years, but not 3 years.

Table. Perioperative, radiographic, and clinical outcomes

Variable	Hybrid (n = 89)	cMIS (n = 108)	p Value	
			Unadjusted	Adjusted*
Operative and fusion data				
Mean EBL ± SD, ml	1512.7 ± 1467.4	464.3 ± 508.5	**<0.001**	—
Mean operative time ± SD, mins	621.8 ± 260.8	426.3 ± 181.3	**<0.001**	—
Mean radiographic outcomes ± SD				
CC, °				
Baseline	37.5 ± 18.6	31.5 ± 15.1	**0.039**	—
Postop	16.5 ± 11.0	17.2 ± 11.1	0.703	**0.017**
Change	–20.9 ± 13.6	–14.5 ± 12.6	**0.003**	**0.022**
SVA, mm				
Baseline	51.6 ± 62.3	39.9 ± 53.0	0.408	—
Postop	48.9 ± 56.6	37.7 ± 56.6	0.150	0.152
Change	–5.9 ± 60.0	2.8 ± 48.7	0.530	0.884
PI-LL, °				
Baseline	17.9 ± 17.6	14.6 ± 14.5	0.310	—
Postop	11.2 ± 16.5	10.4 ± 13.5	0.691	0.472
Change	–6.8 ± 16.8	–3.8 ± 14.7	0.354	0.467
PT, °				
Baseline	23.1 ± 10.5	23.5 ± 10.5	0.944	—
Postop	23.4 ± 10.4	23.9 ± 10.2	0.749	0.812
Change	–0.1 ± 7.9	0.6 ± 7.1	0.926	0.381
SS, °				
Baseline	31.2 ± 13.0	29.7 ± 9.5	0.187	—
Postop	31.7 ± 11.5	28.5 ± 9.8	**0.043**	0.107
Change	1.1 ± 8.6	–0.5 ± 6.9	0.214	0.163
Clinical outcomes				
Mean ODI ± SD				
24 mos	35.1 ± 17.3	28.2 ± 21.1	**0.011**	**<0.001**
36 mos	33.8 ± 17.0	33.2 ± 21.3	0.931	0.501
24-mo change	–19.3 ± 18.0	–21.1 ± 21.1	0.497	0.146
24-mo percentage change	–33% ± 33%	–42% ± 43%	0.051	**0.006**
36-mo change	–18.5 ± 17.4	–19.7 ± 23.3	0.656	0.805
36-mo percentage change	–34% ± 30%	–33% ± 48%	0.669	0.838
Mean VAS back pain score ± SD				
24 mos	4.0 ± 2.7	3.2 ± 2.7	**0.022**	**0.006**
36 mos	4.2 ± 2.4	3.5 ± 2.7	0.115	0.106
24-mo change	–2.8 ± 2.9	–3.6 ± 2.8	0.091	0.073
24-mo percentage change	–37% ± 45%	–52% ± 44%	**0.019**	**0.001**
36-mo change	–3.1 ± 2.5	–3.4 ± 2.6	0.326	0.335
36-mo percentage change	–41% ± 34%	–50% ± 42%	0.121	0.110
Mean VAS leg pain ± SD				
24 mos	2.9 ± 2.7	2.9 ± 2.8	0.828	0.398
36 mos	2.9 ± 3.0	1.9 ± 2.5	0.114	**0.032**
24-mo change	–2.7 ± 3.6	–2.7 ± 3.4	0.938	0.891
24-mo percentage change	–19% ± 131%	–31% ± 109%	0.749	0.254
36-mo change	–3.0 ± 3.4	–4.6 ± 2.5	**0.007**	0.074
36-mo percentage change	–42% ± 60%	–71% ± 55%	**0.003**	0.097

Percentages reported are considered from available information. Frequencies may not add up to the total cohort size where there are missing data. Boldface type indicates statistical significance.
* Adjusted for age, preoperative CC, levels of surgery, levels of interbody fusion, presence of L5–S1 ALIF, LIV, and LIV.

133. A Multicenter Analysis of the Utilization of Robot for Adult Spinal Deformity: Are We Improving After 5 Years?

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Summary
This is the first and largest multicenter study to examine the trends in outcomes and complications over a 5-year period in this population. Adult patients with complex ASD underwent robot-assisted spine surgery from 2016-2020 at four independent institutions. Operative time reduced significantly over time; however, robot time per screw and fluoroscopy time per screw remained consistent. Significant improvement in screw accuracy and robot abandonment were observed.

Hypothesis
To investigate the trends in robot time per screw, radiation exposure, screw accuracy, robot abandonment, and postoperative complications after robot-assisted ASD surgery.

Design
Multicenter cohort

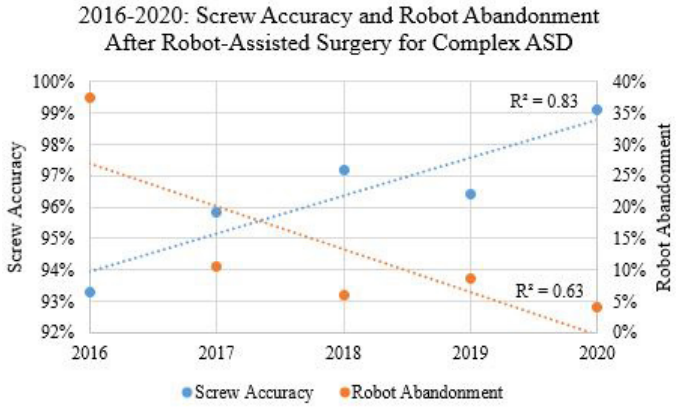
Introduction
The advent of robot-assisted platforms continues to evolve the landscape of spine surgery. Ample evidence suggests that robots can achieve excellent pedicle screw accuracy and outcomes compared to freehand techniques. Robots can be particularly advantageous in patients with adult spinal deformity (ASD), that involve intensive perioperative planning, long surgeries, and upwards of 30 screws placed per patient. This is the first and largest multicenter study to examine the trends in outcomes and complications over a 5-year period in this population.

Methods
Adult patients with complex ASD (>5 fusion levels and pelvic fixation) underwent robot-assisted spine surgery from 2016-2020 at four independent institutions. Primary outcomes included robot time per screw, fluoroscopy time per screw, screw accuracy, robot abandonment, and 90-day complications. Chi-square/fisher exact test and t-test/ANOVA were used for categorical and continuous variables. The Cochran-Armitage test was used to examine statistically significant trends.

Results
141 patients were included (Mazor Renaissance:22, X:104, Stealth:15). The mean age was 59.7, 58.2% female, total instrumented levels was 9.9, and robot screws/patient was 17.2. Operative time reduced significantly over time(-77 minutes); however, robot time per screw and fluoroscopy time per screw remained consistent averaging 4.3 minutes/screw and 3.9 seconds/screw. Significant improvement in screw accuracy and robot abandonment were observed.

Conclusion
In this large, multicenter study, robot screw accuracy and robot abandonment have significantly improved over the last five years in ASD surgery, leading to faster, more efficient surgeries in a complex patient population with an inherently high surgical morbidity. 90-day outcomes and length of stay remained consistent with prior literature on freehand techniques. These findings further validate the significant advances in robot technology for the most complex cases.

Take Home Message
Significantly improvement in robotic over the last five years in adult spinal deformity surgery, leading to faster, more efficient surgeries in a complex patient population.



134. The Influence of Long Fusions on the Change of Pelvic Incidence in Degenerative Patient: Sacrum Fixation vs. S2AI Fixation

Zhikai Qian, MD; Zezhang Zhu, MD; Zongshan Hu, PhD; Ziyang Tang, MD; Jie Li, MD; Yong Qiu, MD; Zhen Liu, MD

Summary
There are many controversies about the causes of postoperative change of pelvic incidence. Pelvic fixation might result in a significant mechanical change. This study showed a positive result that in patients with degenerative scoliosis who underwent posterior long segment internal fixation, the pelvic incidence decreased significantly in the patients utilizing S2AI screws.

Hypothesis
The insertion of S2AI screws may change the anatomical morphology of the sacroiliac joint and pelvic incidence.

Design
Retrospective study

Introduction
There are many controversies about the causes of postoperative change of pelvic incidence. Pelvic fixation might result in a

significant mechanical change. The purpose of this study was to investigate the influence of different fusion segments on pelvic incidence in patients with degenerative scoliosis.

Methods
The present study reviewed degenerative patients with kyphoscoliosis who accepted posterior long segment internal fixation between May 2010 and April 2018. 42 patients were included in our study, 5 males and 37 females. According to distal fusion segment, we divided patients into two groups, Group A(sacrum,14) and Group B (pelvic,28) LL, SVA, PI, PT, SS were recorded at pre-operation, post-operation. The difference of pelvic incidence between the two groups and the relationship with the parameters of sagittal plane before operation were analyzed.

Results
There was no statistical difference in gender and age between two groups. In group A, pelvic incidence changed postoperatively from 46.42°±16.73° to 44.11°±13.61° without statistical significance. (p=0.104)In group B, pelvic incidence significantly decreased postoperatively from 50.88°±13.59°to 43.99°±13.69°($p<0.05$).PI decreased postoperatively over 5 degrees in 55% of patients. Inter-group analysis showed that change in PI, preoperative PI-LL and postoperative SS were significantly different between both groups. Correlation analysis showed that the change in PI and preoperative LL and PI were significantly associated. The formula provided by the regression analysis was $\Delta PI=-3.117-0.116PreLL+0.201PrePI$.

Conclusion
In patients with degenerative scoliosis who underwent posterior long segment internal fixation, the pelvic incidence decreased significantly in the patients utilizing S2AI screws. However, the pelvic incidence did not change significantly in patients fixed distal to sacrum. The significant change of pelvic incidence in pelvic fixation group may be related to the greater degree of sagittal imbalance before operation.

Take Home Message
In patients with degenerative scoliosis who underwent posterior long segment internal fixation, the pelvic incidence decreased significantly in the patients utilizing S2AI screws.

135. Predicting Proximal Junctional Kyphosis Using Machine Learning in Patients Undergoing Adult Spinal Deformity Surgery

Yong Shen, BA; Cole Morrissette, MS; Mark M. Herbert, BS; Amogh Inamdar, MS; Ansaf Salleb-Aouissi, PhD; Ammran H. Mohamed; Zeeshan M. Sardar, MD; Ronald A. Lehman Jr., MD; Lawrence G. Lenke, MD; Joseph M. Lombardi, MD

Summary
Proximal junctional kyphosis (PJK) is one of the most debilitating complications of adult spinal deformity (ASD) surgery, causing patient disability and necessitating revision surgery. Currently, there is an incomplete understanding about the etiology of PJK. Using preoperative patient features, we utilized machine learning (ML) algorithms to predict whether ASD patients at the most recent follow up will require revision surgery, develop symptomatic PJK, or develop radiographic PJK. Additionally, we explored important features predictive of patient outcome.

Hypothesis
ML models can predict whether ASD patients will develop proximal junctional failure (PJF), symptomatic PJK, and radiographic asymptomatic PJK at the most recent follow up.

Design
Retrospective consecutive cohort.

Introduction
PJK increases the risk for patient disability. The etiology and prevention of PJK is not understood. We utilized an ML approach to predict whether ASD patients will develop PJF, symptomatic PJK, or radiographic PJK at their most recent follow up, as well as investigate the predictors for PJK status postoperatively.

Methods
366 consecutive patients from a single academic center who underwent posterior spinal fusion of ≥5 vertebral levels between 2015 and 2021 were included. ML models were developed in Python for classification of PJK status at the most recent follow up. The targets for prediction were revision surgery, symptomatic PJK defined as pain near the upper instrumented vertebra, and radiographic PJK defined as the change in proximal junctional angle (PJA) > 10° between most recent follow up and preoperative baseline. Accuracy, sensitivity, specificity, and area under the receiver-operating-curve (AUC) were calculated. Principle component analysis (PCA) was used for dimensionality reduction.

Results
19.1% of subjects developed PJK and 5.7% of subjects required revision surgery. Extreme Gradient Boosting (XGBoost) decision tree model achieved optimal performance trained on preoperative patient features. XGBoost model achieved an accuracy of 0.87, sensitivity of 0.17, specificity of 0.92, and AUC of 0.54 for revision surgery, accuracy of 0.66, sensitivity of 0.56, specificity of 0.68, and AUC of 0.62 for symptomatic PJK, and accuracy of 0.66, sensitivity of 0.60, specificity of 0.67, and AUC of 0.63 for radiographic PJK. PCA revealed that 65% of variance in data can be explained by a few patient features. Some important patient features were bone density, baseline SRS score, and age.

Conclusion
We developed an ML model to predict risk of developing PJK. Sensitivity remains a challenge while other metrics showed modest performance. Large, well-curated deformity databases are necessary for enhancement of model performance.

Take Home Message
ML models achieved modest performance in predicting the

development of PJK in ASD patients. Enhancing sensitivity remains the primary challenge. ML also uncovered patient features predictive of PJK status.

136. Patients With Fibromyalgia Have Higher Postoperative Opioid Utilization and Greater Odds of Developing Opioid Use Disorder Following Single-Level Thoracolumbar Spinal Fusions

Sai S. Chilakapati, MS; Syed Khalid, MD; Michael Burton, PhD; Owoicho Adogwa, MD

Summary
Patients with fibromyalgia are at risk for chronic opioid use and are often refractory to traditional pain therapy. In a retrospective study, we characterize the risk for opioid use disorder after single-level thoracolumbar spinal fusions among patients with fibromyalgia who were opioid naïve prior to surgery. We demonstrate increased opioid utilization and risk for opioid use disorder at 6 months postoperatively.

Hypothesis
Patients with fibromyalgia are at increased risk for opioid use disorder following spine surgery.

Design
Retrospective review

Introduction
Fibromyalgia is a disabling disease characterized by chronic generalized body aches that is refractory to traditional pain therapy. Patients with fibromyalgia undergoing spine surgery are a uniquely challenging population given the high-risk for chronic opioid use. However, the impact of fibromyalgia on postoperative opioid utilization and abuse following spine surgery has not been well characterized in literature.

Methods
This was a retrospective analysis using the Mariner-53 database (administrative database containing 53 million participants). ICD-9 and ICD-10 diagnostic codes were used to identify the sample population. Patients (age > 18 years) with a history of fibromyalgia who were opioid naïve preoperatively and underwent single-level thoracolumbar fusions were compared to a similar randomly selected sample of patients without fibromyalgia who underwent single-level thoracolumbar fusion. Exact 1:1 matching based on baseline patient demographics, smoking history, affective disorders (depression, anxiety), and social determinants of health were used to create two groups with identical covariates: fibromyalgia (n=1,191), non-fibromyalgia group (n=1,191). Opioid utilization and rates of opioid use disorder were compared between both groups.

Results
Both groups were balanced at baseline. At 6 months, opioid naïve patients with fibromyalgia had higher odds of developing opioid use disorder postoperatively compared to those without fibromyalgia (OR 1.73, 95% CI: 1.17 – 2.56). Opioid utilization was higher in patients with fibromyalgia at 3 and 6 months postoperatively compared to patients without fibromyalgia ($p<0.001$).

Conclusion
This study suggests that patients with fibromyalgia who are opioid naïve prior to thoracolumbar surgery have 73% higher odds of developing opioid use disorder postoperatively compared to patients without fibromyalgia. Postoperative opioid utilization at 3 and 6 months was also higher in patients with fibromyalgia.

Take Home Message
Patients with fibromyalgia are at increased risk for greater opioid utilization and opioid use disorder following single-level thoracolumbar fusions. Further prospective multi-center studies are needed to corroborate our findings.

138. Changes in Plasma Cytokine Markers Are Predictive of Persistent Postsurgical Pain Following Complex Spine Surgery

Sai S. Chilakapati, MS; Owoicho Adogwa, MD; Michael Burton, PhD

Summary
The physiological mechanisms underlying persistent post-surgical pain remain unclear. In this study we aimed to correlate immune activity with postoperative pain states by elucidating the principal immune changes in the plasma by analyzing cytokine levels following complex spine surgery. A pilot study with 15 patients found an increase in IL-6 in response to sterile trauma. However, patients with a blunted immune response immediately after surgery were associated with higher pain scores at 3-months postoperatively.

Hypothesis
Changes in immune profile following spine surgery are associated with increased risk of persistent post-operative pain

Design
Prospective, single-center cohort

Introduction
Spine surgery in older adults is beneficial and often results in decreased pain. However, in a subset of older adults, surgical outcomes are less desirable, with up to 20% experiencing persistent postsurgical pain (> 3 months). The physiological mechanisms underlying persistent post-surgical pain remain unclear. An emerging hypothesis focuses on the immune system's interplay with the nervous system wherein immune responses modulate the excitability of pain pathways, eventually driving chronic pain hypersensitivity.

Methods
15 patients undergoing complex spine surgery for adult spinal deformity were enrolled in this study. Whole blood samples were collected at three timepoints: preoperatively (Pre-Op), postoperative day 0 (POD0), then at postoperative day 3 (POD3). Plasma was isolated using Ficoll density centrifugation. Plasma IL-4, IL-6, IL-8, IL-10, IL-22, TNF-α were measured using a Quanterix Multi-Plex

cytokine assay. Pearson correlation and linear regression models were used to assess the association between cytokine profile and patient reported pain outcomes at 3 months (VAS Back and PROMIS pain scores).

Results
Compared to baseline there was a 2.7-fold and 5-fold increase in IL-6 at POD0 and POD3, respectively ($p<0.01$). There were no statistically significant differences in other cytokines expression levels following surgery. On linear regression analysis, increase in IL-6 levels from baseline to POD3 were correlated with increased opioid utilization on POD3. At 3-months, cytokine expression levels in IL-6, IL-10, and TNF-α at POD0 were inversely correlated with 3-month VAS Back Pain scores and PROMIS scores.

Conclusion
Following spine surgery, patients exhibited a robust increase in IL-6, a pro-inflammatory cytokine, in response to sterile trauma. Patients with higher pain scores at 3-months postoperatively had a more blunted immune response immediately after surgery (POD0). Further biochemical and ex-vivo studies are needed to fully characterize immune response to surgery.

Take Home Message
Following complex spine surgery, patients exhibit an acute pro-inflammatory response. However, those with less robust immune response immediately after surgery are at risk for persistent postsurgical pain at 3 months.

139. An In Vitro Biomechanical Analysis of Contralateral Sacroiliac Joint Motion following Unilateral Sacroiliac Reconstruction

Woojin Cho, MD, PhD; Brandon Bucklen, PhD

Summary
There is concern that unilateral sacroiliac joint (SIJ) fusion may increase contralateral SI joint degeneration due to stress concentration at contralateral SIJ. In this study, both 2 screw and 3 screw fixation were applied to the left SI-joint after destabilization with and without simulated screw/rod fixation to the sacrum. No significant contralateral SI-joint hypermobility was observed.

Hypothesis
Unilateral reconstruction and fusion of the SI joint may result in contralateral joint instability or hypermobility.

Design
In vitro human cadaver study from L3-pelvis

Introduction
Sacroiliac joint (SIJ) fusion is an innovative surgery, yet concerns exist that unilateral SIJ fusion can increase contralateral SI joint degeneration due to stress concentration at the contralateral SIJ. While SI screw fixation has been evaluated in a limited context, the role of unilateral fixation remains unknown.

Methods
Seven lumbopelvic spines were used in this study. Each specimen was affixed to a six-degrees-of-freedom testing apparatus and pure unconstrained bending moments of 8 N-m were applied in physiological planes. Plexiglas markers were secured to L3, L4, L5, sacrum, left and right iliac crest via bone screws to track motion. An SI joint fixation system was used for all lateral iliosacral screws (Slotted SIJ screws, 30–45mm length, 10mm diameter). Both left sided iliosacral ligaments and posterior ligaments were cut. Subsequently, the surgical reconstruction groups were: (1) 2 left side SI screws, and (2) 3 left side SI screws. Each group was tested with and without pedicle screws and rods at L5-S1.

Results
There were no statistical differences between left and right side SI-joint motion following unilateral SIJ screws (2 or 3) (Fig 1). The posterior ligamentous injury and the addition of pedicle rods at L5-S1 provided the highest increases in motion across both joints, however, there were no differences specific to the contralateral side in any loading mode. All loading modes showed similar trends, exhibiting small amounts of motion (flexion-extension~1°; lateral bending~0.2°; Axial Rotation~0.5°).

Conclusion
Preferential treatment of unilateral SI joint dysfunction appears to be biomechanically equivalent to bilateral treatment, in terms of immediate post-operative stability. This biomechanical study suggests unilateral SIJ fixation does not have a negative mechanical consequence on contralateral SIJ motion.

Take Home Message
Unilateral SIJ fixation does not have a negative mechanical consequence on contralateral SIJ motion.

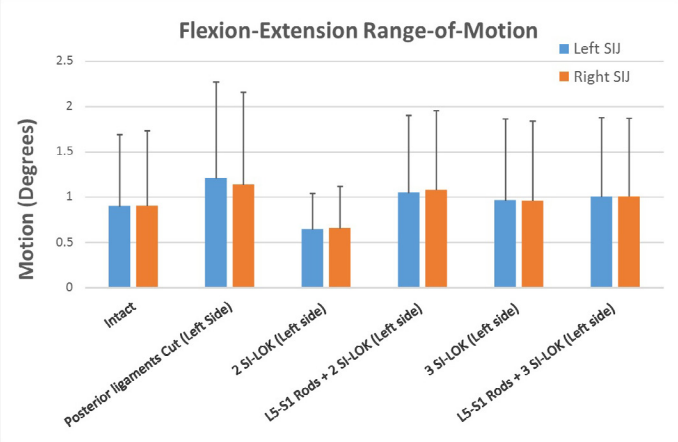


Figure 1. Flexion-extension range of motion

140. Dipeptidyl Peptidase-4 is Associated with Myogenesis in Patients with Adolescent Idiopathic Scoliosis Possibly via Mediation of Insulin Sensitivity

Zhicheng Dai, MS; Zhenhua Feng, MS; Yong Qiu, MD; Zezhang Zhu, MD

Summary
DPP-4 expression was down-regulated in serum and muscle tissue of AIS patients. Aberrant DPP-4 expression could affect insulin sensitivity in myoblasts and further influence the cell viability during myogenesis. The molecular mechanism connecting DPP-4 and insulin-related signaling in AIS is worthy of further investigation.

Hypothesis
DPP-4 expression was down-regulated in serum and muscle tissue of AIS patients. Aberrant DPP-4 expression could affect insulin sensitivity in myoblasts and further influence the cell viability during myogenesis.

Design
A case-control study

Introduction
Abnormal metabolic features have been previously described in AIS patients. As an important regulator involved in energy metabolism, DPP-4 activity was reported to be remarkably decreased in osteoblasts of AIS patients. To date, there was still a lack of knowledge concerning the role of DPP-4 in the myogenesis of AIS.

Methods
Circulation DPP-4 level was assessed in the serum of 80 AIS girls and 50 healthy controls by ELISA. Myoblasts were purified from muscle specimens of AIS patients and LDH controls, and then treated with metabolic effectors including glucose and insulin. CCK-8 assay was used to assess the cell viability and myotube fusion index was calculated to evaluate myogenesis ability. Gene expressions of downstream signals of DPP-4 were evaluated by RT-qPCR and Western blot respectively.

Results
AIS girls had remarkably down-expressed DPP-4 in both serum level (0.76 fold) and tissue (0.68 fold) level. Treatment with metabolic effectors led to significantly increased DPP-4 expression in the control cells, while there was no increase of DPP-4 in AIS cells. CCK-8 assay showed that the proliferation rate of control cells was significantly increased after being treated. Remarkably higher fusion index was also observed in the treated control cells. By contrast, the fusion index and cell proliferation rate were comparable between the treated and the untreated AIS cells.

Conclusion
Our study suggested a potential role of DPP-4 in abnormal metabolic condition of AIS patients. Compared with control cells, AIS myoblasts presented obviously impaired sensitivity to the treatment of glucose and insulin. Aberrant DPP-4 expression could lead to impaired insulin sensitivity in myoblasts and further influence the cell viability during myogenesis. The molecular mechanism connecting DPP-4 and insulin-related signaling in AIS is worthy of further investigation.

Take Home Message
1.DPP-4 expression was down-regulated in AIS patients. 2.Aberrant DPP-4 expression could affect insulin sensitivity in myoblasts and influence myogenesis. 3.The molecular mechanism connecting DPP-4 and insulin-related signaling is worthy of further investigation.

141. Reducing Set Screw Loosening Failures: An Analysis of Final Tightening Technique

David W. Polly Jr., MD; Gregory M. Mundis Jr., MD; Corey Gladieux

Summary
Pedicle Screw construct failures can occur through a variety of modalities. Related to set screw loosening failures; the practice of final tightening the set screws in a slow and controlled manner has been shown to increase the strength of the fixation construct.

Hypothesis
Final set screw locking torque technique may affect the strength of the fixation construct.

Design
Controlled Benchtop Study

Introduction
A 5% rate of S2AI screw failure consisting of rod slippage/set screw displacement has been reported (Martin, Polly et al JNS 2021). The fixation construct strength is largely dependent on the set screw's locking torque. Both the magnitude (how much torque is applied) and the rate (how fast the torque is applied) can impact set screw loosening failure.

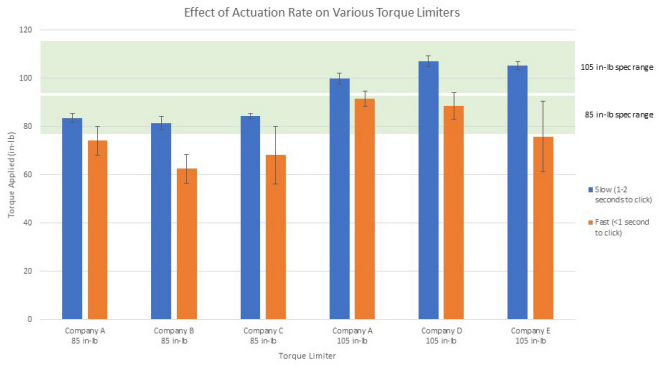
Methods
Commercially available, Ti Alloy 5.5mm polyaxial pedicle screws and set screws were used. To test the effect of the locking torque magnitude on construct strength, the set screws were tightened onto a Ti Alloy rod at 85 and 105in-lbs (N=8 each). A torque meter (TM)[Transducer Techniques, SWS-20] was attached to the driver to record both the locking and loosening torque. To test the effect of the rod alloy, the same implants were tested with 5.5 CoCr and Ti Alloy rods (N=8 each). The set screws' locking and loosening torque were measured. Also,6 torque limiting handles from 5 suppliers were attached to the same TM. To test the effect of torque application rate, an experienced user torqued the handle until the device's internal limit was reached. The resulting torque was measured. Each handle was subjected to 11 actuations at two rates, fast and slow.

Results
Set screws tightened to 105.8(±.54)in-lbs retained 39.6% more torque than those tightened to 85.4(±.57)in-lbs ($p<0.001$), demonstrating that more torque applied results in more torque retained. Set screws tightened onto a Ti Alloy Rod retained 15.0% more torque than those tightened onto a CoCr rod ($p<.003$). When torque limiting handles are actuated at a slow rate the resulting

torque output produced is 22.6% higher than when actuated at a fast rate, demonstrating the magnitude of the torque applied is dependent on the rate at which the handle is rotated ($p<0.05$).

Conclusion
The choice of spinal rod alloy used may affect set screw security. More torque applied results in more torque retained; therefore we recommend the final locking torque be applied in a slow and controlled manner to ensure the intended locking torque magnitude is applied.

Take Home Message
When final tightening set screws with a torque limiting handle, the torque should be applied in a slow and controlled manner to ensure the intended locking torque is produced.



142. A Novel Splice Site Mutation in the PLS3 Gene Responsible for Severe X-linked Osteogenesis and Scoliosis

Zhichong Wu, PhD; Zhicheng Dai, MS; Zezhang Zhu, MD; Yong Qiu, MD

Summary
X-linked early-onset osteoporosis, caused by mutations in the plastin3 (PLS3), is an extreme rare disease characterized by low bone mineral density, recurrent vertebral compression fractures (VCFs), and/or long bone fractures. However, the genotype–phenotype characteristics of the diseases remains unclear.

Hypothesis
Genetic mutations caused the phenotype of early-onset osteoporosis and recurrent osteoporotic fractures in the patients

Design
A genetic study

Introduction
X-linked early-onset osteoporosis, caused by mutations in the plastin3 (PLS3), is an extreme rare disease characterized by low bone mineral density, recurrent vertebral compression fractures (VCFs), and/or long bone fractures. However, the genotype–phenotype characteristics of the diseases remains unclear.

Methods
The phenotypes of the subjects were investigated in detail. Whole exome sequencing was carried out in the patient with early-onset osteoporosis and scoliosis, and the identified pathogenic mutations were confirmed in the patient, his brother and parents by sanger sequencing. The potential effect of the novel splicing mutation was assessed by RNA transcript analysis by reverse transcription-PCR.

Results
The proband, a 16-year-old boy experienced recurrent osteoporotic fractures and scoliosis. Brace treatment is effective in controlling the progression of the curve. His younger brother also had early-onset osteoporosis. A novel splicing mutation (c.892-2A>G) in the PLS3 was identified in the brothers which was inherited from their mother. RT-PCR reveals that the splicing mutation caused the skipping of exon 8 of PLS3 with in-frame deletion of 32 amino acids (p.298-329del).

Conclusion
We successfully identified a novel splicing mutation in PLS3 and elucidated the underlying mechanism of the mutation, which led to severe primary osteoporosis. Scoliosis can also be presented in the patients which may be controlled by brace treatment. Our findings broaden the genetic and phenotypic spectrum and provide practical information for the diagnosis and treatment of the disease

Take Home Message
Whole exome sequencing should be performed in patients with early-onset osteoporosis. Scoliosis can also be presented in the patients which may be controlled by brace treatment.

143. Establishing the Minimal Clinically Important Difference for the PROMIS Physical Domains in Cervical Deformity Patients

Peter G. Passias, MD; Oscar Krol, BS; Bailey Imbo, BA; Lara Passfall, BS; Peter Tretiakov, BS; Tyler K. Williamson, MS, BS; Waleed Ahmad, BS; Stephane Owusu-Sarpong, MD; Rachel Joujon-Roche, BS

Summary
PROMIS involves computer adaptive testing and the VAS-Neck is essential for analyzing neck pain and functionality. By anchoring PROMIS to VAS, we developed the MCID for the physical domains of PROMIS: Physical Function (PF), Pain Intensity (PI) and Pain Interference (Int).

Hypothesis
The MCID of the PROMIS physical domains can be established through the anchor-based methodology in CD patients.

Design
Retrospective

Introduction
PROMIS has been shown to correlate with VAS-Neck scores in a surgical CD patient population.

Methods
141 surgical CD patients were isolated. Changes in HRQLs: ΔBL-3M. VAS-Neck scores were multiplied by 10 to scale out of 100. An anchor-based methodology was used (Carreon et al). The cohort was divided into four groups: 'worse' (ΔVAS-Neck ≥12.5), 'unchanged' (≥ -12.5, but <12.5), 'slightly improve' (<-12.5, but ≥ -25), and 'markedly improved'(< -25) [Based off of 25 as the MCID for VAS-Neck]. PROMIS-PF, PI and Int at 3M was compared between patients who were 'slightly improved' and those 'unchanged' and the difference was taken to be the MCID. ROC analysis computed discrete values for the MCID by evaluating the change in PROMIS that yielded the smallest difference between sensitivity ('slightly improved', change above MCID threshold) and specificity ('unchanged', below). We repeated anchor-based methods for CD as classified by Ames-ISSG (Low [0], Moderate [1], Severe [2]).

Results
BL, 3M and ΔBL-3M means of PROMIS and VAS-Neck are in Table 1. The VAS-Neck groups were as follows: 12.8% 'worse', 57.4% 'unchanged', 7.8% 'slightly improved', 22% 'markedly improved'. Patients classified as 'unchanged' exhibited an average PROMIS-PF improvement of 10±20.4 and those that were 'slightly improved' had an average gain of 11.6 ±19.4. This gave an MCID for PROMIS-PF of 1.6(11.6-10). PROMIS-PI 'unchanged' was -11.4±25.8 and a 'slightly improved' average of -18, for an MCID of -6.6. PROMIS-Int 'unchanged' mean was -7.6 and 'slightly improved' of -8.6, for an MCID of -1. The ROC analysis for the PROMIS-PF demonstrated an MCID of +8.5, for PROMIS-PI of -13.0, and PROMIS-Int of -10.6. Across Ames-ISSG TS-CL CD modifiers, ROC analysis found MCID's for Low, Moderate, and Severe deformity for PF, PI and Int (Table 1).

Conclusion
The MCID for PROMIS physical domains were established for a cervical deformity population. MCIDs varied across deformity severity groups, with highest differences noted in Moderately deformed patients.

Take Home Message
Utilization of an anchor-based methodology, an MCID of +8.5 for PROMIS Physical Function, -13 for PROMIS Pain Intensity, and -10.6 for PROMIS Pain Interference were established in a CD population.

SRS-22r		
Overall	2.6	
Function	2.6	
Pain	2.5	
Self/Image	2.2	
Mental Health	3	
PROMIS		
Physical Function	12.4	
Pain Intensity	91.7	
Pain Interference	55.9	
Responsiveness		
	Cohen's d	Effect
SRS-22r	0.37	Medium
SRS-22 Function	0.04	-
SRS-22 Pain	0.23	Small
SRS-22 Self/Image	0.91	Large
SRS-22 Mental Health	0.04	-
PROMIS Physical Function	0.58	Large
PROMIS Pain Intensity	0.17	Small
PROMIS Pain Interference	0.66	Large

144. Transient Perioperative Complications Should Not Preclude Efforts to Achieve Optimal Realignment in Cervical Deformity Surgery

Peter G. Passias, MD; Tyler K. Williamson, MS, BS; Bailey Imbo, BA; Kevin Moattari, BS; Lara Passfall, BS; Peter Tretiakov, BS; Rachel Joujon-Roche, BS; Stephane Owusu-Sarpong, MD; Oscar Krol, BS; Shaleen Vira, MD; Bassel G. Diebo, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Praveen V. Mummaneni, MD; Jordan Lebovic, MBA; Dean Chou, MD; Paul Park, MD; Saman Shabani, MD; M. Burhan Janjua, MD

Summary
Recent emphasis on perioperative outcomes have become the focus of healthcare because of their tie to reimbursement by Medicare and Medicaid. However, it is unknown whether these perioperative complications have any effect on achieving a successful outcome. Our study demonstrated the perioperative risk of increased invasiveness and correction needed to achieve optimal realignment is warranted to obtain long-term, durable outcomes during ACD surgery.

Hypothesis
The superiority in achieving optimal realignment on long-term outcomes despite the increased risk of transient perioperative complications in ACD surgery.

Design
Retrospective cohort

Introduction
An increased risk of perioperative complications comes with increasing complexity. However, some patients persevere through short-term complications and manage to still achieve optimal, long-term outcomes.

Methods
Operative ACD patients with baseline (BL) & 1-year (1Y) data were included. Patients were stratified based on meeting 1Y optimal

outcome. Optimal outcome: improvement in Ames-ISSG cSVA AND Horizontal modifiers, AND meeting Virk's Good Clinical Outcome at 1 year. Multivariate analysis was used to determine significance for complications. Published methods converted NDI to SF-6D. Cost was calculated using the PearlDiver database and CMS.gov definitions. Cost per QALY at 1Y were calculated.

Results

87 ACD patients (61.7±9.9yrs, 28.3±7.1kg/m2, CCI: 0.93±1.3, mFI: 3.12±1.65) were included. Patients were grouped as follows: 45 "optimal" (O) and 42 "not optimal" (NO). Means comparison tests revealed significant differences in age. The two groups had no significant differences in surgical characteristics, other than approach. Results are displayed in Table 2. Analysis of short-term complications, showed that the O group had significantly more dysphagia (7.0% vs. 1.0% in the NO group, p=.039) and neurological complications (p=.020), and more overall medical complications (56% vs. 50% in NO, p=.523), and while the NO group had significantly more cardiopulmonary complications (p=.014) and were more likely to develop either DJF or reoperation (36% vs. 14%, p=.021).

Conclusion

Despite undergoing more invasive procedures and sustaining more perioperative complications, patients who met optimal outcome experienced less major complications and adverse events, and a lower rate of either developing DJF or undergoing reoperation by one year. Accordingly, a higher, transient perioperative complication profile should not preclude surgical correction in ACD patients who demonstrate baseline characteristics suggestive of successful long-term outcomes.

Take Home Message

Achieving optimal realignment in adult cervical deformity surgery often incurs increased perioperative complications, but these higher, transient complications do not prevent successful, long-term outcomes.

Table 2. Group Differences in Perioperative and Long-Term Complications

Complication	Did Not Meet Optimal Outcome	Met Optimal Outcome	p-value
Any Complication	50%	56%	.523
Major Complication	31%	20%	.209
Adverse Event	40%	17%	.195
Cardiopulmonary	6.3%	0.0%	.014
Infection	2.8%	7.0%	.333
Neuro	6.6%	11.6%	.020
Dysphagia	1.0%	7.0%	.039
Operative	8.5%	4.7%	.420
DJF	13.3%	2.4%	.064
Reoperation	31.1%	14.3%	.061
DJF or Reoperation	35.6%	14.3%	.021
Low Deformity in Modified Ames-ISSG Modifier			
Cervical Lordosis	39%	72%	.004
TS-CL	46%	67%	.089
C2-T3	80%	93%	.086
C2-Slope	78%	93%	.061
McGregor's Slope	52%	44%	.593

145. Unplanned Additional Surgery following Cervical Deformity Correction: Analysis of a Prospective Multi-Center Database

Mitchell Fourman, MD, PhD; Renaud Lafage, MS; Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Peter G. Passias, MD; Christopher I. Shaffrey, MD; Gregory M. Mundis Jr., MD; Themistocles S. Protopsaltis, MD; Shay Bess, MD; Eric O. Klineberg, MD; Munish C. Gupta, MD; Virginie Lafage, PhD; Han Jo Kim, MD; International Spine Study Group

Summary

Additional surgery following adult cervical spine deformity (ACSD) correction in already vulnerable hosts can lead to suboptimal outcomes. In a retrospective analysis of 121 ACSD corrections in a prospective multicenter database, 28 (23.1%) required unplanned additional surgery. The majority of the additional procedures (67.9%) were performed within 1 year of deformity correction. The most common indications were recurrent/new neurologic deficits (radiculopathy/myelopathy, 25.0%) and infection/wound complications (17.9%). Unplanned procedures following ACSD correction may be preventable and therefore merit specific focus

Hypothesis

Unplanned returns to the OR after adult cervical deformity (ACSD) correction are predictive of poor short-term radiographic and quality of life outcomes.

Design
Retrospective analysis of a prospective multicenter deformity database

Introduction
Complications after ACSD correction are common, and unplanned returns to the OR are particularly devastating. We sought to characterize those patients who had an unplanned return to the OR following ACSD correction

Methods
This was a retrospective analysis of ACSD corrections included in a prospectively collected, multi-center deformity database with at least 1-year of follow-up. The primary outcome was survival without an unplanned return to the OR. Secondary outcomes were health-related quality of life scores and sagittal alignment measurements.

Results
A total of 121 (121 / 168, 72.0%) ACSD patients were included in this work. Mean age was 61.9 ± 10.1 years old, mean BMI was 28.4 ± 6.9, and mean Charlson Comorbidity Index was 1.0 ± 1.4. Seventy-six patients were female (62.8%). Mean follow-up was 383 ± 72 days. An unplanned return to the OR was required for 28 patients (23.1%), with 67.9% of procedures performed within 1 year of ACSD correction. Notably, there were 5 infection/wound complications (4.1%), 7 myelopathy/radiculopathy (5.8%), and 5 junctional complications (4.1%). Median time to revision for each complication subtype was 26 days for wound issues, 152 days for neurologic issues and 112 days for junctional issues. Estimated survival 30 days post-op was 93%, 90 days post-op 92%, 180 days post-op 86% and 365 days post-op 83%. The age, BMI, sex, comorbidities, surgical characteristics, and 1-year health-related quality of life scores and radiographic measurements of patients who had an unplanned reoperation were equivalent to those without a reoperation (Table).

Conclusion
The reoperation rate after ACSD correction was 23.1%. Unplanned return to OR does not impact short term outcomes. The long-term consequences of an early reoperation are unclear and are necessary to completely characterize this distinct patient group.

Take Home Message
Early returns to the OR after cervical deformity correction are common (23.1%) and may be preventable. Common indications for additional surgery were infectious/wound complications and recurrent neurologic pathology

RETURN TO OR WITHIN 1 YEAR OF SURGERY		**N = 19 (67.9%)**
N = 5	Neurologic (Radiculopathy/Myelopathy)	4, 8, 10, 152, 331 days
N = 2	Trauma	13, 177 days
N = 4	Infection / Wound Complication	15, 15, 26, 134 days
N = 3	Junctional Complication (2 DJK, 1 PJK)	70, 104, 112 days
N = 3	Hardware Complication	126, 143, 318 days
N = 1	Airway Edema	3 days
N = 1	Other (unplanned staged procedure)	70 days
RETURN TO OR > 1 YEAR AFTER SURGERY		**N = 9 (32.1%)**
N = 2	Junctional Complication (2 DJK)	351, 352 days
N = 1	Wound Complication	435 days
N = 1	Pseudoarthrosis	560 days
N = 2	Neurologic	289, 388 days
N = 2	Hardware Complication	356, 619 days
N = 1	Other (poor outcome improvement)	330 days
TOTAL RETURN TO OR RATE		**N = 28 (23.1%)**

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146. What is the Ideal Cervical Spine Realignment in Operative Cervical Deformity Patients When the Thoracolumbar Spine is Not Addressed?

Lara Passfall, BS; Oscar Krol, BS; Nicholas A. Kummer, BS; Bailey Imbo, BA; Peter Tretiakov, BS; Kevin Moattari, BS; Rachel Joujon-Roche, BS; Tyler K. Williamson, MS, BS; Virginie Lafage, PhD; Bassel G. Diebo, MD; Shaleen Vira, MD; *Peter G. Passias, MD*; Renaud Lafage, MS; Praveen V. Mummaneni, MD; Dean Chou, MD; Paul Park, MD; Saman Shabani, MD

Summary
There is a paucity in the literature regarding the extent of correction that should be undertaken in patients with cervical deformity (CD) who have an isolated cervical spine intervention as opposed to having a fusion construct extend to the thoracic or lumbar regions. This study found that for CD patients undergoing reconstruction with LIV above the thoracic kyphosis apex, realignment goals should emphasize optimization of TS-CL and cervical lordosis to achieve favorable functional and radiographic outcomes.

Hypothesis
Isolated CD correction should emphasize cervical alignment parameters regardless of concurrent TL deformity.

Design
Retrospective cohort

Introduction
There is a paucity in the literature regarding the extent of correction that should be undertaken in patients with cervical deformity (CD) who have an isolated cervical spine intervention.

Methods
Included: operative CD patients >18yrs with preop (BL) and up to 2-year (2Y) HRQL/radiographic data. Patients with LIV at or below the thoracic kyphosis apex were excluded. An optimal outcome [Opt] was defined as: 1) no DJF and 2) having Virk et al. good clinical outcome at 2Y [≥2 of the following: NDI<20 or meeting MCID, mild myelopathy (mJOA ≥14), NRS-Neck≤5 or improved by ≥2 points

from BL]. Univariate analyses assessed postoperative alignment for Opt pts. Opt pts were grouped based on concurrent thoracolumbar deformity at BL [CD-TL (coronal Cobb angle ≥20°, SVA≥50mm, PT≥25°, TK>60°)] or not [CD-nonTL]. Postop alignment was compared for CD-TL and CD-nonTL pts with optimal outcome.

Results
70 CD patients with LIV above TK apex were included (58yrs, 57%F, 27.8kg/m2, levels fused: 5.7±4.2). Mean BL radiographic parameters: T1S 32.2°, C2-C7 lordosis -8.3°, TS-CL 31.4º, CL flexibility 26.9°, cSVA 40.8mm. 25 of the CD pts (35.7%) had concurrent TL deformity [CD-TL] at BL. 30 CD pts (42.9%) met optimal outcome criteria [Opt]. At 2Y, Opt patients had higher C2-C7 lordosis and C2-T3, as well as lower TS-CL (all $p<0.05$). There were no differences in BL to 2Y changes by Opt outcome (all $p>0.05$). Opt pts were more likely to improve in Ames TS-CL modifier from BL to 2Y, to improve in ≥1 SRS-Schwab modifier, and to have age-adjusted match at 2Y (all $p<0.05$). Opt pts classified as CD-TL did not differ from CD-nonTL pts in any BL to 2Y changes, in improving in alignment targets, or in DJK rates (all $p>0.05$).

Conclusion
For cervical deformity patients undergoing reconstruction with LIV above the thoracic kyphosis apex, realignment goals should emphasize optimization of TS-CL and cervical lordosis to achieve favorable functional and radiographic outcomes regardless of concurrent thoracolumbar deformity.

Take Home Message
For cervical deformity patients undergoing reconstruction with LIV above the thoracic kyphosis apex, realignment goals should emphasize optimization of TS-CL and cervical lordosis to achieve favorable functional and radiographic outcomes.

147. The Clinical Impact of Addressing Thoracic Secondary Drivers Concurrently at the Onset of Corrective Realignment Surgery for Adult Cervical Deformities

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Summary
In recent years, the relationship between the structural drivers of cervical sagittal malalignment and their characterization of cervical deformity (CD) have been investigated. This study assessed differences in outcomes when secondary thoracic driver is treated with long fusion extending to or past the thoracic apex. Despite the more severe radiographic and neurological markers noted and more invasive surgeries undertaken, patients whose fusions extended past the thoracic driver demonstrated significantly lowered risk of distal junctional kyphosis (DJK) or subsequent reoperation.

Hypothesis
Extending the fusion construct past the thoracic secondary driver will reduce post-operative complications and improve patient outcomes by 1Y post-op.

Design
Retrospective review.

Introduction
There is a paucity in the literature regarding the clinical and radiographic outcomes of patients with secondary drivers with fusion constructs extending to or past the thoracic apex. Comparative analyses of including or excluding secondary deformity drivers have yet to be conducted.

Methods
Operative CD patients with BL and 1Y HRQL and radiographic data were included, characterized by primary deformity driver (Cervical/CT Junction) then stratified by the presence or absence of a secondary thoracic driver (SD). Patients with secondary driver were divided based on the inclusion (IN) or exclusion (EX) of the thoracic driver apex in the construct. Means comparison tests assessed differences in clinical and radiographic factors. Binary logistic regression controlling for age and BL C2-T3 assessed the effect of fusion length on postoperative CD outcomes.

Results
94 patients (62.1yrs, 65%F, 27.6kg/m2) were included. 19 patients (20.2%) were categorized as SD+IN. SD+IN patients were significantly less likely to report BL hand numbness ($p=.004$) or hand clumsiness ($p=.008$). In terms of surgical differences, SD+IN patients were significantly more likely to undergo a posterior approach ($p=.001$). Additionally, SD+IN patients were more likely to undergo any osteotomy ($p=.002$), a SPO ($p=.045$), or VCR ($p=.005$). At 1Y, SD+IN patients had higher mean EQ5D VAS scores ($p=.000$). If the secondary driver was not included in the fusion, patients were significantly more likely to be reoperated for DJK ($p=.030$). Logistic regression revealed a 3.603 times increased risk of severe DJK by 1Y ($p = .011$).

Conclusion
Patients with secondary thoracic drivers that had fusions extending to the thoracic apex experienced more invasive treatment including greater levels fused and greater likelihood of undergoing an osteotomy. Despite this, patients whose fusions extended past the thoracic driver displayed lowered risk of DJK or subsequent reoperation.

Take Home Message
Extending the fusion construct past the thoracic secondary driver in cervical deformity patients significantly lowers risk of distal junctional kyphosis (DJK) or reoperation despite more invasive surgeries.

148. Cervical Deformity Score: A Composite Alignment Tool to Optimize Outcomes while Mitigating Complications

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Summary
Cervical alignment and Cervical deformity surgery are complex topics. Recently a Cervical Deformity Score (CDS) was designed to predict early mechanical failures. Correlations between 1-year post-operative CDS and patient reported outcomes showed significant association between increased CDS and increase disability, pain, and lower general health. Patients without any complications before 1Y had a lower CDS, as did patients without major complication. In a multivariate analysis, controlling for age and comorbidities, 1-year CDS was a significant predictor of complications.

Hypothesis
A newly described Cervical Score will be associated with better outcomes and lower complications rate.

Design
Retrospective review of Prospective multicenter database.

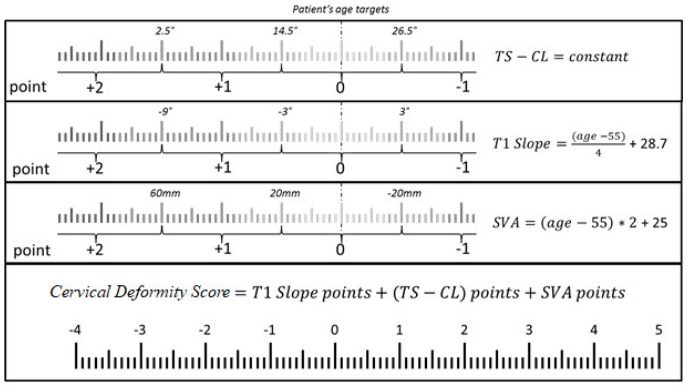
Introduction
Cervical alignment and Cervical deformity surgery are complex topics. Recently a Cervical Deformity Score (CDS) was designed to predict early mechanical failures. Its association with patient reported outcomes (PROM) remains unclear.

Methods
CD patient with baseline and 1yr FU were included. After calculating the post-operative CDS (an age-adjusted composite alignment score based on TS-CL, T1 Slope, and SVA), its association with patient reported outcomes was investigated using Pearson's correlations. Comparison of CDS between patients with and without complication within 1-year was conducted, along with logistical regressions.

Results
102 patients met inclusion criteria (61.7yo±10, 66.7% F). Pre-operatively, they had elevated disability (NDI: 47.1±18.1), Pain (NSR Neck: 6.6±2.5), and lower general health (EQ5D: 0.74±0.07). They presented with cervical kyphosis (C2-C7: -6.3°±20.9), and a moderate cervical anterior alignment (cSVA: 39mm±20; TS-CL: 37.9°±19.4). The median of number of levels fused was 7 [4 9] (49%= posterior approach, 30.4%=combined approach). 83.2% received an osteotomy, with 16.8% of grade 6 or 7. The mean Op Time was 368min±208, with a median EBL of 525cc [200 1025], and a LOS o 5days [4 8]. At 1-year PROM improved significantly (all p<0.001). The cervical alignment significantly changed (C2-C7: 7.8±14.5m, cSVA: 34mm±15, all p <0.002), with a 1Y CDS of 1.68±2.46. There was a significant association between increase CDS and increase disability (r=0.273), pain (r=0.336) and lower general health (r=-0.283). Patients without any complications before 1Y had a lower CDS, as did patients without major complication (figure). In a multivariate analysis, controlling for age and comorbidities, 1-year CDS was a significant predictor of complications (p=0.002, OR=1.409).

Conclusion
With better outcomes and lower complication rate, maintaining a proportionate alignment post-operatively can result in superior outcomes following CD surgery.

Take Home Message
Previously described Cervical Deformity Score demonstrated a significant association with post-operative outcomes, with a lower disability and lower rate of complications for proportionate score.



		N	Mean	StD	25th	50th	75th	p-value
Any Complication?	No	37	0.78	2.33	-1.0	0.0	3.0	0.0051
	Yes	65	2.18	2.4	1.0	2.0	4.0	
Major Complications?	No	74	1.36	2.27	0.0	2.0	3.0	0.0368
	Yes	28	2.5	2.78	0.3	2.5	4.0	
Post-op NDI > 20?	No	34	0.71	2.34	-1.3	1.0	2.3	0.0043
	Yes	68	2.16	2.39	0.0	2.0	4.0	

149. Baseline Myelopathic Severity is an Independent Determinant of Adverse Outcomes, Complications and Functional Recovery Following Adult Cervical Deformity Corrective Surgery

Peter G. Passias, MD; Katherine E. Pierce, BS; Bailey Imbo, BA; Lara Passfall, BS; Peter Tretiakov, BS; Rachel Joujon-Roche, BS; Sara Naessig, BS; Stephane Owusu-Sarpong, MD; Tyler K. Williamson, MS, BS; Waleed Ahmad, BS; Jordan Lebovic, MBA; Renaud Lafage, MS; Virginie Lafage, PhD; Bassel G. Diebo, MD; Shaleen Vira, MD; M. Burhan Janjua, MD; Dean Chou, MD; Paul Park, MD; Praveen V. Mummaneni, MD

Summary
This study sought to investigate the relationship between baseline myelopathy and neck function severity at baseline, and how the

ratio of severity impacts outcomes following cervical deformity (CD) corrective surgery. In conclusion, we determined that patients who report more myelopathy severity over neck disability have an increased risk for poor neurologic outcomes and distal junction kyphosis.

Hypothesis
Baseline myelopathy severity will impact postoperative outcomes.

Design
Retrospective

Introduction
Little is known of the impact of myelopathy severity in CD patients on patient-reported outcomes when taking into account symptomatic presentation.

Methods
Surgical CD patients with baseline HRQLs and radiographic follow-up[1-yr]. mJOA assessed baseline myelopathy severity, Tetreault et al. (Severe <12). Ratios of baseline myelopathy groups to neck disability groups (Vernon et. al:), assessed myelopathy in conjunction with neck disability. A ratio >1 indicated that myelopathy severity weighed more than neck disability, and vice versa. In a subanalysis, Severe and Not Severe myelopathy groups were PSM for cSVA. Univariate analyses were performed to determine whether myelopathy severity impacted postop outcomes.

Results
136 CD patients included (56.6yrs, 49%F, 29.9kg/m2). Baseline mJOA: 13.1±2.9, NDI of 58.9±18.8. 28.7% had Severe baseline myelopathy, 71.3% Not Severe. Severe patients had greater baseline NDI scores (68.2 vs. Not Severe: 55.1, p<0.001). Ratios distribution can be seen in Table 1. Patients more impacted by myelopathy had greater postop neurological complications (25%, vs. greater NDI:3%, p=0.042) and DJK (25%), p=0.034. After PSM for cSVA in the subanalysis, 26 patients remained in Severe and Not Severe myelopathy groups. Severe had increased neuro complications(15.4%) and met MCID for EQ5D significantly less than the Not Severe baseline myelopathy patients (11.5% vs. 34.6%), both p<0.05. From baseline to 1-year, 31.5% improved, 49.3% same, and 19.2% deteriorated in their myelopathy severity. Patients who improved in mJOA severity by 1-yr had less incidence of DJK (0% vs. 8.3 vs. 28.6)

Conclusion
Patients who report more severe myelopathy over neck disability preoperatively are at increased risk for neurologic complications and distal junctional kyphosis occurrence. When controlling for baseline deformity severity, this remained true for patients with severe myelopathy presentation along with decreased overall quality of life at follow up.

Take Home Message
Baseline myelopathy severity impacts postoperative outcomes to a greater extent than patient reported neck disability in adult cervical deformity patients.

150. Do Newly Proposed Realignment Targets Bridge the Gap Between Radiographic and Clinical Success in Adult Cervical Deformity Corrective Surgery

Peter G. Passias, MD; Katherine E. Pierce, BS; Sara Naessig, BS; Oscar Krol, BS; Peter Tretiakov, BS; Waleed Ahmad, BS; Bailey Imbo, BA; Rachel Joujon-Roche, BS; Tyler K. Williamson, MS, BS; Bassel G. Diebo, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Andrew J. Schoenfeld, MD, MS; Praveen V. Mummaneni, MD; Dean Chou, MD

Summary
The novel thresholds for low, moderate and severe deformity through McGregor's Slope, CL, TS-CL, C2-T3 angle, C2 Slope and frailty based upon myelopathy severity by way of the health-related quality of life (HRQL), mJOA have yet to be connected to outcomes. Through the investigation of this relationship, the increased severity of the proposed thresholds showed worse postoperative outcomes in the present CD cohort.

Hypothesis
The myelopathy-based CD thresholds will associate with patient-reported outcomes and complications.

Design
Retrospective

Introduction
Passias et al. developed novel thresholds for grades of deformity linked to baseline (BL) JOA scores. Improved associations with outcomes have yet to be determined.

Methods
CD patients (C2-C7 Cobb>10°,CL>10°,cSVA>4cm, or CBVA>25°) with BL and 1-year(1Y) data. Modifiers assessed low(L), moderate(M) and severe(S) deformity: CL(L:>3°; M:-21° to 3°; S:<-21°), TS-CL(L:<26°; M:26° to 45°; S:>45°), C2-T3 angle(L:>-25°; M:-35° to -25°; S:<-35°), C2 slope(L:<33°; M:33° to 49°; S:>49°), MGS(L:>-9° and <0°; M:-12° to -9° or 0° to 19°; S:<-12° or >19°), and frailty(L:<0.18; M:0.18 to 0.27, S:>0.27). Means comparison and ANOVA assessed outcomes in the severity groups at BL at 1Y. Correlations ran between modifiers assessed the internal relationship.

Results
104 pts included (57.1yrs, 50%, 29.3kg/m2). At BL, the patients distribution among the myelopathy-modifier groups is described Table 1 as well as the Δ BL to 1Y. Baseline S TS-CL, C2-T3, and C2S modifiers were associated with increased reoperations(p<0.01), while S MGS, CL, C2-T3 had increased EBL (>1000ccs, p<0.001). S MGS and C2-T3 had more postop DJK (60%, p=0.018). Improved in TS-CL, C2S, C2-T3 and CL patients had better NSR Back (<5) and EQ5D at 1-year(p<0.05). Improved frailty modifier at 1-year met MCID for NDI (50%) and EQ5D more (30%), p<0.001. Worsened or

remained severe Δ ranged from 3.8-10.6% (majorly in the frailty category). Improving the modifiers correlated strongly with each other (0.213-0.785, p<0.001). Worsened TS-CL had increased NRS Back scores at 1-year (9, p=0.042). Worsened CL had increased 1-year mJOA (7, p=0.001). Worsened C2-T3 had worse NRS Neck scores at 1-year(p=0.048). Improvement in all 6 modifiers (8.7%) had significantly better HRQL scores at follow up (EQ5D, NRS, NDI).

Conclusion

Newly proposed CD modifiers based on mJOA were closely associated with outcomes. Improvement and deterioration in the modifiers significantly impacted health-related quality of life outcomes.

Take Home Message

Collective worsening of the newly-proposed cervical deformity modifiers rooted in myelopathy severity significantly effected postoperative HRQLs.

	TS-CL	McGregor's Slope	C2-C7 Angle	C2-T3 Angle	C2 Slope	Frailty
Low	60.2%	38.2%	41.3%	88.9%	77.2%	54.1%
Moderate	30.6%	47.1%	50.0%	3.2%	12.3%	37.7%
Severe	9.2%	14.7%	8.7%	7.9%	10.5%	8.2%
Δ Baseline to 1-Year						
Improved or Remained Low	41.4%	42.9%	43.8%	20.0%	26.7%	13.1%
Worsened or Remained Severe	13.8%	28.6%	15.6%	6.7%	6.7%	18.0%

151. Electromyographic Analysis of Mechanical Load Szenarios of the Cervicothoracic Junction: First in-vivo Study to evaluate the potential Decrease of Myofascial Dehiscences following Posterior Cervicothoracic Fusion

Bennet M. Schröder, MD; Heiko Koller, MD; Emmanouil Liodakis, MD; Stephan Sehmisch, MD; *Sebastian Decker, MD*

Summary

The aim of this study was to develop a postoperative protocol to reduce myofascial dehiscences. Different myofascial activation patterns of the upper thoracic spine during daily activities were analyzed using EMG (electromyography). These first in-vivo results of cervicothoracic muscle activity demonstrate that myofascial strain sometimes is significantly different in between various daily activities.

Hypothesis

Myofascial upper thoracic spine activity can be influenced by the adjustment of daily activities as the latter result in different muscle activation levels. This may help to reduce the rate of myofascial dehiscences.

Design

Prospective study of healthy volunteers.

Introduction

So far it is unknown whether patients can affect the prevalence of myofascial cervicothoracic dehiscences by adjusted motion behaviors. This study aimed to analyze, how much daily activities, patients routinely do following surgery, mechanically stress muscles and fascias in the upper thoracic spine.

Methods

This study was approved by the local ethics committee (8891_BO_S_2020). We chose 28 healthy volunteers. Surface EMG was applied next to the upper thoracic spine at the trapezius muscle. All volunteers were performing 22 different daily activities / tasks, i.e. toothbrushing, dressing, standing up and different horizontal positions. EMG was measured during the exercises. RMS (root mean square) values were graded as to their amount for each healthy volunteer. Afterwards the individual rankings were statistically compared interindividually. Additionally, we performed a descriptive analysis. Statistical analysis was done using anova, cross tables and qui-square-test.

Results

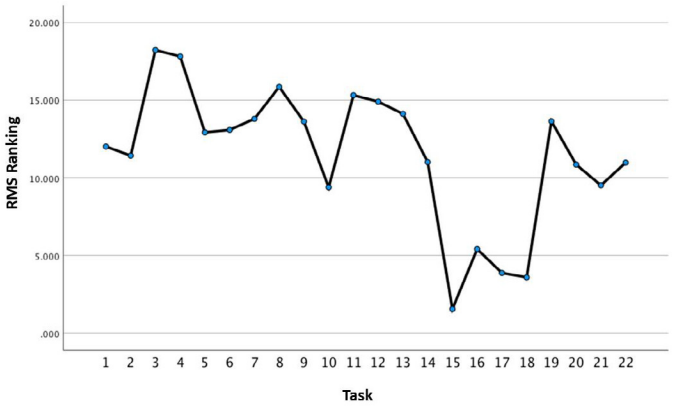
We did examine 14 women and 14 men (age: 30 ± 2 Jahre; BMI: 23 ± 2 kg/m²). Tasks often presented with significant differences of the RMS values. Figure 1 demonstrates the average ranking of the 22 tasks tested. Different horizontal positions all presented with significant less muscle activation compared to all other exercises (p ≤ 0,001). All exercises were repeated with the use of a clavicular bandage to dorsalize the shoulders. We did not find electromyographic differences in between the tasks with and without the bandage.

Conclusion

Postoperative protocols for mobilization and also behavioral instructions may have high potential to reduce the risk of postoperative myofascial dehiscences and therefore may help to reduce complication and revision rates.

Take Home Message

When performing cervicothoracic surgery, postoperative mobilization protocols should be adapted to maybe reduce the risk for myofascial dehiscences.



Tasks resulted in different myofascial activation.

152. Comparative Analysis of 30-day Readmission, Reoperation, and Morbidity Between Posterior Cervical Decompression and Fusion Performed in the Inpatient and Outpatient Settings

Junho Song, BS; Austen Katz, MD; Alan Job, MD; Matthew T. Morris, MD; Sohrab Virk, MD; Jeff Silber, MD; David Essig, MD

Summary

30-day readmission, reoperation, and morbidity rates were compared for patients undergoing PCDF in inpatient vs. outpatient settings. 30-day outcomes were statistically similar between surgical settings, indicating that PCDF can be safely performed as an outpatient procedure.

Hypothesis

There will be a significant difference in 30-day outcomes between inpatient and outpatient PCDF.

Design

Retrospective cohort study.

Introduction

Spine surgery, in general, has been increasingly performed in the outpatient setting. Posterior cervical decompression and fusion (PCDF) has followed this pattern, with recent increase in procedures performed in the outpatient settings, often utilizing minimally invasive techniques. However, there is a paucity of data evaluating short-term outcomes for PCDF, and there are currently no large-scale database studies comparing short-term outcomes between PCDF performed in the inpatient and outpatient settings.

Methods

Patients who underwent PCDF from 2005-2018 were identified using the NSQIP database. Univariate and multivariate regression analyses were utilized to compare primary outcomes between surgical settings and to evaluate for predictors thereof.

Results

We identified 8,912 patients. Unadjusted analysis revealed that outpatients had lower readmission (4.7 vs. 8.8%, p=0.020), reoperation (1.7 vs. 3.8%, p=0.038), and morbidity (4.5 vs. 11.2%, p<0.001) rates. After adjusting for baseline differences, readmission, reoperation, and morbidity no longer statistically differed between surgical setting. Outpatients had lower operative time and levels fused (p<0.001). In multivariate analysis, age, weight loss, and increased creatinine (p≤0.045) independently predicted readmission. ASA-class ≥3 predicted reoperation (p=0.028, OR=1.406). Rehabilitation discharge (p<0.001, OR=1.412), ASA-class ≥3 (p=0.008, OR=1.296), decreased hematocrit (p<0.001, OR=1.700), and operative time (p<0.001, OR=1.005) predicted morbidity.

Conclusion

30-day outcomes were statistically similar between surgical settings, indicating that PCDF can be safely performed as an outpatient procedure. Surrogates for poor health predicted negative outcomes. These results are particularly important as we continue to shift spine surgery to outpatient centers.

Take Home Message

Our results indicate that PCDF can be safely performed as an outpatient procedure.

	Outpatient, *n* (%)	Inpatient, *n* (%)	*P*	Cases available
	N = 353	N = 8,559		8,912
Demographics				
Mean age (years; SD)	55.1 (10.8)	61.5 (11.9)	**<0.001**	8,912
African American race	40 (11.9%)	1,223 (15.8%)	0.057	8,080
Hispanic Ethnicity	16 (5.6%)	436 (5.5%)	0.960	8,147
Male gender	197 (55.8%)	4,840 (56.5%)	0.783	8,912
Rehabilitation discharge	26 (7.4%)	2,161 (25.2%)	**<0.001**	8,912
Comorbidities				
Functionally dependent	4 (1.1%)	384 (4.5%)	**0.002**	8,864
Obese	184 (52.1%)	3,899 (45.7%)	**0.018**	8,876
Smoker	116 (32.9%)	2,116 (24.7%)	**0.001**	8,912
Diabetes mellitus	60 (17.0%)	1,710 (20.0%)	0.169	8,912
COPD	20 (5.7%)	570 (6.7%)	0.462	8,912
Hypertension	168 (47.6%)	5,038 (58.9%)	**<0.001**	8,912
Chronic steroid use	11 (3.1%)	445 (5.2%)	0.082	8,912
ASA-class ≥3	169 (47.9%)	5,459 (63.8%)	**<0.001**	8,904
Lab Values				
Elevated creatinine	13 (4.5%)	316 (4.1%)	0.751	8,043
Elevated white cell count	22 (6.9%)	523 (6.6%)	0.861	8,186
Decreased hematocrit	32 (9.9%)	1,471 (18.5%)	**<0.001**	8,282
Abnormal platelet count	16 (5.0%)	567 (7.2%)	0.144	8,196
Procedural Factors				
Operative time (min)	126 (72)	179 (88)	**<0.001**	8,908
Wound class ≥2	2 (0.6%)	59 (0.7%)	0.784	8,912
Levels fused	1.8 (0.9)	2.2 (1.1)	**<0.001**	8,912
Single-level fusion	155 (43.9%)	2,128 (24.9%)	**<0.001**	8,912
Two-level fusion	155 (43.9%)	4,736 (55.3%)	**<0.001**	8,912
≥ Three-level fusion	43 (12.2%)	1,695 (19.8%)	**<0.001**	8,912
Primary Outcomes				
Readmission	13 (4.7%)	607 (8.8%)	**0.020**	7,186
Reoperation	6 (1.7%)	329 (3.8%)	**0.038**	8,912
Morbidity	16 (4.5%)	956 (11.2%)	**<0.001**	8,912

Bold values indicate significance (*P*<0.05). ASA, American Society of Anesthesiologists. COPD, chronic obstructive pulmonary disease. SD, standard deviation.

Baseline patient factors and primary outcomes compared by surgical setting

153. Correction, Maintenance of Cervical Alignment and Revision Rates: 3-Level ACDF vs. Corpectomy-ACDF Hybrid Procedures

Chad Campion, MD; Charles H. Crawford III, MD; Fehmi Berkay, MD; Tino Mkorombindo, BS; Steven D. Glassman, MD; Leah Y. Carreon, MD

Summary
Three level ACDF resulted in greater global and segmental lordosis, similar Patient Reported Outcomes and less revision surgeries compared to hybrid instrumentation

Hypothesis
Three level ACDF and hybrid instrumentation produces similar outcomes to hybrid instrumentation

Design
Longitudinal comparative observational cohort.

Introduction
Anterior Cervical Discectomy and Fusion (ACDF), Anterior Cervical Corpectomy and Fusion (ACCF), and hybrid (combination ACCF-ACDF) are commonly used to treat symptomatic cervical spondylosis. Although there are studies comparing 1-level ACCF vs. 2-level ACDF and 2-level ACCF vs. 3-level ACDF, comparisons of 3-level ACDF vs. hybrid procedures have not been extensively addressed. The objective of this study is to compare outcomes in patients who underwent 3-level ACDF or a hybrid procedure.

Methods
Patients who underwent a Three-Level ACDF (3L-ACDF, N=47) or One-Level Corpectomy/One Level ACDF (Hybrid, N=52) with at least a 12-month post-op data available were identified. Standard demographic, surgical and Patient-reported Outcomes were collected in addition to pre- and post-operative radiographic data including C2 plumb line (C2PL), C2-C7 lordosis (CL), segmental lordosis (SL), and T1 slope (T1S). PROs collected included EuroQOL-5D (EQ-5D), Neck Disability Index (NDI), Neck and Arm Pain.

Results
The two cohorts were similar in terms of demographics at baseline. At 3 months post-op, CL (9.04° vs. -2.12°, p=0.00) and SL (6.06° vs. -2.26°, p=0.003) were significantly greater in the 3L-ACDF group vs. the HYBRID group. This significant difference was maintained at 12 months post-op for CL (6.62° vs. -0.60°, p=0.015) but not for SL (2.36° vs. -1.09°, p=0.199). There were no differences in PROs between the two groups prior to surgery, at 3 months post-op, nor twelve months post-op. Seven patients required revision surgery in the one year study period (one in the 3L-ACDF, and six in the Hybrid p<0.001).

Conclusion
Three level ACDF resulted in greater C2-C7 lordosis and segmental lordosis post-operatively, which was maintained at 1 year for cervical lordosis. While Patient Reported Outcomes were similar between the groups, patients with hybrid instrumentation required significantly more revision surgeries than those treated with 3-level ACDF.

Take Home Message
Three level ACDF resulted in greater global and segmental lordosis, similar Patient Reported Outcomes and less revision surgeries compared to hybrid instrumentation.

VARIABLE	3L ACDF	Hybrid	p-value
Neck Disability Index	Mean (SD)	Mean (SD)	
Pre-Op	52.59 (20.42)	45.81 (21.19)	0.194
3 months Post-op	43.55 (21.3)	35.48 (22.57)	0.127
12 months Post-op	39.77 (21.35)	34.87 (26.46)	0.366
Neck Pain			
Pre-Op	6.26 (2.46)	5.67 (2.45)	0.339
3 months Post-op	4.55 (2.71)	3.54 (2.87)	0.136
12 months Post-op	4.28 (3)	4.18 (3.32)	0.887
Arm Pain			
Pre-Op	5.68 (3.08)	5.81 (3.29)	0.874
3 months Post-op	2.87 (2.69)	2.33 (2.93)	0.428
12 months Post-op	3.84 (2.88)	3.14 (3.21)	0.327
Euro-QOL			
Pre-Op	0.68 (0.27)	0.66 (0.27)	0.733
3 months Post-op	0.71 (0.23)	0.79 (0.24)	0.179
12 months Post-op	0.74 (0.26)	0.76 (0.28)	0.708
C2 Plumb Line, mm			
Pre-Op	2.96 (1.63)	2.93 (1.53)	0.924
3 months Post-op	2.82 (1.33)	2.92 (1.42)	0.725
12 months Post-op	3.09 (1.56)	3.06 (1.64)	0.934
C2-C7 Lordosis, °			
Pre-Op	2.37 (13.47)	-2.54 (11.59)	0.056
3 months Post-op	9.04 (14.67)	-2.12 (13.58)	0
12 months Post-op	6.62 (14.13)	-0.6 (14.96)	0.015
Segmental Lordosis, °			
Pre-Op	0.28 (10.39)	-0.75 (9.93)	0.615
3 months Post-op	6.06 (14.34)	-2.26 (11.74)	0.003
12 months Post-op	2.36 (13.24)	-1.09 (13.3)	0.199
T1 Slope, °			
Pre-Op	31.48 (10.4)	30.29 (13.32)	0.644
3 months Post-op	34.17 (8.42)	31.01 (13.77)	0.206
12 months Post-op	33.76 (8.63)	32.02 (12.33)	0.444

Summary of Results

155. A Clinical Model to Predict Postoperative Improvement in Sub-Domains of the Modified Japanese Orthopedic Association Score for Degenerative Cervical Myelopathy

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Summary
A commonly used metric to quantify severity of cervical myelopathy is the modified Japanese Orthopedic Association (mJOA) score. We constructed a clinical prediction model for improvement of mJOA sub-domains at 12-months following surgery utilizing data from a longitudinal, multi-center clinical spine registry. A multivariable

analysis identified variables predictive of 12-month scores. This data was used to create a prediction model to help assist surgeons and patients when considering surgery for cervical myelopathy by providing useful information in the preoperative setting.

Hypothesis
We predict that a patient's age and their baseline mJOA scores will be the most significant variables in predicting mJOA scores at one year following surgery.

Design
This study was conducted using data from the cervical module of the Quality Outcomes Database (QOD), a longitudinal, multi-center, prospective spine outcomes registry.

Introduction
A commonly used metric to quantify the severity of cervical myelopathy is the modified Japanese Orthopedic Association (mJOA) score. In this study, the primary objective was to construct a clinical prediction model for improvement of mJOA six sub-domains at 12-months following surgery.

Methods
Data was obtained from the cervical module of the Quality Outcomes Database (QOD). A multivariable proportional odds ordinal regression model was developed for patients with cervical myelopathy. Patient demographic, clinical, and surgery covariates as well as baseline sub-domain scores were included in the model.

Results
5,000 patients who underwent surgery for cervical myelopathy and had 12-month follow-up data were enrolled. A multivariable analysis identified that baseline mJOA sub-domains were the strongest predictors of 12-month scores, with numbness in legs and ability to walk predicting 5 of the 6 mJOA items. Additional covariates that predicted 3 or more of the sub-domain mJOA scores included age, preoperative anxiety or depression, gender, race, employment status, duration of symptoms, smoking status, and presence of listhesis on radiology.

Conclusion
Our study developed and validated a clinical prediction model for improvement in mJOA scores at 12-months following surgery. This has the potential to assist surgeons, patients and families when considering surgery for cervical myelopathy and provides clinically useful information in the preoperative setting. Future steps include prospective, external validation of the model to assess the reproducibility and clinical utility of this work.

Take Home Message
Our clinical prediction model for improvement in mJOA scores at 12-months following surgery has the potential to assist surgeons, patients and families when considering surgery for cervical myelopathy.

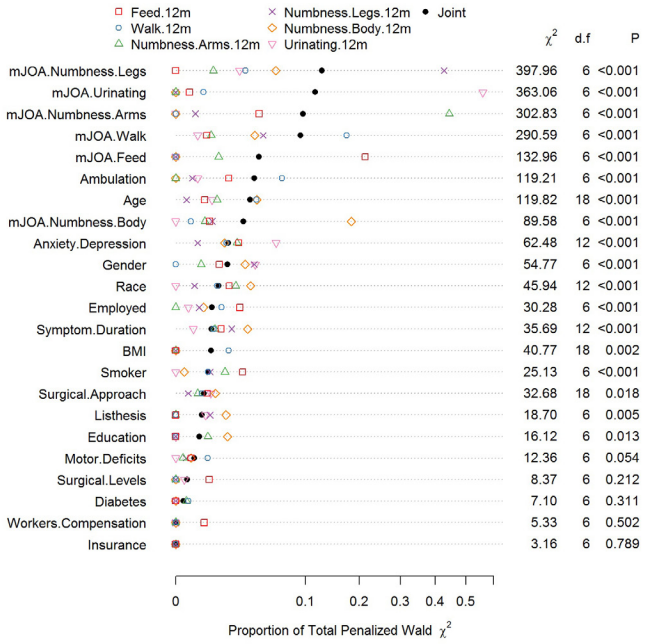

Fig. 1 shows the importance of each variable in predicting each sub-item at 12 months and all six mJOA sub-items by using penalized chi-square statistics based on multivariate analysis

156. Baseline NDI and PROMIS PF Predict Postoperative Return to Normal in Cervical Spine Surgery

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Summary
Predicting which patients may benefit from cervical spine surgery remains a clinical challenge. This study aims assess whether preoperative patient-reported outcomes (PROs) can be used to predict which patients return to normative levels after cervical spine surgery. Our data shows that patients with worse baseline function is associated with a lower likelihood of attaining PASS for NDI and PROMIS PF normative mean, while the association for PROMIS PI did not reach statistical significance.

Hypothesis
Preop pt-reported outcomes (PROs) can be used to predict which pts return to normative levels after cervical spine surgery

Design
Prospective Cohort

Introduction
Postop improvement in degenerative cervical disease has been well described, but the proportion of pts who return to normal remains unknown. This study aims assess whether preop pt-reported outcomes (PROs) can be used to predict which pts return to normative levels after cervical spine surgery

Methods
Pts undergoing cervical spine surgery between 2016-2018 were prospectively enrolled, completing questionnaires NDI and PROMIS-CAT (Pain Interference [PI] and Physical Function [PF]) preop and at 6-months postop. Logistic regression analysis was used to determine the association between preop outcome measures and postop patient acceptable symptom state (PASS = NDI<17) for NDI and the normative mean (50) for PROMIS

Results
139 pts (56.4 yo) with myelopathy (n=36), radiculopathy (n=48) and myeloradiculopathy (n=49) were enrolled. Patients with worst baseline NDI and PROMIS PF were statistically more likely to reach postop PASS (NDI) and the PROMIS-norm. A one-point increase in pre-op NDI resulted in OR of achieving PASS of 0.96 ($p<0.001$). For PROMIS PF, a one-point increase in preop score resulted in OR of achieving the PROMIS-norm of 1.10 ($p<0.001$). When stratified by baseline level of disability, the proportion of patients reaching PASS was 83%, 100%, 80%, 57%, and 52% for baseline NDI 0-4, 5-15, 15-24, 25-34, and >34, respectively. For PROMIS PF, the proportion of patients reaching the normative threshold was 62%, 46%, 30%, 33%, and 26% for baseline PF 47.7-66.2, 43.3-47.2, 40.1-43.1, 34.7-40.0, and 23.5-34.6, respectively

Conclusion
Preop PROs can predict postop benefit for pts undergoing cervical spine surgery, with worse baseline function associated with a lower likelihood of attaining PASS for NDI and the PROMIS PF normative mean. PROMIS PI did not demonstrate this correlation and may not be as useful as a predictor of postoperative outcome. These data will better enable surgeons and patients to estimate prognosis after cervical spine surgery

Take Home Message
Preoperative PROs can predict postoperative advantages for pts undergoing cervical spine surgery, with significant correlation between worse baseline function and attaining PASS for NDI and PROMIS PF normative mean.

157. Pulmonary Functions After Self Sliding Growth Guidance for Early-Onset Scoliosis with Minimum Six (6-14) Years of Follow-up

Hamisi M. Mraja, MD; Halil Gok, MD; Ugur Tasci, MD; Ayhan Mutlu, MD; Tunay Sanli, MA; Selhan Karadereler, MD; *Meric Enercan, MD*; Azmi Hamzaoglu, MD

Summary
Preoperative and follow-up pulmonary functions of 17 early onset scoliosis (EOS) patients were compared who underwent self sliding growth guidance technique (SSGG) with minimum 6 years follow-up. Pulmonary functions were preserved from preoperative to final follow up period. Pulmonary functions of 11 patients who achieved ultimate spinal growth did not decline after the final fusion procedure.

Hypothesis
SSGG technique will preserve pulmonary functions in early onset scoliosis patients.

Design
Retrospective study.

Introduction
SSGG technique was developed to allow growth during treatment of EOS, and eliminate the need for repeated operations for lengthening procedures. The aim of this study is to evaluate the effect of the SSGG technique on pulmonary functions. Pulmonary functions were also evaluated in patients who underwent final fusion.

Methods
17(10f,7m) EOS pts treated with SSGG were evaluated. The etiology was idiopathic in 9, syndromic in 5, and NF in 3. Preop and f/up pulmonary function test (PFT)including FVC, FEV1, IC and FEV1/FVC were compared. The effect of final fusion procedure on PFTs were also compared in pts who were fused. SRS22 scores were used for HRQoL.

Results
Av. age at index surgery was 6.5 yrs (3-10). Mean f/up was 8,2 yrs (6-14). Preop av MT curve of 57° was corrected to 21° with a %65 correction rate at final f/up. Preop avg TL/L curve of 47° was corrected to 16° with a %68 correction rate at final f/up. Overall, SSGG prevented 98 planned lengthening procedures. In all pts mean preop % pre.FEV1 of 83 remained stable at 85 f/up,and %pre FVC of 76 improved to 80 at f/up. Mean preop % pre.IC of 80% improved to 92% and preop % FEV1/FVC remained stable from 109 to 107 at last f/up.11 pts (64%) underwent final fusion following achievement of ultimate spinal growth with a mean of 4.5 yrs (2-6)f/up after the fusion procedure. In these fused groups, all of the predicted % PFT values were higher between the index surgery and last f/up and between the last rod exchange and 2 years after the fusion procedure. Mean SRS22 scores were 4.07 at f/up.

Conclusion
SSGG technique preserves preoperative pulmonary functions after 6

yrs f/up and pulmonary functions did not decline after the final fusion procedure in patients who reached skeletally maturity at the end of SSGG treatment. The mean pre.% FVC and pre.% IC before the index surgery increased at final f/up.

Take Home Message
Pulmonary functions can be preserved with Self Sliding Growth Guidance (SSGG) technique from preoperative to last follow up. Final fusion did not decline pulmonary functions in EOS patients who underwent SSGG technique.

160. Does Transitioning to a Brace Improve HRQoL after Casting for Early Onset Scoliosis?

Jeffrey M. Henstenburg, MD; Suken A. Shah, MD; Peter F. Sturm, MD; Laurel C. Blakemore, MD; G.Ying Li, MD; Stephanie Ihnow, MD

Summary
EOSQ scores were compared between casting and bracing treatments among patients with a diagnosis of idiopathic EOS. After patients were transitioned from casting to bracing, a significant improvement in HRQoL was seen, similar to pretreatment scores and at final follow up.

Hypothesis
We hypothesized that patients with a diagnosis of idiopathic EOS experience an improvement in HRQoL when transitioning from serial casting to bracing as measured by the EOSQ-24.

Design
Retrospective Case Control

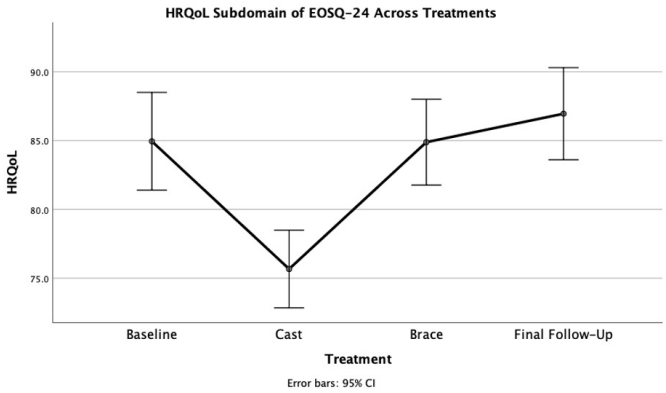
Introduction
Serial casting is favored for initial treatment of early onset scoliosis (EOS), but there is concern about significant morbidity, caregiver burden and healthcare resource utilization with casting for EOS. Bracing may be a viable alternative to casting but little is known about the effects on health-related quality of life (HRQoL) in EOS patients.

Methods
Subjects with idiopathic EOS were retrospectively identified from a multicenter database. EOSQ scores were compared prior to treatment, after index casting, after transition out of cast to brace, and at final follow up. EOSQ scores were compared using repeated measures ANOVA with post hoc tests using Bonferroni correction.

Results
Sixty-six subjects met inclusion criteria and 37 (56%) subjects were male. The average age at the time of index treatment was 1.93 (0.37-6.42) years. The average follow-up was 3.21 (0.90-6.78) years. The HRQoL subdomain was 84.9 (CI 81.4-88.5) pre-index treatment, 75.7 (CI 72.9-78.5) during casting treatment, 84.8 (CI 81.8-88.0) during brace treatment and 87.0 (CI 83.6-90.3) at final follow up. There were no differences between baseline EOSQ scores and bracing (P=1.00) or final follow-up (P=0.171). However, casting showed a significant decrease in HRQoL from all other time points (P<0.001). The parental impact subdomain improved from beginning to end of treatment (77.7 to 87.7, P=0.001) (n=64). Satisfaction significantly improved from casting to bracing (73.4 to 86.7, p<0.001) (n=63) and from casting to final follow up (73.4 to 87.9, p<0.001) but otherwise did not show any changes. Pulmonary function and financial impact did not substantially change throughout the course of treatment.

Conclusion
Patients treated with serial casting for EOS experience significant, but reversible declines in HRQoL. These findings can be used to provide anticipatory guidance for the EOS treatment plan and must be balanced with effectiveness of treatment for EOS.

Take Home Message
Among patients with idiopathic EOS who transitioned from casting to bracing a significant improvement in HRQoL was seen, similar to pretreatment scores and EOSQ scores at final follow up.



Change in HRQoL Across Treatments

161. Impact of Tissue Depth and Preoperative Flexibility on Intended Lengthening of Magnetically Controlled Growing Rods in Early Onset Scoliosis

Zachary Crawford, MD; Cameron Thomson, MD; Caden Schlund; Sarah Gilday, PA-C; Peter F. Sturm, MD

Summary
Magnetically controlled growing rods are utilized for the treatment of early onset scoliosis. Previous research has suggested successful office-based lengthening is correlated to depth of magnetic rods. This research shows preoperative flexibility of the spine is directly correlated to ability to achieve intended lengthening. This will allow clinicians to stratify which patients may be more success with magnetic growing rods compared to standard growing rods.

Hypothesis
Increases in rod length would equal programmed increases, patients with greater flexibility pre-operatively would have improved successful lengthening, and larger tissue depths would decrease lengthening success.

Design
Retrospective chart review on EOS patients with MCGRs placed and distracted at a single institution.

Introduction
Magnetically controlled growing rods (MCGRs) are increasingly used in the treatment of early onset scoliosis (EOS). Few studies have reported whether desired lengthening can reliably be achieved, or if large tissue depths or pre-operative flexibility of curve affect lengthening.

Methods
Rod distraction was measured at each visit using ultrasound. Pre-operative major curve at time of implantation and pre-operative traction curve measurements were used to determine flexibility. Differences between programmed and actual distraction for each patient were determined by 2-tailed t-tests. Regression and correlation were used to determine the relationship between tissue depth, length increases, and changes in pre-operative flexibility.

Results
Fifty-two patients, 24 males, 28 females, age 7.7 (±2.5) years, with major curves measuring 60 (±11.5) degrees were evaluated. Percent of intended lengthening was inversely proportional to tissue depth at 1 year and overall (r^2=0.49, $p<0.001$ and r^2=0.491, $p<0.001$ respectively). Percent of first and year 1 intended lengthening were positively correlated to percent change in major curve with traction (r^2=0.393, p=0.004 and r^2=0.374, p=0.007 respectively) and total overall lengthening and percent change in curve with traction (r^2=0.305, p=0.03).

Conclusion
There is significant correlation between successful programmed distraction and tissue depth. Additionally pre-operative flexibility of curve measured by percent change in major curve with traction is significantly correlated to intended lengthening. Clinicians can utilize this information when planning management of early onset scoliosis and ensure proper patient and caregiver education on goals of rod placement.

Take Home Message
Success of intended lengthening is correlated to preoperative flexibility of curve and tissue depth of magnetic rods.

162. Leave it Alone: The Natural History of Growth Friendly Graduates Without a Final Fusion

Christina K. Hardesty, MD; Bryan Ren, MD; Robert F. Murphy, MD; Jeffrey R. Sawyer, MD; John (Jack) M. Flynn, MD; John B. Emans, MD; John T. Smith, MD; Paul D. Sponseller, MD, MBA; Norman Ramirez, MD; Pediatric Spine Study Group

Summary
Growth friendly graduates who are observed have a high unplanned return to OR (UPROR) rate, but 4% after definitive procedure. The curve magnitude is maintained in this cohort whether implants were removed or kept.

Hypothesis
Graduates of growth friendly surgery who do not undergo a final fusion procedure have an uneventful natural history following their definitive procedure. Those who retain or remove implants maintain their curve magnitudes. The UPROR is similar in these groups.

Design
Retrospective analysis of prospectively collected data from international database of early onset scoliosis.

Introduction
The natural history of growth friendly graduates treated with growing instrumentation but no final fusion is unknown. Two small reports exist, but there is no comprehensive data set in the literature.

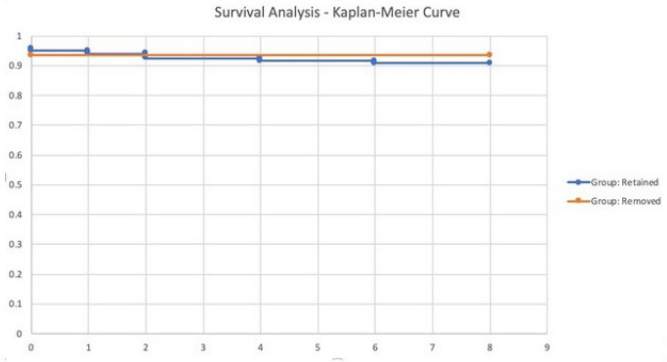
Methods
The Pediatric Spine Study Group database was queried for patients treated with TGR/VEPTR who had at least two years follow up. Patients met inclusion criteria if they had not undergone a final fusion procedure but completed planned interventions for EOS. Demographic data was collected. Radiographic data included relevant parameters.

Results
1215 patients underwent growth-friendly surgery with no final fusion; 234 had minimum 2 year follow up. Diagnoses included 99 congenital, 71 neuromuscular, 43 syndromic, 20 idiopathic, and 1 other. Definitive treatment was implant maintenance in 204 (87%) and removal in 30 (13%). Of those who did not keep their implants, 18/30 (60%) had an UPROR prior to implant removal and 1/30 (3%) had an UPROR as implant removal. Of patients who retained implants, the UPROR rate prior to definitive procedure was 30% (62/204). In that group, 9/204 (4%) had an UPROR following definitive procedure. The proportion of patients who successfully avoided an UPROR after definitive procedure was similar between retained and removed implants (Figure 1). Patients with implants removed lost a mean 7 degrees of curvature compared to 3 degrees when implants were retained. The means of all other measurements were similar between the two groups.

Conclusion
Growth friendly graduates who are observed but do not undergo a final fusion have a high UPROR rate overall, but only 4% after their definitive procedure. The curve magnitude has been maintained in this cohort whether implants were removed or kept.

Take Home Message
Growth friendly graduates who are observed have a high UPROR rate, but 4% after definitive procedure. The curve magnitude is maintained in this cohort whether implants were removed or kept.

Figure 1. Proportion of patients successfully avoiding an UPROR after definitive procedure in those who retained versus removed implants.



The x-axis represents number of years following the patient's definitive procedure. The y-axis represents patients who have successfully avoided an UPROR after their definitive procedure.

Avoiding UPROR after definitive procedure (retained vs. removed implants)

163. Why Are Graduates Failing Late? A Detailed Investigation of Patients with More Than 2 Years Follow-Up

Anjali Prior, BA; Robert F. Murphy, MD; John B. Emans, MD; George H. Thompson, MD; Paul D. Sponseller, MD, MBA; John T. Smith, MD; David L. Skaggs, MD; Pediatric Spine Study Group

Summary
Following growth friendly treatment for early onset scoliosis, patients will either have their implants retained, undergo a spinal fusion, or have their implants removed. This is known as "graduation" from the growing spine program. Within the first two years after graduation, rates of revision surgery are as high as 20%. The purpose of this study was to determine the rate of revision surgery and reasons for revision two or more years after the definitive treatment strategy.

Hypothesis
Our hypothesis is that there may be different reasons for revision in patients who fail early compared to those who fail later, or certain risk factors that can predispose a patient to a late revision.

Design
This is a retrospective cohort study utilizing patients enrolled in the Pediatric Spine Registry, a international registry that enrolls patients from 70 different centers.

Introduction
Modern surgical treatment of early onset scoliosis involves the implantation of a distractable device along the spine that can be progressively lengthened as the spine grows. Our study analyzed reasons for a delayed revision surgery after completing this treatment program.

Methods
Query of a multicenter pediatric spine registry was completed for all patients who underwent growing spine surgery and had a minimum of 2 years follow up documented, either by clinical or radiographic evidence. Curve etiology, graduation strategy, and incidence and number of revision surgeries were queried. Reasons for revision were ascertained.

Results
There were 933 patients with a minimum of 2 years follow up after graduation. A total of 134 underwent ANY revision surgery, and 92 of these occurred between 0 and 2 years after graduation. Further analysis revealed 42 patients (13 males) who underwent first revision greater than 2 years from their "definitive" procedure. There were 16 congenital, 12 neuromuscular, 8 syndromic, and 6 idiopathics. Of these patients, 40 had TGR/VEPTR as their growth friendly construct and 2 had MCGR. Thirty-five patients underwent spinal fusion as their definitive procedure, 6 had implants retained, and 1 had implants removed. Patients underwent an average of 1.2 procedures after graduation (range 1-2). The average time from graduation to revision in this cohort was 3.7 years (range 2.1-7.4). The most common reasons for revision included prominent implants/hardware failure in 17, curve progression in 8, back pain in 8, and infection in 5.

Conclusion
The rate of revision in this cohort of 933 GF spine graduates was 14%, and the rate of late revision (>2 years from graduation) was 5%. The most common reason for revision was due to prominent implants/hardware failure.

Take Home Message
Although it is hoped that "graduation" procedure signals the end to a long stream of treatments, this is not the case for up to 15% of patients, even years later.

165. Genetic and Acquired Risk Factors of Surgical Complications for Early-Onset Scoliosis (EOS)

Nan Wu, MD; Jiashen Shao, MD, PhD; Terry Jianguo Zhang, MD

Summary
The surgical correction of early-onset scoliosis (EOS) is associated with an extensive of perioperative and postoperative complications. The identification of risk factors associated with complications is important for the management of patients with EOS. By integrative analysis of clinical and genetic parameters, we found that disruptions of chondrogenesis-related genes, male gender, and the presence of chest wall/ribs deformity were independent risk factors for perioperative and postoperative complications following surgical treatment in EOS patients.

Hypothesis
We speculate that complications following surgical treatment for EOS may be related to some clinical and genetic factors, and the

determination of these factors can help predict the occurrence of perioperative and postoperative complications.

Design
Retrospective study

Introduction
The surgical correction of early-onset scoliosis (EOS) is associated with a variety of perioperative and postoperative complications. The identification of risk factors associated with complications is important for the management of patients with EOS.

Methods
We retrospectively reviewed patients with EOS who underwent spinal surgery at Peking Union Medical College Hospital from January 2008 to December 2017. Standard demographic information, radiographical data, genetic testing results and surgical records were collected. All patients underwent systematic follow-up for at least two years. Potential risk factors were identified by univariate analysis. Multivariate logistic regression was used to evaluate independent risk factors of surgical complications.

Results
We recruited 319 patients who underwent scoliosis correction surgery with a minimum of a two-year follow up after the initial surgery. Among them, 65 (20.4%) patients developed perioperative or postoperative complications, including 21 (32.3%) with implant-related complications, 26 (40.0%) with alignment-related complications, 6 (9.2%) with wound-related complications, and 15 (23.1%) with other complications. Multivariate analysis revealed three independent risk factors for the development of complications, including Mendelian syndromes caused by chondrogenesis-related genes (odds ratio [OR], 11.392; 95% CI, 2.769, 46.871; p=0.001), male gender (OR, 1.869; 95% CI, 1.028, 3.369; p=0.040), and presence of chest/ribs deformity (OR, 2.175; 95% CI, 1.098, 4.309; p=0.026).

Conclusion
By integrative analysis of clinical and genetic information, we found that Mendelian syndromes caused by chondrogenesis-related genes, male gender, and the presence of chest wall/ribs deformity were independent risk factors for perioperative and postoperative complications following surgical treatment in EOS patients.

Take Home Message
Routine preoperative gene screening in EOS patients may be helpful to identify high-risk patients prone to postoperative complications.

166. Fetal Spinal Anomalies: Incidence & Diagnosis - A Retrospective Study of 10,000 Consecutive Fetal Scans

Hriday Acharya, MBBS, MS; Abhay Nene, MBBS, MS; Prashant Acharya, MD, MBBS

Summary
In the first of a kind study by a team of spine surgeons, we studied 10,000 consecutive prenatal ultrasound scans specifically with respect to the incidence and distribution of spinal anomaly. We also put forward how a spine surgeon would play a pivot role in the 'team approach', comprising of a spine surgeon, obstetrician and a fetal medicine expert in counseling about the pre-treatment, and treatment perspective for these expectant patients and the baby.

Hypothesis
Prenatal anomalies can be diagnosed in the fetus early by a fetal medicine expert and this diagnosis will give a 'lead time' to the spine surgeon in early management of such anomalies before the child is born or immediately after birth without diagnostic delay.

Design
Retrospective Study

Introduction
Prenatal diagnosis of spinal anomalies is now a well-established concept in the developed world. With advances in prenatal ultrasound and the advent of fetal MRI, it is now possible to diagnose fetal anomalies at a very early stage of gestation. The purpose of the study was to find the incidence of various spine anomalies in the fetus and to evaluate the scope of early diagnosis in the management of these anomalies. We also put forward how a spine surgeon would play a pivot role in the 'team approach', comprising of a spine surgeon, obstetrician and a fetal medicine expert in counseling about the pre-treatment, and treatment perspective for these expectant patients and the baby.

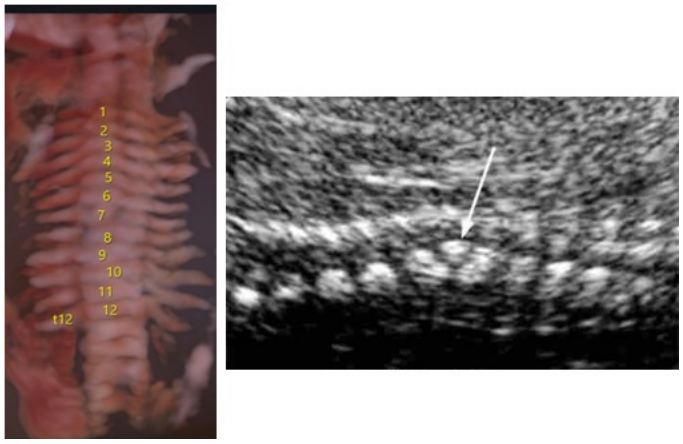
Methods
We report the results of 10,000 consecutive prenatal ultrasound scans specifically with respect to the incidence and distribution of spinal anomaly. All consecutive scans were done at a tertiary center by a single Fetal Medicine expert, between 2011 and 2019, were studied. Of the data obtained, all patients having spinal bony and cord anomalies were included in the study.

Results
Out of 10,000 patients studied,89 (0.008%) were diagnosed with spine and Spinal cord anomalies.Of these 89 patients, 57 had spinal dysraphism.10 had one or more level of hemivertebra.9 patients presented with intra-uterine scoliosis and 22 with kyphosis. Sacral agenesis was present in 7 of these patients

Conclusion
This is the first study to evaluate the incidence of prenatal diagnosis of spinal anomaly. Prenatal information will be of great value to spine surgeons as well as parents for counseling and planning treatment. A team approach comprising of a Spine surgeon, a fetal medicine expert and an obstetrician, in all cases should be the order of the day. The spine surgeon will play pivot role right from the diagnosis to the final treatment of the adult child.

Take Home Message
With prenatal diagnosis being the current standard of care

worldwide, a team approach comprising of a Spine surgeon, a fetal medicine expert & an obstetrician, should be the order of the day.



fetal hemiverterba - intrauterine

167. Correction of L5 Tilt and Fractional Curve in Vertebral Body Tethering vs. Fusion for Idiopathic Scoliosis at Minimum 2 Year Follow-Up

Nathan S. Kim, BA; Constance Maglaras, PhD; Brooke K. O'Connell, MS; Aonnicha Burapachaisri, BS; Kimberly Ashayeri, MD; Themistocles S. Protopsaltis, MD; *Juan Carlos Rodriguez-Olaverri, MD*

Summary
Vertebral body tethering (VBT) has gained popularity as a fusion-alternative for the treatment of idiopathic scoliosis (IS). By avoiding rigid fusion, there is less concern for indicating a more caudal lower instrumented vertebra (LIV). This, in turn, allows for robust coronal imbalance correction. This multi-center retrospective cohort study demonstrates greater improvement in L5 tilt following VBT when compared with fusion for IS.

Hypothesis
Patients undergoing VBT have greater L5 tilt correction and smaller postop fractional curves (FC) than fusions following IS correction.

Design
Multi-center retrospective cohort study.

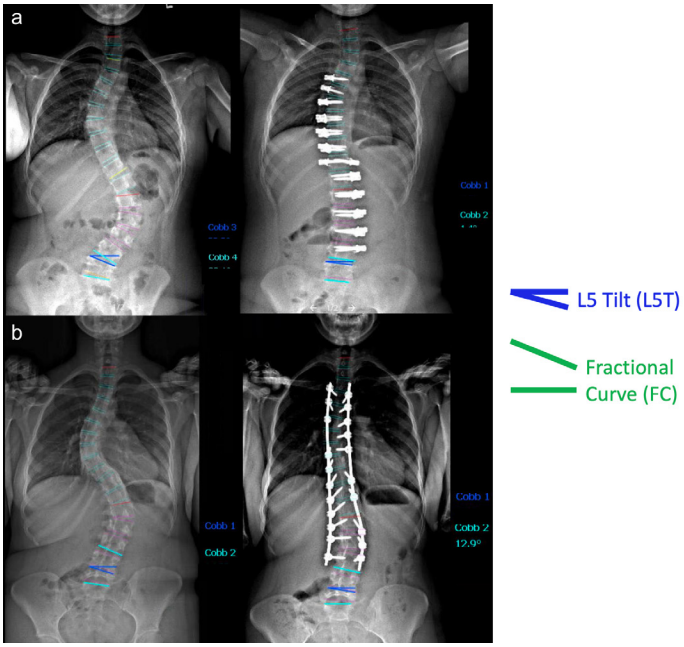
Introduction
VBT shows promising results as a fusion-alternative in IS treatment. Avoidance of rigid fusions allows for routine selection of lower LIVs, offering excellent coronal imbalance correction. Given the novelty of this technique, limited evidence comparing VBT to fusion exists. This study compares FC and L5 tilt correction in IS patients undergoing VBT vs. fusion with LIV in the lumbar spine.

Methods
Retrospective analysis of IS correction surgeries with LIV in the lumbar spine from 2013 to 2020 with pre- and minimum 2-year postop standing full spine plain films available. Patients were grouped into VBT or fusion groups. Outcome measures: Age, Risser score, LIV, and levels instrumented. Radiographic analysis included pre- and postop main, secondary, and FC cobb angles, and L5 tilt. Propensity score matching (PSM) was completed for demographic differences.

Results
Included: 41 patients, 21 VBT and 20 fusion. VBT patients tended to be younger (14.86±2.8 v 15.45±2.9, p=0.511). More VBT cases extended to L4 (61.9% v 15.0%, p=0.002). There were differences in preop secondary curve cobb angles (49.8±12.5 v 41.2±12.6, p=0.035) and L5 tilt (18.3±6.7 v 12.9±8.1, p=0.026), but not in main curve or FC. VBT had smaller postop FC (3.6±4.2 v 15.2±7.2 deg, p<0.001) and postop L5 tilt (5.8±4.1 v 9.0±3.9, p=0.014). VBT had a greater improvement in L5 tilt (-17.2±10.1 v -6.3±6.9 deg, p<0.001). (Fig 1) After PSM for Lenke classification, 24 patients remained: 12 VBT, 12 fusion. Differences between preop L5 tilt or main, secondary, and FC cobb angles were lost. VBT continued to show greater correction of L5 tilt (-16.8±7.1 v 6.2±5.3, p<0.001), and smaller postop FC (4.9±5.1 v 13.3±8.3, p=0.007).

Conclusion
This study with a minimum 2-year follow-up demonstrates that VBT allows for more caudal LIV and offers improved L5 tilt correction and smaller postop FC when compared to fusion for IS after PSM for Lenke Classification.

Take Home Message
VBT avoids rigid fusion and allows for indicating caudal construct extension. In turn, improved correction of L5 tilt and fractional curve is seen in VBT vs. fusions following IS correction.



VBT compared to PSF

168. Non-fusion Anterior Scoliosis Correction (NFASC): A Novel Promising Modality for Treatment of Adolescent Idiopathic Scoliosis (AIS) – A Single Centre Experience

Umesh P. Kanade, MS; Keyur Akbari, MS; Vigneshwara M. Badikillaya, MD; Sajan K. Hegde, MD; Sasidharan Sasidharan, MD, MS

Summary
NFASC is proposed to preserve longitudinal spine growth; however, definitive data is lacking. NFASC differs from vertebral body tethering that it focuses more on intra-op curve correction rather than growth modulation. At 2 years significant curve correction and stabilization of curve progression observed with no complications.

Hypothesis
NFASC offers significant fusionless correction and stabilization of curve progression in AIS with a low risk profile.

Design
Prospective cohort

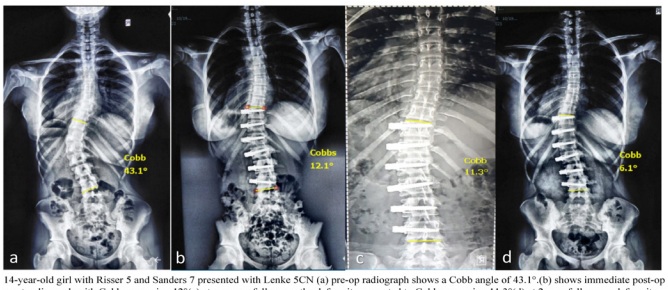
Introduction
The gold standard for managing AIS remains spinal fusion, but recently NFASC has gained interest. NFASC offers an option for fusionless correction, but the technique is novel and there is a visible dearth in relevant clinical data. This study evaluates the NFASC outcomes in patients with AIS.

Methods
45 AIS patients who underwent the NFASC with a mean follow up of 26 ±12.2 months (12 -48 months). These patients were managed for structural major curve, between 40◦and 80◦ having >50% flexibility on dynamic x rays. Data collected regarding skeletal maturity, curve type, cobb angle, surgery details: blood loss, duration and SRS-22 questionnaire. A Post hoc analysis following repeated measures ANOVA test was used to examine statistically significant trends.

Results
43 female and 2 male patients with a mean age of 14.96 ±2.69 years were included. The mean Risser score was noted to be 4.22 ±0.7 while the mean Sanders score was 7.15 ±0.74.Cranial and caudal instrumented levels were T5 and L4. By Lenke classification, 19 patients had type 5 curve,16 patients type 1, 5 patients each type 3 type 6 respectively. The mean Main thoracic (MT)Cobb angle at first follow-up (17.2 ±5.36) and last follow-up (16.92 ±5.06) were significantly lower than the preoperative cobb angle (52.11 ±7.74) by post-hoc analysis ($p<0.05$). Similarly, the mean Thoracolumbar/lumbar (TL/L) cobb angle at first follow-up (13.48 ±5.11) and last follow-up (14.24 ±4.85) were also significantly lower than the preoperative TL/L cobb angle (51.45 ±11.26). Mean preoperative and postoperative SRS-22 scores were 78.0 ±3.2 and 92.5 ±3.1respectively (P value<.01). None of the patient had any complications till the recent follow up.

Conclusion
NFASC offers promising correction and stabilization of curve progression in cases of AIS with a low risk profile and proves to be a favorable alternative to fusion modality.

Take Home Message
Further study with long term follow up will elucidate potential risks and benefits NFASC technique.



14-year-old girl with Risser 5 and Sanders 7 presented with Lenke 5CN (a) pre-op radiograph shows a Cobb angle of 43.1°.(b) shows immediate post-op erect radiograph with Cobb measuring 12°(c) at one year follow up, the deformity corrected to Cobb measuring 11.3°(d) at 2 year follow up, deformity corrected to cobb measuring 6.1°

Table 2: Mean Main Thoracic and TL/L Cobb's angle curve assessments at Follow-up

	Mean Values	P value
Mean MT Cobb angle (in degrees)		
Baseline	52.11 ± 7.74	<0.01*
1st follow-up (First erect)	17.2 ± 5.36	
Recent follow-up	16.92 ± 5.06	
Mean TL/L Cobb angle (in degrees)		
Baseline	51.45 ± 11.26	<0.01*
1st follow-up (First erect)	13.48 ± 5.11	
Recent follow-up	14.24 ± 4.85	

P<0.05 considered significant by Repeated measures ANOVA test.

169. Anterior Vertebral Body Tethering (VBT) Combined with Posterior Spinal Fusion (PSF): Hybrid Surgery for Skeletally Immature Patients with AIS: Preliminary Results of the first 10 Patients with at least 2 Years of Follow-Up

Tuna Pehlivanoglu, MD; Yigit Erdag, MD; Umut Dogu AKTURK, MD; Abdulhalim AKAR, MD; Ozgur BASAL, MD; *Mehmet Aydogan, MD*

Summary
Skeletally immature AIS patients' double curves, comprising a rigid thoracic/thoracolumbar curve and a flexible lumbar curve could be corrected by using hybrid surgery (posterior spinal fusion to thoracic/thoracolumbar and vertebral body tethering to thoracolumbar/lumbar spine) and thus fusion at the lumbar level could be avoided and growth could be spared together with spinal motion. The present study reported about excellent radiographic outcomes of hybrid surgery applied to skeletally immature patients under strict inclusion criteria while underlining its safety and efficacy.

Hypothesis
Skeletally immature AIS patients' double curves, comprising a rigid thoracic/thoracolumbar curve and a flexible lumbar curve might be corrected by using hybrid surgery (posterior spinal fusion to thoracic and vertebral body tethering to thoracolumbar/lumbar spine) by avoiding fusion at the lumbar levels and preserving growth.

Design
Prospective cohort

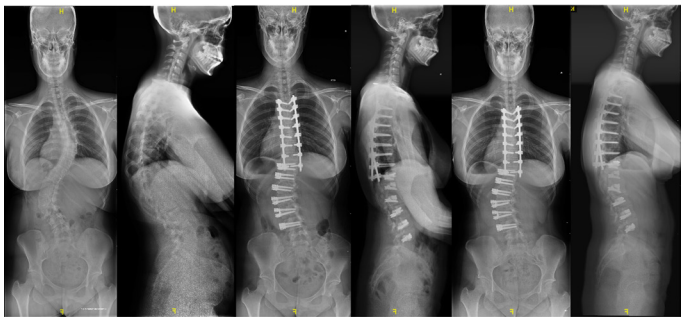
Introduction
The aim of this study was to present the preliminary results of thoracic posterior spinal fusion (PSF) combined with thoracolumbar vertebral body tethering (VBT) for AIS patients with double curves.

Methods
10 skeletally immature patients with double curves were included. They had rigid thoracic(T)/thoracolumbar (TL) curves (flexibility <30%, magnitude:>45) and flexible lumbar(L) curves (flexibility >40%, magnitude: >40). A decision to proceed with T PSF was based on rigid (<30%) and progressive (>45) curves, while the decision to perform TL VBT was mainly based on flexible (>40%) and progressive (>40) curves.

Results
6 females and 4 males had a mean age of 13.1 (10-14), mean-follow up of 27.2 months (24-30), mean pre-operative main T/TL and TL/lL curve magnitudes of 48.6/44.2. All underwent T/TL PSF combined with TL/L VBT. An average of 8.1 levels of T PSF (T2-T11) and 5.2 levels of TL VBT (T11-L4) was performed. Post-operatively, a mean first erect tT/TL major curve magnitudes of 4.2/12.6 were acquired, while they were detected as 3.1/8.3 at the last follow-up. No major complication (including the implant related complications) were detected during the follow-up period of any patient.

Conclusion
This study proposed a novel solution regarding correction of double curves, comprising a rigid T/TL curve and a flexible lumbar curve in skeletally immature patients with AIS. As a result of hybrid surgery, fusion at the lumbar level could be avoided and growth could be spared together with spinal motion. The present study reported about the excellent radiographic outcomes of hybrid surgery under strict inclusion criteria while underlining its safety and efficacy.

Take Home Message
AIS patients' double curves could be corrected by using hybrid surgery(PSF to T/TL and VBT to TL/L) and lumbar fusion could be avoided with the preservation of growth and motion.



14 yo F. Pre-op/Post-op 1st and 3rd year X-rays

170. Correction of L5 Tilt and Fractional Curve in Vertebral Body Tethering Vs. Fusion for Adolescent Idiopathic Scoliosis in a Large Single Center

Nathan S. Kim, BA; Aonnicha Burapachaisri, BS; Kimberly Ashayeri, MD; Zoe Norris, BFA; Nicole Mottole, BE; Hershil Patel, BS; Eaman Balouch, MD, PhD; Samuel Zonshayn, MD; Constance Maglaras, PhD; Brooke K. O'Connell, MS; Themistocles S. Protopsaltis, MD; Aaron J. Buckland, MBBS, FRCSA; *Juan Carlos Rodriguez-Olaverri, MD*

Summary
Vertebral body tethering (VBT) has gained popularity as a fusion-alternative for the treatment of adolescent idiopathic scoliosis (AIS). By avoiding rigid fusion, there is less concern for choosing a more caudal lower instrumented vertebra (LIV). This, in turn, allows for robust coronal imbalance correction. This single-center retrospective cohort study demonstrates greater improvement in L5 tilt following VBT when compared with fusion for AIS.

Hypothesis
Patients undergoing VBT have greater L5 tilt correction and smaller postoperative (postop) fractional curve (FC) than fusion for AIS.

Design
Single-center retrospective cohort study.

Introduction
VBT shows promising results as a fusion-alternative in AIS treatment. Avoidance of rigid fusion allows for routine selection of lower LIVs, allowing for excellent coronal imbalance correction. Given the

novelty of this technique, limited evidence comparing VBT to fusion exists to date. This study compares FC and L5 tilt correction in AIS patients undergoing VBT vs. fusion with LIV in the lumbar spine.

Methods

Retrospective analysis of AIS correction surgeries with LIV in the lumbar spine from 2013 to 2020 with pre- and 3-month postop standing full body plain films available. Patients were grouped as VBT or fusion. Outcome measures: Age, height, weight, BMI, Risser score, LIV and levels instrumented. Radiographic analysis included pre- and postop main, secondary, and FC cobb angles, and pre- and post L5 tilt. Propensity matching (PSM) was completed for demographic differences.

Results

76 patients: 34 VBT, 42 fusion. Demographics and clinical characteristics were obtained. VBT cases were more frequently extended to L4 (61.8% v 11.9%, p<0.001). There were no differences in preop L5 tilt or main, secondary or FC angles. VBT had significantly smaller postop FC (8.4±7.9 v 14.2±6.8 deg, p=0.001) and postop L5 tilt (6.5±4.8 v 9.7±4.6 deg, p=0.004). VBT had a significantly greater improvement in L5 tilt (-7.6±4.5 v -4.4±4.7 deg, p=0.004). (Table 1) After PSM for Lenke classification, 44 patients remained: 25 VBT, 19 fusion. VBT continued to demonstrate significantly greater correction of L5 tilt (-7.6±4.9 v 4.1±4.5 deg, p=0.02) and tended to greater correction of FC (-16.5±10.3 v -10.8±7.7 deg, p=0.043). VBT showed significantly larger postop main curve (29.3±10.7 v 21.5±4.6 deg, p=0.006).

Conclusion

VBT allows for more caudal LIV and offers improved L5 tilt and FC correction when compared to fusion for AIS.

Take Home Message

VBT avoids rigid fusion and allows for routine caudal extension of construct. In turn, improved correction of L5 tilt and FC is seen in VBT vs. fusion for AIS.

		Vertebral Body Tethering	Posterior Spinal Fusion	p value
Demographics	Age	13.97 ± 1.766	13.98 ± 1.675	0.989
	Height, meters	1.59 ± 0.11	1.61 ± 0.10	0.414
	Weight, kg	52.2 ± 8.9	56.7 ± 17.0	0.164
	BMI, kg/m^2	20.6 ± 2.9	21.8 ± 5.6	0.253
	Risser score	2.9 ± 1.8	2.6 ± 1.6	0.496
	LIV	22.2 ± 1.1	21.3 ± 1.1	**<0.001**
	Levels instrumented	8.53 ± 2.2	9.4 ± 2.1	0.077
	LIV at L4	61.80%	11.90%	**<0.001**

		Pre-PSM			Post-PSM		
		Vertebral Body Tethering	Posterior Spinal Fusion	p value	Vertebral Body Tethering	Posterior Spinal Fusion	p value
Radiographic parameters	Preoperative Main Curve	53.8 ± 11.9°	57.1 ± 14.4°	0.281	53.9 ± 13.2	51.0 ± 8.7°	0.419
	Postoperative Main Curve	30.6 ± 11.6°	22.4 ± 7.9°	**<0.001**	29.4 ± 10.7°	21.5 ± 4.6°	**0.006**
	Δ Main Curve	-23.1 ± 10.9°	-34.7 ± 11.9°	**<0.001**	-24.5 ± 11.3°	-29.4 ± 11.8°	0.176
	Preoperative Secondary Curve	41.9 ± 9.9°	40.9 ± 12.7°	0.711	41.0 ± 10.0°	36.4 ± 9.1°	0.134
	Postoperative Secondary Curve	23.4 ± 8.4°	20.0 ± 8.9°	0.100	23.0 ± 7.9°	18.9 ± 9.0°	0.133
	Δ Secondary Curve	-18.9 ± 9.1°	-21.2 ± 10.7°	0.330	-18.6 ± 9.5°	-18.1 ± 11.6°	0.875
	Preoperative Fractional Curve	24.4 ± 13.2°	26.9 ± 9.6°	0.333	25.6 ± 12.5°	22.9 ± 10.0°	0.444
	Postoperative Fractional Curve	8.4 ± 7.9°	14.2 ± 6.8°	**0.001**	9.1 ± 8.0°	12.0 ± 6.9°	0.216
	Δ Fractional Curve	-16.0 ± 10.2°	-12.7 ± 8.2°	0.123	-16.5 ± 10.3°	-10.8 ± 7.7°	0.055
	Preoperative L5 Tilt	12.2 ± 5.8°	12.3 ± 6.6°	0.924	11.9 ± 5.6°	13.0 ± 6.8°	0.556
	Postoperative L5 Tilt	6.5 ± 4.8°	9.7 ± 4.6°	**0.004**	6.6 ± 4.6°	9.8 ± 4.2°	0.076
	Δ L5 Tilt	-7.2 ± 8.4°	-5.5 ± 3.8°	**0.004**	-7.6 ± 4.9°	-4.1 ± 4.5°	**0.020**

Table 1: Baseline demographics and radiographic parameters

173. Initial Intraoperative Experience Using Robotics Coupled with Computer-Assisted Navigation for Pedicle Screw Placement: Are There Differences in Surgical Effectiveness, Safety, and Cost Compared to the Freehand Technique for Patients with Adolescent Idiopathic Scoliosis?

Gabriel S. Linden, BA; Semhal Ghessese, MD; Danielle Cook, MA; Daniel J. Hedequist, MD

Summary

As robotics and computer-assisted navigation (RAN) becomes more mainstream among spine surgeons, research must validate the effectiveness, safety, and cost of this alternative option compared to the traditional freehand (FH) technique. This retrospective cohort study demonstrates that RAN does yield comparable effectiveness, safety, and costs compared to the FH technique, but, increases operative time. These findings, combined with previous research showing RAN increases pedicle screw placement accuracy for adolescent idiopathic scoliosis (AIS) patients, validates RAN as a viable AIS technique.

Hypothesis

RAN will produce comparable effectiveness, safety, and cost compared to the FH method for AIS surgical patients.

Design

Retrospective cohort study

Introduction

Robotics coupled with computer-assisted navigation (RAN) is a modern surgical platform previously shown to improve pedicle screw placement accuracy in patients with adolescent idiopathic scoliosis (AIS). However, RAN's impact on initial intraoperative outcomes, safety, cost, and operative efficiency - compared to the freehand (FH) technique - are unreported in AIS populations. This study also reports on changes in outcomes during the surgeon's acclimation to RAN.

Methods

60 AIS patients who underwent FH or RAN surgery were reviewed. Inclusion criteria were a diagnosis of AIS, and operation by a single-surgeon from 2019 through 2020. The cohort was separated by surgery type and comparisons were conducted using Student's t-tests, Mann-Whitney U-tests, and chi-square tests. P-values less than 0.05 were considered significant.

Results

30 patients had RAN surgery and 30 had FH. The mean age at surgery for the cohort was 15.2 years and 77% were female. Both groups had comparable age, sex, and initial Cobb angle. There were no statistical differences across RAN or FH medians for surgical effectiveness (curve correction), safety (estimated blood loss, percent estimated blood volume lost per level fused, radiation exposure, complication rate, length-of-stay), or costs (Table 1). However, operative time was longer for RAN than FH (Table 1). Over the 18-month study period, there were no changes in operative time

(r=-0.11, p=0.57), radiation exposure (r=0.14, p=0.47), or EBL per level fused (r=0.06, p=0.77).

Conclusion

Despite an increase in operative time secondary to extra surgical steps to register the RAN system, RAN represents a safe, effective, and cost-competitive option which can be used in complement with the FH technique, or by itself, to improve pedicle screw placement accuracy for patients with AIS.

Take Home Message

This study demonstrates that a FH-trained surgeon can acclimate to the RAN platform to yield similar surgical effectiveness, safety, and costs relative to the FH method for AIS correction.

Table 1. Summary of cohort outcomes compared by surgery groups (N=60).

	Full cohort (N=60)		RAN group (n=30)		FH group (n=30)		
Characteristic	Median	(IQR)	Median	(IQR)	Median	(IQR)	P-value*
Curve correction *(%)*	59.4	(50.4-65.4)	61.4	(49.3-65.6)	57.7	(50.8-65.2)	0.62
EBL *(cc)*	150.0	(100.0-300.0)	200.0	(100.0-400.0)	150.0	(100.0-250.0)	0.21
EBL per level fused (PLF,*cc*)	21.4	(14.1-28.6)	21.8	(13.9-33.3)	20.7	(14.3-25.0)	0.55
EBV lost PLF (%)	0.6	(0.4-0.7)	0.6	(0.4-0.9)	0.6	(0.3-0.7)	0.24
Radiation exposure *(min)*	0.2	(0.2-0.4)	0.3	(0.2-0.4)	0.2	(0.2-0.3)	0.52
Complication (freq. (%))	2.0	(3.3)	1.0	(3.3)	1.0	(3.3)	1.00
Length of stay *(days)*	3.0	(3.0-4.0)	3.0	(3.0-4.0)	3.0	(3.0-4.0)	0.86
Total cost PLF ($)	16,230	(14,138-18,246)	16,491	(14,287-19,604)	16,021	(12,960-17,611)	0.24
Operative time *(min)*	202.5	(159.5-234.0)	232.0	(204.0-270.0)	164.0	(139.0-194.0)	<0.001
Operative time PLF *(min)*	22.4	(20.0-25.5)	24.3	(22.0-28.8)	20.9	(18.2-22.8)	<0.001

IQR, interquartile range; EBL, estimated blood loss; EBV, estimated blood volume
*P-values < 0.05 were considered significant

174. Segmentation of Vertebrae and Intervertebral Discs in Lumbar Spine MR Images Using a Deep Learning Algorithm

Jasper W. van der Graaf, MS; Miranda L. Van Hooff, PhD; Constantinus F. Buckens, MD, PhD; Marinus De Kleuver, MD, PhD; Nikolas Lessmann, PhD

Summary

Spine segmentation is an essential first step in automatic lumbar MRI analysis. We evaluated a fully automatic algorithm which jointly segments all visible vertebrae and intervertebral discs (IVD). Both detection and segmentation of these structures were highly accurate. The network was able to effortlessly handle degenerative pathologies such as Schmorl's nodes and collapsed IVDs. Also, this algorithm outperformed a segmentation strategy with separate vertebra and IVD segmentation steps, proving the added value of combined segmentation.

Hypothesis

Automatic segmentation of vertebrae and intervertebral discs in degenerative lumbar MR scans can be combined in a single deep learning model.

Design

Cohort study

Introduction

The use of MRI for diagnosis and treatment decisions in patients with lumbar spine degeneration has drastically increased in the last decades. Automatic image analysis has the potential revolutionize the way lumbar MR scans are used, e.g. by providing objective treatment decision support. To facilitate this, a robust automatic algorithm for segmentation of relevant spinal structures is essential. We assessed the performance of a state-of-the-art 3D automatic segmentation method in degenerative lumbar MR scans.

Methods

We evaluated a 3D deep learning algorithm which detects and segments the vertebrae and intervertebral discs (IVD) one-by-one by alternating between the structures (see figure). We collected and manually segmented T2-weighted sagittal lumbar spine MR scans of 53 patients with degenerative conditions, of which 33 scans were used to train the algorithm. The remaining 20 scans were used to test its accuracy and calculate the Dice score (segmentation accuracy) for the vertebrae and IVDs separately.

Results

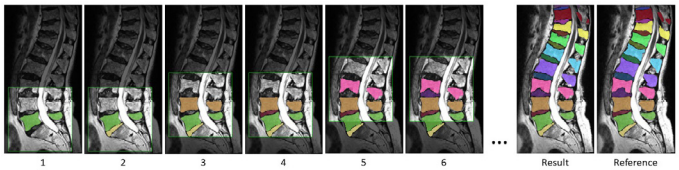
The automatic algorithm achieved a mean Dice score of 93% +/- 2% for vertebra segmentation and 86% +/- 7% for IVD segmentation. The method was able to cope with pathological abnormalities such as compression fractures, Schmorl's nodes and collapsed IVDs. In comparison, the same model trained for only IVD segmentation, not combined with vertebra segmentation, did not detect all IVDs (89%) and achieved a lower Dice score of 83% +/- 9 %.

Conclusion

Segmentation of the vertebrae and IVDs with an automatic deep learning method was highly accurate even in pathological lumbar MR scans. Also, combining IVD segmentation with vertebra segmentation improves the IVD detection and segmentation performance.

Take Home Message

Spine segmentation is an essential first step in automatic lumbar MRI analysis. The evaluated algorithm accurately detects and segments vertebrae and intervertebral discs in degenerative lumbar MR scans fully automatically.



Segmentation process in a degenerative lumbar spine MRI. Images 1-6 show the iterative process in which the 3D region of interest traverses along the spine and vertebra and IVD segmentation steps alternate. The result and the manual reference segmentation are shown on the right.

175. Decision Making Factors Leading to Fusion vs. Decompression for One Level Degenerative Spondylolisthesis

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Summary
Degenerative spondylolisthesis is one of the most common pathologies spine surgeons treat but there is no current consensus on which variables impact the decision to fuse vs. decompress alone. A survey was sent to two spine societies. The majority of respondents are fusing for the treatment of this pathology. The most common radiographic parameters impacting treatment are instability, spondylolisthesis grade, and laterolisthesis while mechanical low back pain, activity level, and neurogenic claudication are the most common clinical parameters.

Hypothesis
Respondents fuse for the treatment of spondylolisthesis and instability is the most common radiographic parameter leading to a decision to fuse.

Design
Cross-Sectional Study

Introduction
Degenerative spondylolisthesis is one of the most common pathologies spine surgeons treat. While a number of potential factors have been identified, there is no current consensus on which variables most impact the decision to fuse vs. decompress alone in this population.

Methods
A survey consisting of questions pertaining to decision factors leading to fusion or decompression alone in the setting of degenerative lumbar spondylolisthesis was administered to the Lumbar Spine Research Society and Society of Minimally Invasive Spine Surgery. Multiple radiographic and clinical parameters were queried. The primary analysis was limited to completed surveys. Baseline characteristics were summarized. Clinical and radiographic parameters were ranked and compared. The most important, top three most important, and top five most important parameters were ordered given each parameter ranking.

Results
Of 561 surveys, 381 (67.9%) were returned completed. Respondents mean years in practice was 17.8 ± 9.4 years and 77.7% had undergone a formal spine fellowship. With regards to fusion vs. decompression, 19.9% fuse all cases, 39.1% fuse > 75%, 17.8% fuse 50-75%, and 23.2% fuse <25%. Instability (93.2%), spondylolisthesis grade (59.8%), and laterolisthesis (37.3%) were the most common radiographic factors impacting the decision to fuse (Table 1), whereas mechanical low back pain (83.2%), activity level (58.3%), and neurogenic claudication (42.8%) were the top clinical parameters (Table 2).

Conclusion
There is little consensus on the treatment of degenerative spondylolisthesis, with society members showing substantial variation in treatment patterns. The most common radiographic parameters impacting treatment are instability, spondylolisthesis grade, and laterolisthesis while mechanical low back pain, activity level, and neurogenic claudication are the most common clinical parameters.

Take Home Message
To treat one-level degenerative spondylolisthesis, surgeons are primarily fusing the operative level. Instability and mechanical low back pain are the radiographic and clinical parameter leading to a choice of fusion.

Table 1: Radiographic Parameters Leading to the Decision to Fuse Ranked in the Most Important (Top 1), Three Most Important (Top 3), and Five Most Important (Top 5).

	Top 1	Top 3	Top 5
Grade of Spondylolisthesis	76 (19.9%)	228 (59.84%)	279 (73.23%)
Instability	254 (66.7%)	355 (93.18%)	361 (94.75%)
Facet orientation > 60 deg	3 (0.8%)	67 (17.59%)	133 (34.91%)
Facet diastasis	11 (2.9%)	129 (33.86%)	219 (57.48%)
Laterolisthesis or scoliosis	13 (3.4%)	142 (37.27%)	223 (58.53%)
Synovial cysts	2 (0.5%)	39 (10.24%)	113 (29.66%)
Vacuum disc	1 (0.3%)	25 (6.56%)	72 (18.9%)
Vertical disc space (e.g. high PI)	0 (0%)	11 (2.89%)	39 (10.24%)
Preserved disc height (>7mm)	1 (0.3%)	16 (4.2%)	39 (10.24%)
Concomitant Herniated Nucleus Pulposus	1 (0.3%)	14 (3.67%)	52 (13.65%)
Symptomatic foraminal stenosis	19 (5%)	114 (29.92%)	170 (44.62%)

Table 2: Clinical Parameters Leading to the Decision to Fuse Ranked in the Most Important (Top 1), Three Most Important (Top 3), and Five Most Important (Top 5).

	Top 1	Top 3	Top 5
Age >70	20 (5.20%)	97 (25.46%)	148 (38.85%)
Activity level	54 (14.20%)	222 (58.27%)	249 (65.35%)
Patient Sex	4 (1.04%)	21 (5.51%)	29 (7.61%)
BMI >35	10 (2.60%)	121 (31.76%)	161 (42.26%)
Bone Mineral Density	26 (6.80%)	106 (27.82%)	155 (40.68%)
Mechanical Low Back Pain	188 (49.30%)	317 (83.2%)	329 (86.35%)
Neurogenic Claudication	58 (15.20%)	163 (42.78%)	185 (48.56%)
Smoking	17 (4.50%)	59 (15.49%)	79 (20.73%)
Anxiety/depression	4 (1.04%)	23 (6.04%)	40 (10.5%)

Radiographic and Clinical Parameters leaning to Decisions to Fuse Ranked in Most Important Order

176. Navigated Lateral Lumbar Interbody Fusion (LLIF) has Equivalent Outcomes and Decreased Radiation vs. Fluoroscopically Guided

Fares Ani, MD; Julianna Bono, BS; Arnaav Walia, BS; Gregory Van Perrier, BS; Brooke K. O'Connell, MS; Nathan S. Kim, BA; Aonnicha Burapachaisri, BS; Hershil Patel, BS; Constance Maglaras, PhD; Tina Raman, MD; *Themistocles S. Protopsaltis, MD*

Summary
Reducing radiation doses for patients and staff is an imperative for spine surgeons. Advancing technology now allows for the navigation of interbodies placed during Lateral Lumbar Interbody fusions. This study demonstrates that comparable outcomes and reduced radiation to patients and staff and reduced blood loss can be attained by navigating interbodies during LLIF procedures.

Hypothesis
Computer-navigation guided LLIF will have equivalent outcomes with decreased radiation dose compared to Fluoroscopically-guided LLIF.

Design
Retrospective review of a prospectively collected single center database.

Introduction
Guiding placement of an interbody device during lateral trans-psoas anterior approach is commonly completed via fluoroscopic-guidance, but utilizing the computer navigation often used for pedicle screws with this approach may be a superior option. This study explores differences between cases with interbodies placed fluoroscopically and via navigation.

Methods
365 patients over 18 years of age that underwent lateral lumbar interbody fusion with <4 levels fused (mean age: 61.4 ± 10.8, BMI: 29.7 ± 6.1, ASA: 2.5 ± 0.6, Levels fused: 2.25 ± 1.1, and 55.3% female) were included. Independent-samples T-test and Pearson Chi-square analysis were performed for the cohort; significant set at $p<0.05$.

Results
There was no difference in patient demographics between the groups. The estimated blood loss (EBL) and fluoroscopic dosage was significantly greater within the fluoroscopically-guided LLIF cohort (380.6ml ± 400.4 vs. 259.6ml ± 151.7, p=0.00; 66.8mGy ± 78.7 vs. 41.7mGy ± 50.9, p=0.04). There were no significant differences between fluoroscopic LLIFs and Navigated LLIFs for overall intraoperative complications (2.4% vs. 3.6%, p=0.70), neuro-monitoring changes (2.4% vs. 3.6%, p=0.70), and durotomy (1.5% vs. 0%, p=0.70). Post-operative complications (22.3% vs. 25%, p=0.74), neurological complications (3.9% vs. 3.6%, p=0.94), surgical site infections (1.8% vs. 3.2%. p=056), mechanical complications (1.2% vs. 3.6%, p=0.558), and return to the operating room within 90-days (2.4% vs. 0%, p=0.41) were also similar between Flouroscopic vs. Navigated LLIFs.

Conclusion
The navigation-guided LLIF cohort had reduced radiation dose compared to the fluoroscopy-guided LLIF cohort, without a change in post-operative outcomes or complications. Utilizing computer-navigation should be considered for guidance of all implanted devices and should be studied in more detail.

Take Home Message
Comparable outcomes with reduced radiation and estimated blood loss can be attained through navigating interbodies instead of using fluoroscopic guidance.

Table 1: Comparison of demographics, surgical outcomes, perioperative complications, and return to OR for Lateral Lumbar Interbody fusions with Navigation or flouroscopy

		Fluoroscopy-guided LLIF	Navigated LLIF	P-value
Demographics	N=365	337 (92.3%)	28 (7.3%)	
	Age	62.4 ± 10.8	62.5 ± 9.7	0.959
	% Female Patients	188 (56.1%)	14 (50.0%)	0.531
	BMI	29.6 ± 6.1	29.6 ± 5.9	0.987
	Revision Surgery	131 (38.9%)	9 (32.1%)	0.482
	Levels fused	2.3 ± 1.1	1.9 ± 1.2	0.098
Surgical characteristics	Operative time (min)	309.1 ± 124.7	291.1 ± 89.5	0.329
	Estimated Blood Loss (ml)	380.6 ± 400.4	259.6 ± 151.7	**0.001**
	Length of Stay (days)	4.3 ± 3.2	3.5 ± 1.5	0.228
	Flouroscopy dosage (mGy)	66.8 ± 78.7	41.7 ± 50.9	**0.035**
	Interbody device type			**0.001**
	Peek	127 (52.7%)	0 (0%)	
	Titanium	114 (47.3%)	28 (100%)	
Complications	Intraoperative complications	8 (2.4%)	1 (3.6%)	0.695
	Neuromonitoring	8 (2.4%)	1 (3.6%)	0.695
	Durotomy	5 (1.5%)	0 (0%)	0.516
	Mass Blood Loss	2 (0.5%)	0 (0%)	0.693
	Delayed Extubation	2 (1.5%)	0 (0%)	0.683
	Post-operative complications	75 (22.3%)	7 (25.0%)	0.738
	Cardiac complications	19 (5.6%)	2 (7.1%)	0.742
	Neurological complications	13 (3.9%)	1 (3.6%)	0.94
	DVT/PE	3 (0.9%)	1 (3.6%)	0.19
	Pulmonary complications	10 (3.0%)	1 (3.6%)	0.857
	Post-operative ileus	18 (5.3%)	0 (0%)	0.21
	Mechanical complication	4 (1.2%)	0 (0%)	0.562
	Surgical Site Infection	7 (1.8%)	1 (3.2%)	0.558
	Urinary Complication	14 (4.2%)	3 (10.7%)	0.113
	Return to OR 30 days	3 (0.9%)	0 (0%)	0.616
	Return to OR 90 days	8 (2.4%)	0 (0%)	0.41

177. Fate of the Degenerative Spine Revision Patient

Fares Ani, MD; Arnaav Walia, BS; Gregory Van Perrier, BS; Julianna Bono, BS; Nathan S. Kim, BA; Constance Maglaras, PhD; Hershil Patel, BS; Aonnicha Burapachaisri, BS; Brooke K. O'Connell, MS; Themistocles S. Protopsaltis, MD; *Tina Raman, MD*

Summary
Patients with degenerative spine that undergo revision once, are at higher risk to undergo subsequent revisions. This study investigates the characteristics and outcomes of patients that go through with their second and third revisions.

Hypothesis
Patients who undergo secondary and tertiary spinal procedures for degenerative spine are at increased likelihood of going on to further revisions

Design
Retrospective case series.

Introduction
Patients with degenerative spinal pathology often undergo extensive revisions. Although there is much data on primary revision surgeries, there is a lack of literature on the patients that continue to fail

treatment and undergo multiple revisions over their lifetime. The goal of this analysis is to better understand patients that undergo multiple revisions.

Methods

455 patients (Age: 60.1±13.4; BMI: 30.3±6.3; % Female 53.0±0.8) with 1-3 levels fused undergoing a thoracolumbar revision surgery were reviewed. Patients were separated based on the number of spinal revision surgeries that have had previously. Patients were separated based on instances of revision surgeries. Comparison of patients that underwent a primary vs. secondary revision and primary vs. tertiary revision were performed. Cohorts were compared using an Independent-sample T-test and Pearson Chi-square; significance set at $p<0.05$.

Results

Amongst the 455 patients, 491 surgeries were included. The overall secondary revision rate was 8.6%, with 84% occuring within the first 2-years (table 1). Reasons for 2nd revision included: mechanical failure or malpositioning (20.5%), Adjacent Segment disease (18.0%), pseudarthrosis (15.4%), and to receive additional decompression (10.2%). Examining the tertiary revisions, rate of revision increased to 24.8% with 85% occuring within the first 2-years (table 2). Reasons for 3rd revision included: pseudarthrosis (42.9%), Adjacent segment disease (42.9%), and flat back syndrome (14.3%).

Conclusion

The 2-year rate of revision for primary revisions was 7.3% and for secondary revisions 20.7%. Further, those that had a second revision surgery had a 1-year readmission rate of 13.6%.

Take Home Message

Patients that continue to fail surgical treatment of degenerative spine should continue to be investigated as the rates of revision increase dramatically with each additional surgery.

Table 1. surgical characteristics and outcomes of patients that undergo their first revision for 1-3 level thoracolumbar fusion

		No subsequent revision	Go on to 2nd revision	p value
	n= 455	416 (91.4%)	39 (8.6%)	
Revision rate	1st year revision rate	5.70%		
	2nd year revision rate	7.30%		
	Avg days between surgeries	322.5		
Patient characteristics	Gender (% Female)	220 (54.5%)	21 (65.3%)	0.924
	Age	59.2 ± 12.4	60.9 ± 14.4	0.423
	BMI	30.1 ± 6.6	30.7 ± 5.9	0.549
	Diabetes	62 (20.3%)	3 (7.9%)	0.064
	Current Smokers	152 (40.1%)	11 (28.9%)	0.178
	Previous levels fused	1.4 ± 0.6	1.5 ± 0.8	0.359
Diagnosis	Flat Back	10 (2.5%)	3 (7.9%)	0.053
	Degenerative Spondylolisthesis	157 (41.3%)	20 (52.6%)	0.178
	Adjacent segment disease	100 (24.8%)	5 (13.2%)	0.106
	Pseudoarthrosis	112 (27.7%)	15 (39.5%)	0.138
Surgical characteristics	Pelvic Fixation	23 (5.7%)	3 (7.9%)	0.561
	Interbody device	305 (75.5%)	28 (73.7%)	0.804
	ALIF*	90 (22.3%)	6 (15.8%)	0.354
	LLIF*	68 (16.8%)	4 (10.5%)	0.318
	TLIF*	153 (37.9%)	16 (42.1%)	0.606
	Ponte Osteotomy	28 (6.9%)	0 (0%)	0.107
	Levels fused	1.9 ± 0.8	1.9 ± 0.9	0.662
	Op time (min)	281.5 ± 113.1	281.9 ± 104.9	0.335
	Estimated Blood Loss (mL)	427.3 ± 458.5	424.6 ± 360.4	0.973
	Length of Stay (days)	6.15 ± 2.5	5.68 ± 3.5	0.088
Complications	Intra-op complication	27 (6.7%)	6 (15.8%)	0.041
	Durotomy	19 (4.7%)	2 (5.3%)	0.877
	Delayed Extubation	10 (2.5%)	0 (0%)	0.759
	Neuromonitoring	27 (6.7%)	5 (13.2%)	0.141
	Intraop Fracture	0 (0%)	1 (2.6%)	**0.001**
	PostOp Complication	62 (15.3%)	20 (52.6%)	**0.001**
	Cardiac Complication	22 (5.4%)	1 (2.6%)	0.455
	Neurological Complication	14 (3.5%)	12 (31.6%)	0.001
	DVT/PE	10 (2.5%)	0 (0%)	0.753
	Pulmonary Complication	4 (1.0%)	1 (2.6%)	0.36
	Ileus	9 (2.2%)	2 (5.3%)	0.251
	Urinary Complication	14 (3.5%)	5 (15.8%)	0.007
	Surgical site infection	0 (0%)	1 (2.6%)	0.768
	Mechanical complication	2 (0.5%)	10 (26.3%)	**0.001**
	Return to OR within 30days	0 (0%)	15 (39.5%)	**0.001**

*ALIF: Anterior Lumbar Interbody fusion, LLIF: lateral Lumbar Interbody fusion, TLIF: Transforaminal Lumbar Interbody fusion

Table 2. surgical characteristics and outcomes of patients that undergo a second revision for 1-3 level thoracolumbar fusion

		No subsequent revision	Go on to 3rd revision	p value
	N=29	21 (72.5%)	7 (24.1%)	
Revision rate	1st year revision rate	10.30%		
	2nd year revision rate	20.70%		
	Avg days between surgeries	406.8 ± 337.0		
	1 year readmission rate	13.60%		
Patient characteristics	Gender	14 (66.7%)	3 (42.9%)	0.264
	Age	62.6 ± 12.7	61.4 ± 15.9	0.848
	BMI	31.2 ± 6.5	30.2 ± 5.5	0.758
	Diabetes	3 (14.3%)	0 (0%)	0.253
	Current smokers	2 (9.5%)	1 (12.5%)	0.814
	Previous levels fused	1.8 ± 0.9	2.0 ± 1.0	0.307
Diagnosis	Flat Back	1 (4.8%)	1 (12.5%)	0.462
	Degenerative Spondylolisthesis	8 (38.1%)	3 (37.5%)	0.976
	Asacent segment disease	4 (19.0%)	4 (50.0%)	0.036
	Pseudoarthrosis	9 (42.9%)	2 (25.0%)	0.376
Surgical characteristics	Pelvic Fixation	3 (14.3%)	1 (12.5%)	0.901
	BD	13 (61.9%)	3 (37.5%)	0.238
	ALIF*	4 (19.0%)	0 (0%)	0.194
	LLIF*	2 (9.5%)	0 (0%)	0.366
	TLIF*	6 (28.6%)	3 (37.5%)	0.642
	Levels fused	2.1 ± 0.9	2.5 ± 1.1	0.285
	Op time (min)	210.4 ± 89.6	217.7 ± 157.0	0.879
	Estimated Blood Loss (mL)	305.0 ± 276.9	357.1 ± 255.6	0.664
	Length of Stay (days)	5.8 ± 5.0	8.7 ± 11.2	0.523
Complications	Intra-op complication	1 (4.8%)	1 (12.5%)	0.462
	Durotomy	0 (0%)	1 (12.5%)	0.039
	Neuromonitoring	3 (14.3%)	0 (0%)	0.253
	PostOp Complication	7 (33.3%)	2 (25.0%)	0.665
	Cardiac Complication	0 (0%)	0 (0%)	
	Neurological Complication	3 (14.3%)	1 (12.5%)	0.901
	DVT/PE	0 (0%)	0 (0%)	
	Pulmonary Complication	1 (4.8%)	0 (0%)	0.53
	Ileus	1 (4.8%)	0 (0%)	0.53
	Urinary Complication	2 (9.5%)	0 (0%)	0.366
	Surgical site infection	0 (0%)	0 (0%)	
	Mechanical complication	1 (4.8%)	1 (12.5%)	0.462
	Return to OR within 30days	1 (4.8%)	1 (12.5%)	0.462

*ALIF: Anterior Lumbar Interbody fusion, LLIF: lateral Lumbar Interbody fusion, TLIF: Transforaminal Lumbar Interbody fusion

178. Prevention of Surgical Site Infections in Degenerative Lumbar Spine Surgery: The Optimal Amount of Normal Saline for Irrigation

Wei Hsiung, MD; Po-Hsin Chou, MD, PhD; Hsi-Hsien Lin, MD; Shih-Tien Wang, MD; Lei Hsiung, BS; Ming-Chau Chang, MD; Yu-Cheng Yao, MD

Summary

This study found that more intraoperative normal saline irrigation may reduce postoperative surgical site infection in degenerative lumbar spinal surgery. We also identified the optimal irrigation amount to prevent SSI. Patients who had diabetes and had received insufficient intraoperative irrigation less than 1400ml/hour were risks factors for surgical site infection following degenerative lumbar spine surgery.

Hypothesis

Insufficient intraoperative irrigation may be a risk factor for postoperative surgical site infection.

Design

Retrospective cohort study

Introduction

The incidence of surgical site infection (SSI) in degenerative lumbar spine surgery was reported diversely, ranging from 1% to 14%. Intraoperative preventive methods for reducing the rate of SSI included normal saline irrigation, dilute betadine solution irrigation, and intrawound vancomycin powder. The efficacy and optimal irrigation amount of normal saline to prevent SSI in degenerative lumbar spine surgery are not clear.

Methods

There are 444 patients from January 2015 through April 2021 included. All patients had degenerative lumbar spine disease and had received spinal fusion surgeries and at least 6 months follow-up. 193 patients were enrolled in the standard protocol group (irrigation with 2000ml normal saline) compared with 251 patients in the enhanced protocol group (irrigation with > 6000ml normal saline). Patients' demographic and surgical parameters were recorded. The outcome measures include overall infection, superficial wound infection, and deep infection.

Results

The demographics and surgical parameters between the two groups were comparable. The incidence of overall SSI was 4.66% in the Standard protocol group and 1.59% in the enhanced protocol group. There were significantly more diabetes and less irrigation amount per hour in the infection group. (Table) We determined the optimal irrigation amount is 1400 ml/hour in predicting SSI using the receiver operating characteristic curve. Patients with diabetes and received intraoperative irrigation amount less than 1400ml/hour are two significant risk factors in predicting postoperative SSI.

Conclusion

Diabetes and insufficient intraoperative irrigation were risk factors

for postoperative surgical site infection following degenerative lumbar spine surgery. Irrigation with more than 1400ml of normal saline per hour during surgery may reduce the risk of surgical site infection.

Take Home Message
Patients who had diabetes and had received insufficient intraoperative irrigation less than 1400ml/hour were risk factors for postoperative surgical site infection following degenerative lumbar spine surgery.

Table Risk factors for SSI between 2 groups

	infection group n=13	non-infection group n=431	*p* -value
Age	71.9 (10.0)	66.5 (12.6)	0.128
Body mass index	26.8 (4.5)	26.6 (4.5)	0.886
Blood loss (ml)	605.0 (547.9)	609.8 (415.7)	0.969
Surgical time (minute)	245.5 (65.4)	239.1 (91.6)	0.804
Irrigation amount (ml/hour)	852.5 (542.8)	1210.9 (719.6)	0.035
Fusion levels	2.9 (1.2)	2.89 (0.9)	0.852
Smoking (%)	1 (8%)	56 (13%)	0.575
Diabetes (%)	9 (69%)	93 (21%)	< 0.001

SSI, surgical site infection; Results were showed in means (standard deviation) or number (%)

Risk factors for SSI between 2 groups

180. Socioeconomic Burden of LBP in the US and Globally

Diana Chang, MA, MS; Michael Safaee, MD; Christopher P. Ames, MD

Summary
The global prevalence of lower back pain (LBP) grows secondary to increased longevity and sedentary lifestyles. In low-income countries, infections and occupational hazards significantly increase the LBP risk particularly among those of lower socioeconomic status. In high income countries, costs have risen significantly due to increased surgical rates and post-surgical revisions, frequent outpatient visits, and increased psychiatric co-morbidities. Cost containment methods should limit the frequency of outpatient specialist visits, surgical intervention, early imaging, and use of ineffective pain medications.

Hypothesis
The US has the highest cost burden of LBP globally.

Design
Review of cost studies on LBP in the US and globally.

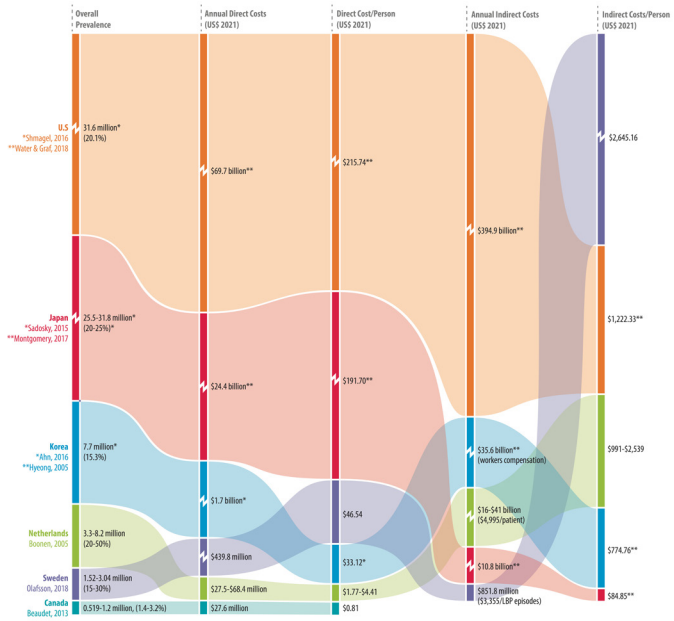
Introduction
Between 1997 and 2005, LBP expenditure increased 65% after inflation—faster than the national health expenditure growth rate. In 2016, LBP cost $69.7 billion US$2021.

Methods
Policymakers have attempted to curb costs by limiting "low-value" services: radiographic imaging for nonspecific LBP and spinal injections.

Results
32% of US patients with LBP undergo surgery compared to 6% in Sweden. Between 2004 and 2015, elective lumbar fusion rates increased 62.3% to 79.8 fusions/100,000 adults The rate increase of spine surgery mirrors that internationally. Surgery, while not the most widespread is the costliest intervention, ~$51,500 US$2021 per admission, >$10 billion total in 2015. Prescription drugs are another source of economic waste since 88% of LBP patients found them ineffective. Amongst chronic diseases, LBP is the third most common (after HTN and CVD) and second costliest after diabetes in the US. Internationally, the total cost of diabetes is responsible for the highest cost/capita and is the only chronic disease consistently more costly per capita than LBP.

Conclusion
The high cost of LBP in the US is in proportion to its high national healthcare costs, not the population's health status. While the US boasts the highest obesity rates, the prevalence of LBP in the US parallels other high-income countries. The US healthcare's litigious nature may predispose to overutilization of imaging. The US performs more CT scans (278.5/1000 people) than any other countries. 7% of the national health expenditure difference between the US and Netherlands is due to imaging. The indirect cost of LBP due to loss productivity in the US is disproportionately lower than countries like Sweden or the Netherlands, which have more lenient disability compensation policies.

Take Home Message
The growing global burden of LBP costs is driven by increasing rates of surgery, particularly fusions, imaging, and an aging population.



The relative prevalence, direct and indirect cost, and costs per person (US$2021) are depicted for the US, Japan, Korea,

Netherlands, Sweden, and Canada by colored ribbons and sorted by their rank. Asterisks denote the cited source for countries with more than one source.

181. Evaluating a Nanosurface-Modulated Titanium Interbody Device in Anterior Lumbar Interbody Fusion

Mark A. Ochoa, BS; Hani Malone, MD; Behrooz A. Akbarnia, MD; Gregory M. Mundis Jr., MD; Robert K. Eastlack, MD

Summary
Titanium (Ti) interbody devices with nanosurface technology facilitate high levels of fusion in ALIF and significant improvement in patient-reported outcomes, while reducing the typical costs associated with accompanying biologics/grafts.

Hypothesis
High levels of fusion and low levels of subsidence will be observed in patients undergoing ALIF with a nanosurface-modulated Ti device without biologics/BMP.

Design
Prospective single cohort

Introduction
Advances in surface architecture have made interbody devices more bioactive and facilitate high rates of fusion. The advent of bioactive titanium implants may reduce reliance on biologics for lumbar interbody fusion, thus significantly reducing treatment costs.

Methods
A prospective study (August 2018-December 2019) was conducted of consecutively performed anterior lumbar interbody fusions (ALIF) with a nanosurface-modulated titanium interbody device packed only with allograft chips and local blood. Fusion was assessed via CT and/or dynamic radiographs, along with subsidence, and HRQOL measures (ODI, VAS-back/leg) were collected pre and postoperatively.

Results
In total, 69 lumbar levels were treated in 55 patients. Mean age was 67 with 47% female. Roughly one-third (35%) had previous spinal surgery, and a tenth (11%) prior lumbar fusion. 20.6% were treated at multiple levels (mean levels per patient=1.2). One year after surgery, mean improvement in patient reported outcomes (vs. preop) were: ODI -23.46, VAS back -3.75, VAS leg -3.72. All levels achieved fusion at 1 year post op based on CT (65/69 levels) or dynamic x-ray (4/69 levels, flexion-extension delta less than 5%). Low-grade graft subsidence (Marchi Grade <1) occurred in 22 levels (31.9%) and high-grade subsidence was not found. No patients required reoperation at the level of ALIF and no radiographic or clinical evidence of pedicle screw loosening was observed.

Conclusion
The combination of advances in materials science and surface technology with this nanosurface modulated titanium cage results in a markedly diminished demand for expensive biologics in achieving a high fusion rate.

Take Home Message
Usage of nanosurface-modulated Ti devices in patients undergoing ALIF yield high levels of fusion and low levels of subsidence without biologics/BMP.

182. Risk Factors for Postoperative Complaints in Patients Following Lumbar Decompression and Fusion: Analyses Focusing on Preoperative Symptoms

Sang Yun Seok, MD; Jae Hwan Cho, MD, PhD

Summary
More than half of patients who underwent lumbar decompression and fusion complained of residual symptoms. Risk factors are sensory symptoms, motor power decrease, long duration, pain to below knee location, presence of psychotic disease. It is considered that the postoperative patient's compliant could be predicted and explained in advance by checking the preoperative symptoms, including the duration and site. This could be helpful in enhancing the understanding of the surgical results preoperatively, which could control the anticipation of the patients.

Hypothesis
The postoperative patients' complaints after lumbar decompression and fusion surgery could be predicted and explained in advance by checking the preoperative characteristics of patients' symptoms.

Design
Retrospective study

Introduction
Many patients complained of residual symptoms following lumbar decompression surgery. However, few studies analyze this dissatisfaction by focusing on preoperative patients' symptoms. Therefore, we designed this study to determine (1) What are the common symptoms of patients' postoperative complaints? (2) Which preoperative symptoms are the risk factors associated with postoperative complaints?

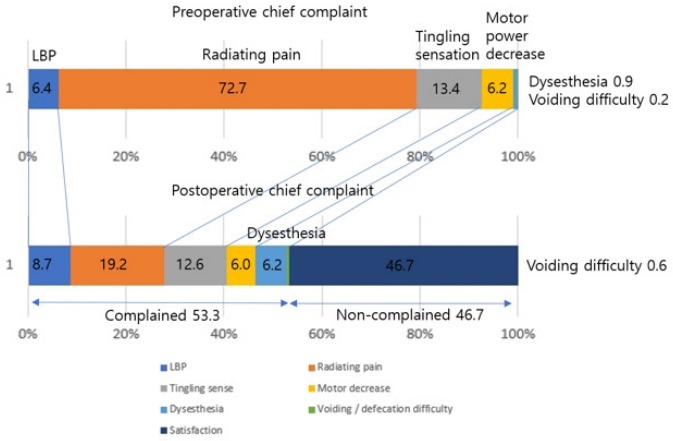
Methods
469 consecutive patients who underwent lumbar decompression and fusion surgery for lumbar degenerative disease were included. Postoperative complaint was defined by at least twice complaint during the outpatient follow-up of 3,6,12, and 24 months after surgery. A comparative analysis was performed between complaint group (group C, n=250) and non-complaint group (group NC, n=219). Preoperative and postoperative chief complaints were analyzed through chart review.

Results
Most common postoperative complaint was residual radiating pain (36.0%, n=90) followed by tingling sensation (23.6%, n=59). The presence of psychotic disease (odds ratio [OR], 4.666; p=0.019), longer pain duration (OR, 1.021; p<0.001), pain to below the

knee (OR, 2.326; p=0.001), preoperative tingling sensation (OR, 2.631; p<0.001), preoperative sensory and motor power decrease (OR, 2.152 and 1.678; p=0,047 and 0.007, respectively) were significantly correlated with postoperative patients' complaints in multivariate analysis.

Conclusion
Based on the current study, the postoperative patients' complaints could be predicted and explained in advance by checking the preoperative characteristics of patients' symptoms, including the duration and site carefully. This could be helpful to enhance the understanding of the surgical results preoperatively, which could control the anticipation of the patients.

Take Home Message
More than half of patients complained of residual symptoms. The risk factors are sensory symptoms, motor power decrease, long duration, pain to below knee location, presence of psychotic disease.



Comparisons of preoperative and postoperative patients' chief complaints

183. Beware of the Underweight Patient! Underweight Patients Are at Increased Risk of Complications Following Lumbar Fusion

Keir Johnson, BS; Daniel J. Alsoof, MBBS; Christopher McDonald, MD; Alan H. Daniels, MD; Eric Cohen, MD

Summary
Previous studies have demonstrated that obesity is associated with increased complications following lumbar fusion. However, there is little published data on the effect of being underweight on lumbar fusion outcomes. We conducted a retrospective review of lumbar spinal fusion patients, identified through the PearlDiver Mariner database. Our analysis indicates that both underweight and obese patients are at high risk for complications. Therefore, underweight patients may benefit from preoperative optimization via nutrition counselling to avoid potential complications.

Hypothesis
We hypothesized that both obese and underweight patients are at higher risk of complications after lumbar fusion when compared to patients with normal BMI.

Design
This is a retrospective study using the PearlDiver Mariner database.

Introduction
Previous studies demonstrated that obesity is associated with increased complications following lumbar fusion. There is little published data on the effect of being underweight on outcomes.

Methods
Lumbar spinal fusion patients were identified through the PearlDiver database between 2010-2020. Study groups were created using ICD-10 codes to identify preoperative BMI category as morbid obesity (BMI>40), obesity (BMI 30-40), normal BMI (BMI 20-30), and underweight (BMI<20) cohorts. Complications that occurred within 1 year postoperatively were then isolated and similar complications were grouped. Statistical analyses were performed using the Pearson Chi-square method to calculate odds ratios and confidence intervals.

Results
65,834 patients were identified in the study groups. This included 1,182 (1.8%) underweight patients, 43,377 (65.9%) obese patients, and 21,275 (32.3%) morbidly obese patients. The control groups (BMI 20-30) for the underweight, obese, and morbidly obese cohorts contained 4,686, 43,377, and 21,275 patients respectively. When compared to controls, underweight patients showed increased likelihood of complications related to mechanical (odds ratio [OR]: 3.73; $p < 0.001$), posterior lumbar refusion (OR: 2.28; $p < 0.001$), pulmonary (OR: 4.01; $p < 0.001$), sepsis (OR: 3.78; $p < 0.001$), surgical site complications (OR: 2.12; $p < 0.001$), thromboembolism (OR: 2.70; $p < 0.001$), and urinary (OR: 1.98; $p < 0.001$). Overweight patients additionally showed an increased likelihood of dural tear (morbid OR 1.84, $p = 0.0092$) and hemorrhages and hematomas (obese OR 1.50, P<0.001; morbid OR 2.05, P<0.001) when compared to controls

Conclusion
Both underweight and obese patients are at high risk for complications. Underweight patients may benefit from preoperative optimization via nutrition counselling to avoid potential complications.

Take Home Message
Following lumbar spinal fusion surgery, both underweight and obese patients are at high risk for complications. Underweight patients may benefit from preoperative optimization via nutrition counselling to avoid potential complications.

184. Prediction of Probability for Surgical Treatment in the Patients with Lumbar Spinal Stenosis according to the Severity of Stenotic Lesions: A 5- to 10-Year Follow-Up Study

Ho-Joong Kim, MD; Sanghoon Lee, MD; Dong-ho Kang, MD

Summary

We aimed to clarify difference in the natural history of lumbar spinal stenosis with respect to surgical treatment according to severity of stenosis. As a results, the high grades of maximal central and foraminal stenoses were risk factors for surgical treatment. Surgical probabilities were 57.9%–62.3% in grade 3 maximal central stenosis, 22.2%–62.3% and 33.3%–57.9% in grade 2 and 3 maximal foraminal stenosis. These indicate that the natural history of LSS differs according to grade of maximal central and foraminal stenoses.

Hypothesis

We hypothesized that there would be a difference in the probability of surgical decompression according to the grade of stenosis on MRI.

Design

A retrospective observational study

Introduction

Despite the benign natural history of LSS, results of deterioration have been reported in some studies. Due to this uncertainty in the natural history and clinical course, some patients with LSS might continue with ineffective conservative treatment or undergo unnecessary surgery. This study aimed to clarify the difference in the natural history of LSS with respect to surgical treatment according to the severity of stenosis on MRI using a qualitative grading system for central and foraminal stenoses and to estimate the probability of surgical treatment depending on the severity of canal stenosis on MRI.

Methods

A total of 1,248 patients diagnosed with LSS between 2011 and 2014 at our hospital were followed up for the mean duration of 7.7 years (5.17–9.8 years). We investigated severity of central and foraminal stenoses on initial MRI using qualitative grading system and whether surgical treatment was performed. Logistic regression models were used to identify risk factors for surgery.

Results

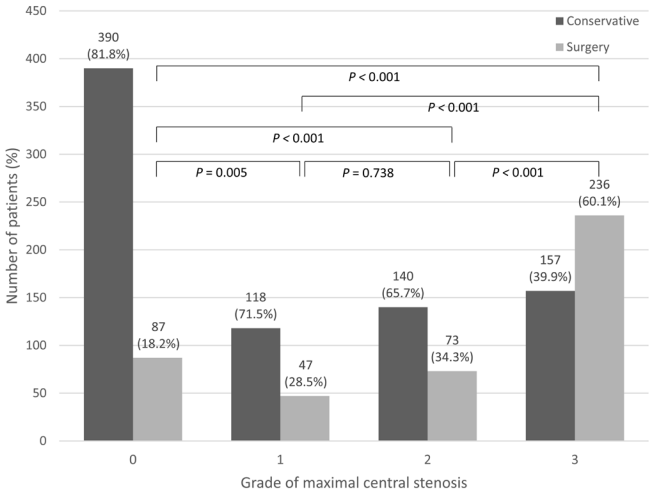
Grade 3 maximal central stenosis showed the highest percentage of surgical treatment (57.9%–62.3%) with no significant difference in surgical probabilities according to concomitant foraminal stenosis. Surgical probabilities in grade 2 and 3 maximal foraminal stenosis, were 22.2%–62.3% and 33.3%–57.9%, respectively, depending on concomitant central stenosis. Maximal central stenosis of grades 1, 2, and 3 (odds ratio [OR]: 1.79, 2.21, and 6.26, respectively), and maximal foraminal stenosis of grades 2 and 3 (OR: 2.22 and 2.12, respectively) were significant risk factors for surgical treatment.

Conclusion

This study highlights the difference in the natural history of LSS with respect to surgical treatment depending on the severity of stenosis. Altogether, 57.9%–62.3% of patients with grade 3 maximal central stenosis eventually underwent surgery during the mean 7.7 years of follow-up period.

Take Home Message

The severity of stenosis on MRI can predict the probability of surgical treatment, and the natural history in the view of surgical treatment depends on the grade of stenosis.



185. Outcomes Analysis of Minimally Invasive vs. Open Surgery (Laminectomy and Micro Lumbar Discectomy)

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Summary

Some studies have noted that Open surgeries can result in lengthier recovery times and increased potential for infection due to larger incisions relative to minimally invasive surgery (MIS). This study demonstrates that Open laminectomy and micro-lumbar discectomy (MLD) surgeries did not result in more negative peri-operative outcomes relative to MIS laminectomy and MLD surgery. These results suggest that MIS peri-operative outcomes were comparable to Open.

Hypothesis

Open surgery can contribute to more negative perioperative outcomes vs. MIS surgery in patients undergoing lumbar laminectomy vs. (MLD).

Design

Retrospective review at a single institution.

Introduction
Existing research has documented the advantages of MIS surgery compared to Open with respect to fusions. However, the benefits in the context of laminectomy and MLD are not as clearly defined.

Methods
Included: 460 patients ≥ 18 years of age, with no prior history of spinal instrumentation, who underwent either lumbar laminectomy or MLD with 2 year follow-ups from 2012-2020. Outcome measures: returns to OR within 2 years, surgical characteristics, and returns to operating room. Statistical analysis included independent t-tests and chi-square analysis with significance set at $p<0.05$.

Results
460 lumbar laminectomies and MLD were included, with 202 Open laminectomies (37.3% female, mean age 66.69±12.474, mean BMI 29.297±5.837), 36 MIS laminectomies (41.7% female, mean age 63.83±13.107, mean BMI 28.758±4.650), 180 Open MLD (37.8% female, mean age 46.13±15.240, mean BMI 27.885±4.691) and 42 MIS MLD (31.0% female, mean age 49.61±15.124, mean BMI 27.989±5.950). With regard to MIS vs. Open MLD groups, there were differences in operative time (89.2 vs. 74.29, p=.004) and 90 day returns to OR (1 vs. 0, p=.038), with MIS having a higher operative time and revision rate. However, there was no difference in 2 year revision rates between the groups.

Conclusion
Perioperative outcomes between MIS and Open surgeries were comparable. Minor differences were noted between Open and MIS MLD. These results require further direct analysis as this was a single center analysis.

Take Home Message
Open MLD had shorter operative time and a lower revision rate within 90 days relative to MIS MLD. There was no difference in outcomes between Open and MIS laminectomies.

Table 1: Outcomes in patients undergoing Minimally Invasive versus Open Surgery (Laminectomy and Micro-Lumbar Discectomy)

		Open Laminectomy (n=202)	MIS Laminectomy (n=36)	p-value	Open Micro-Lumbar Discectomy (n=180)	MIS Micro-Lumbar Discectomy (n=42)	p-value
Demographics	Age (years)	66.69 ± 12.474	63.83 ± 13.107	0.211	46.13 ± 15.240	49.61 ± 15.124	0.188
	Gender (Female)	75 (37.3%)	15 (41.7%)	0.620	68 (37.8%)	13 (31.0%)	0.408
	Charlson Comorbidity Index (CCI)	3.224 ± 2.004	3.361 ± 2.057	0.707	1.128 ± 1.638	1.214 ± 1.298	0.750
	BMI (kg/m²)	29.297 ± 5.837	28.758 ± 4.650	0.596	27.885 ± 4.691	27.989 ± 5.950	0.903
	Levels Treated	1.99 ± 1.030	1.36 ± 0.683	**<.001**	1.04 ± 0.221	1.07 ± 0.261	0.412
Surgical Characteristics	Operative Time (min)	152.62 ± 64.962	152.14 ± 74.552	0.955	74.29 ± 28.513	89.24 ± 37.336	**0.004**
	Estimated Blood Loss (mL)	140.28 ± 195.938	104.29 ± 255.090	0.342	32.01 ± 57.063	31.28 ± 31.658	0.939
	Durotomy	15 (7.5%)	6 (16.7%)	0.074	7 (3.9%)	0 (0%)	0.194
	Length of Stay (Days)	2.662 ± 7.087	1.713 ± 2.374	0.454	.462 ± .941	.514 ± .735	0.739
	Intra-Operative Complications	11 (5.5%)	3 (8.3%)	0.503	5 (2.8%)	0 (0%)	0.275
	Post-Operative Complications	27 (13.4%)	6 (16.7%)	0.606	5 (2.8%)	3 (7.1%)	0.172
	Surgical Site Infection (SSI)	5 (2.5%)	1 (2.8%)	0.919	2 (1.1%)	0 (0%)	0.493
	Return to OR within 30 Days	3 (1.5%)	1 (2.8%)	0.581	1 (0.6%)	0 (0%)	0.628
	Return to OR within 90 Days	3 (1.5%)	0 (0%)	0.461	0 (0%)	1 (2.4%)	**0.038**
	Return to OR within 2 years	26 (12.9%)	1 (2.8%)	0.077	22 (12.2%)	8 (19.04%)	0.244

*Levels treated defined as number of levels with laminectomy performed or intervertebral levels with micro-discectomy performed.

186. Propensity-score match analysis of subsidence and reoperation after lateral lumbar interbody fusion using 3D porous titanium vs. PEEK

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Summary
Cage material property is an important determinant of subsidence after interbody fusion. 3D-printed porous titanium has a stiffness that mimics that of native vertebral body bone, therefore, theoretically resulting in lower subsidence. We studied rate of subsidence and reoperation after lateral lumbar interbody fusion comparing porous Ti to PEEK in an institutional matched analysis. We observed that porous Ti lowered the odds of subsidence and resulted in less frequent reoperations.

Hypothesis
3D-printed porous titanium results in lower reoperation due to subsidence

Design
Retrospective observation cohort

Introduction
Porous 3D-printed titanium (Ti) cage has a stiffness that mimics that of modulus of elasticity of native vertebral cortical bone. In

biomechanical studies, this property results in reduction of stress at bone-hardware interface, theoretically lowering the risk of subsidence after lateral lumbar interbody fusion (LLIF). We compared the rate of subsidence and reoperation after LLIF using 3D porous Ti vs. PEEK.

Methods
This is a retrospective observational cohort of consecutive adult patients who underwent LLIF from 2016 to 2020. A total of 86 patients (43 with PEEK and 43 with porous Ti grafts) were propensity matched 1:1 based on age, gender, spinal pathology (degenerative vs. deformity), bone mineral density, number of fused levels, staged posterior instrumentation, and cage size.. Multivariable regression was performed to evaluate for predictors of subsidence while controlling for the length of follow-up.

Results
The two patient cohorts were well-matched, without statistically significant difference in demographic and clinical characteristics. In patients with PEEK, 58 (73.4%) grafts had grade 0 subsidence, 12 (15.2%) grade I, 7 (8.9%) grade II, and 2 (2.5%) grade III. In patients with porous titanium implants, 59 (89.4%) showed grade 0, 4 (6.1%) grade I, 2 (3.0%) grade II, and 1 (1.5%) grade III subsidence (p=0.03). Porous titanium implant was associated with lower odds of subsidence (OR = 0.23, 95% CI [0.07-0.78], p = 0.018). Compared to PEEK (13.2%), reoperation occurred less frequently with porous Ti (4.6%; p=0.01).

Conclusion
In a well-matched cohort of patients who underwent LLIF using porous Ti cage vs. PEEK, the former was associated with significantly lower rate of radiographic subsidence, and less frequent reoperation.

Take Home Message
Compared to PEEK, 3D-porous titanium results in lower reoperation due to subsidence after LLIF

187. Significantly Higher Surgical Site Infection Rates Observed in MIS-TLIF Compared to Endo-TLIF in Lumbar Stenosis Patients

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Summary
Minimally Invasive Transforaminal Lumbar Interbody Fusion [MIS_TLIF] as a surgical technique for lumbar decompression and fusion in lumbar spondylotic degenerative disk disease (LS-DDD) has rapidly gained popularity in the field since its inception by Foley et al., in 2002. In conjunction with the evolution of endoscopic (Endo) spine surgery which is also believed to be a less invasive procedure, performing [MIS_TLIF] or [Endo_TLIF] for LS-DDD patients is anticipated to delineate comparable clinical outcomes, particularly, technique efficacy and surgical complication rates.

Hypothesis
To investigate if [Endo_TLIF] and [MIS_TLIF] show comparable surgical complication rates.

Design
Systematic Review and Meta-Analysis

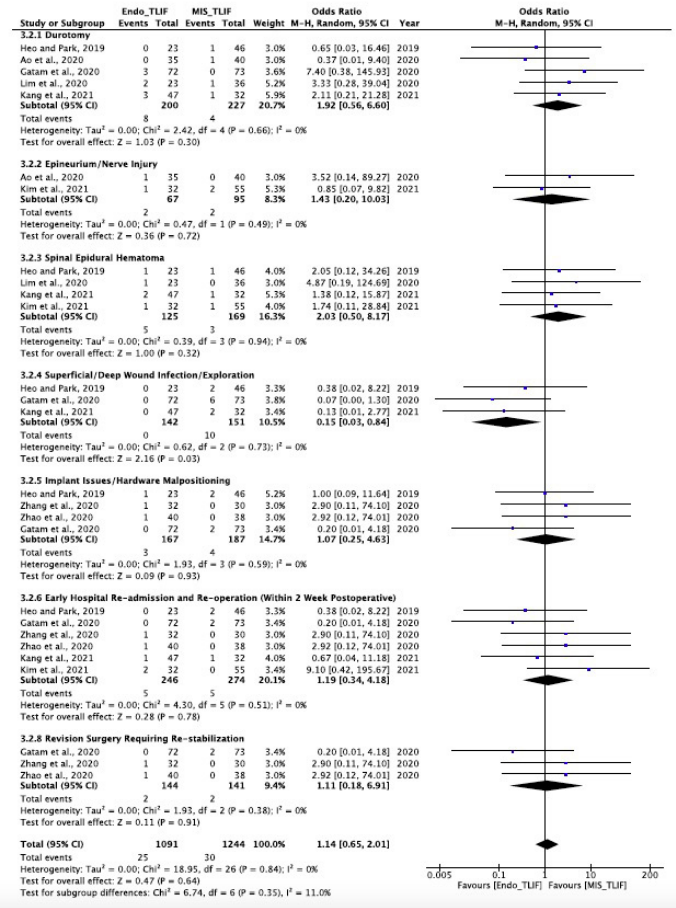
Introduction
The current shift in healthcare paradigm from fee-for-service models towards value-based care models emphasizes the need to weigh currently employed surgical techniques in spine patients to evaluate the complication and quality outcomes of surgical patients. In this study, the authors purposed to determine if Endo_TLIF vs. MIS_TLIF show paralleled rates of peri-operative complications. We anticipate that the findings obtained from this meta-review study may evidently expose the potential health-related risk(s) associated with [Endo_TLIF] and [MIS_TLIF] surgical approaches in LSS management.

Methods
A comprehensive literature review was performed from January 2000 to September 2021. The selection criteria for included studies comprised: case series of ≥10 patients, reported complication incidence and a ≥1-year follow-up period. The main outcomes compared between the [Endo_TLIF] and [MIS_TLIF] surgical approaches included: overall surgical complication incidence, intra-operative, immediate postoperative (defined as: < 2 weeks post-surgery), and later postoperative (defined as: ≥ 2 weeks post-surgery) surgical complication incidence.

Results
Of the 654 LSS patients, 46.48% (n=304) and 53.52% (n=350) were [Endo_TLIF] and [MIS_TLIF], respectively. Among the subgroup entities of immediate postoperative complications defined at < 2 week following decompression and fusion, significantly lower incidence of superficial/deep wound infection/exploration; [Odds Ratio (OR)= 0.15; 95% confidence interval (CI) = (0.03, 0.84); I2= 0%, (p=0.03)] was observed in the [Endo_TLIF] approach. Overall surgical complication rates as well as the other subgroup analyzed complication incidences were comparable between [Endo_TLIF] and [MIS_TLIF] approaches.

Conclusion
Except for surgical site infections/explorations, all compared complication rate outcomes between [Endo_TLIF] and [MIS_TLIF] approaches were paralleled with safe indication.

Take Home Message
1. Both [Endo_TLIF] and [MIS_TLIF] show similar efficacy in the management of LSS patients. 2. [MIS_TLIF] approach is significantly associated with exposure to surgical site infections compared to [Endo_TLIF] approach.



Generally Reported Complication Rates Between Endo-TLIF and MIS-TLIF Surgical Techniques

188. Practical Answers to Frequently Asked Questions in Minimally Invasive Lumbar Spine Surgery

Pratyush Shahi, MBBS; Avani S. Vaishnav, MBBS; Eric Mai, BS; Jeong Hoon Kim, BS; *Francis C. Lovecchio, MD*; Virginie Lafage, PhD; Sheeraz Qureshi, MD; Sravisht Iyer, MD

Summary

Surgical counseling enables SDM. This study retrospectively analyzed outcomes of patients undergoing primary minimally invasive lumbar spine surgery to provide answers to complied FAQs. It was found that most patients were discharged by the first day, reported clinical improvement in pain and activity level, and returned to activities within a month. Only a minority had a complication, reoperation, or worsening. We believe that concise answers to these FAQs can be used as a reference to enable SDM.

Hypothesis

Patient outcomes can be retrospectively analyzed to provide answers to frequently asked questions (FAQs) in minimally invasive lumbar spine surgery.

Design

Retrospective case series

Introduction

Surgical counseling enables shared decision-making (SDM). We aimed to provide answers to FAQs in minimally invasive lumbar spine surgery.

Methods

Patients who underwent primary minimally invasive lumbar spine surgery in form of transforaminal lumbar interbody fusion (MI-TLIF), decompression, or tubular microdiscectomy were included and their patient-reported outcomes, return to activities, complications, and radiation exposure were analyzed to answer the compiled FAQs.

Results

104 TLIF, 147 decompression and 115 microdiscectomy patients were included. These FAQs were answered: 1. Will my back pain improve? Most patients report improvement by >50%. 2. Will my leg pain improve? Most patients report improvement by >50%. 3. Will my activity level improve? Most patients report significant improvement. 4. Is there a chance I will get worse? 6% after TLIF, 14% after decompression and 5% after microdiscectomy. 5. Will I receive a significant amount of radiation? Radiation exposure is nearly insignificant for health risks. 6. What is the likelihood I will have a complication? 17% (15% minor, 2% major) for TLIF, 10% (9.3% minor and 0.7% major) for decompression, and 1.7% (all minor) for microdiscectomy. 7. Will I need another surgery? 6% after TLIF, 16.3% after decompression, 13% after microdiscectomy. 8. How long will I stay in the hospital? Likely to be discharged one day after TLIF and same day after decompression and microdiscectomy. 9. When will I be able to return to work? >80% of patients return to work (average: 25 days after TLIF, 14 days after decompression, 11 days after microdiscectomy). 10. Will I be able to drive again? >90% of patients return to driving (average: 22 days after TLIF, 11 days after decompression, 14 days after microdiscectomy).

Conclusion

These concise answers to FAQs in minimally invasive lumbar spine surgery can be used by physicians as a reference to enable patient education.

Take Home Message

Most patients reported clinical improvement and returned to activities within a month. A minority had worsening. Concise answers to FAQs can be used as a reference to enable patient education.

189. Outcomes of Spinal Surgery in Patients with Fibromyalgia: Results from the British Spine Registry

Alvin Pun, FRACS; Kiran G. Divani, MBBS, FRCS; Nitin Adsul, DNB (ortho); Robert S. Lee, FRCS

Summary

This is the first registry-based study investigating the clinical

outcomes of patients diagnosed with fibromyalgia who underwent spinal surgeries between June 2012 and June 2021 (nine years). 303 patients were identified on the British Spine Registry (BSR) with cervical (93) and lumbar degenerative conditions (200), trauma (8) and tumours (2). Analysis of patient-reported outcome measures (PROMS) showed improved outcomes in patients with degenerative conditions.

Hypothesis
Patients with fibromyalgia undergoing spinal surgery have poor clinical outcomes.

Design
Observational cohort study.

Introduction
Fibromyalgia is present in 2-8% of the population, characterized by a complex spectrum of symptoms that includes widespread pain, fatigue, sleep disturbances and functional symptoms. Surgeries including various spinal procedures have been thought to produce less favourable outcomes in such patients. The literature suggests that spinal surgery neither ameliorates the symptoms nor improves the poor quality of life of fibromyalgia patients. We embarked on a first registry-based study to explore the PROMS in this group of patients to provide evidence to guide future treatments.

Methods
Pre- and post-operative EQ-5D 5L index, EQ-5D 5L VAS and Oswestry Disability Index (ODI) were obtained from BSR for patients with a diagnosis of fibromyalgia from June 2012 to June 2021 (nine years). Patients had spinal procedures for various degenerative conditions, trauma, and tumours. Follow-up PROMS ranged from 6 weeks to 2 years.

Results
Of the 303 patients recorded on BSR with a diagnosis of fibromyalgia, 272 were females and 31 were males. Mean age was 55 years old (median: 54, range: 25 to 85). 293 underwent surgery for various degenerative conditions (cervical: 93; lumbar: 200), 8 for trauma and 2 for tumours. 158 patients had completed PROMS. Follow up ranged from 6 weeks to 2 years. At 1 year, EQ-5D 5L index increased for degenerative conditions (cervical: 0.23 to 0.35; lumbar: 0.14 to 0.31) but decreased for trauma (0.48 to 0.36) and tumours (0.8 to 0.53) patients. EQ-5D 5L VAS increased for degenerative conditions (cervical: 43.52 to 46.05; lumbar: 36.82 to 42.93) but decreased for trauma (71 to 15) and tumour (80 to 50). ODI decreased for lumbar degenerative conditions (66 to 55.61) and tumours (84 to 26).

Conclusion
The results from our study demonstrate that patients with fibromyalgia have improved outcomes with spine surgeries for degenerative conditions but potentially worse outcomes for trauma and tumour.

Take Home Message
Patients with fibromyalgia do get improved clinical outcomes in spinal surgeries for degenerative conditions. They may have worse outcomes with surgeries for trauma or tumours.

190. Cervical Laminoplasty vs. Posterior Laminectomy and Fusion: Trends in Utilization and Evaluation of Complication and Revision Surgery Rates

Christopher McDonald, MD; Stuart Hershman, MD; William B. Hogan, BS; Daniel J. Alsoof, MBBS; Kevin Disilvestro, MD; Andrew S. Zhang, MD; Eren Kuris, MD; Alan H. Daniels, MD

Summary
This is a retrospective comparative database study evaluating the trends of laminoplasty compared to laminectomy with fusion over the past decade in patients with cervical myelopathy. From 2010 to 2019, rates of laminoplasty have not increased and represent under 15% of posterior-based myelopathy operations. Up to 5-year follow up, there were no differences in revision rates for laminoplasty compared to laminectomy with fusion, however laminoplasty was associated with fewer post-operative complications than laminectomy and fusion.

Hypothesis
We hypothesize the annual incidence of laminoplasty is increasing with similar complication and revision rates for the two procedures.

Design
This is a retrospective study using the PearlDiver Mariner database.

Introduction
Cervical laminoplasty and posterior laminectomy with fusion are operations to treat spondylotic myelopathy. Conflicting data exists regarding which operation provides superior outcomes while minimizing the risk of complications.

Methods
Records with an ICD-9 or 10 diagnosis code for cervical myelopathy were retained. Patients undergoing either laminectomy and fusion or laminoplasty were identified using CPT procedural codes; patients were grouped independently (fusion vs. laminoplasty) and assessed for common complications. Revision spinal surgery codes were used to identify reoperations occurring at 3 months, 6 months, 1 year, and 5 years following the initial CPT procedure code for fusion or laminoplasty.

Results
417,328 patients with cervical myelopathy met inclusion, including laminoplasty (1,420 patients) and posterior laminectomy and fusion (10,440 patients). Rates of procedures remained stable, although the number of procedures nearly doubled. On matched analysis laminoplasty exhibited lower rates of wound complications (OR = 0.67, p = 0.002), surgical site infections (OR = 0.60, p = 0.002), spinal cord injury (OR = 0.6, p = 0.02) dysphagia (OR = 0.77, p = 0.01), cervical kyphosis (OR = 0.55, p = 0,01), limb paralysis (OR =

0.67, p < 0.0001), incision and drainage (OR = 0.45, p < 0.0001), instrumentation removal (OR = 0.28, p = 0.001), respiratory failure (OR = 0.74, p = 0.01), renal failure (OR = 0.84, p = 0.04), and sepsis (OR = 0.85, p = 0.04). Revision rates at 3 months, 6 months, 1 year, and 5 years, were not significantly different and were within 1 percentage point at each time point (p>0.05).

Conclusion
Rates of laminoplasty have not increased and represent under 15% of posterior-based myelopathy operations. There were no differences in revision rates, however laminoplasty was associated with fewer post-operative complications than laminectomy and fusion.

Take Home Message
From 2010 to 2019, rates of laminoplasty have not increased. Up to 5-year follow up, there were no differences in revision, however laminoplasty was associated with fewer post-operative complications.

191. Frequency of Radiologist Reported Vacuum Phenomenon in the SI Joint on CT Scan

Taylor J. Freetly, MD; Cyrus Nouraee, BS; Kenneth J. Holton, MD; Frederick W. Ott, MD; Takashi Takahashi, MD; David W. Polly Jr., MD

Summary
Vacuum phenomenon (VP) is an underreported finding within the sacroiliac joint on computed tomography (CT) scans. When present bilaterally, it suggests sacroiliac joint instability and is a possible pain generator. Variations in the rate of VP reporting are seen across radiologist subspecialities.

Hypothesis
When present, we hypothesized that musculoskeletal radiologists would report the finding more often due to the search for back pain.

Design
Retrospective Imaging Review

Introduction
Vacuum phenomenon (VP) is an underreported finding within the sacroiliac joint on computed tomography (CT) scans. When present bilaterally, it suggests sacroiliac joint instability and is a possible pain generator.

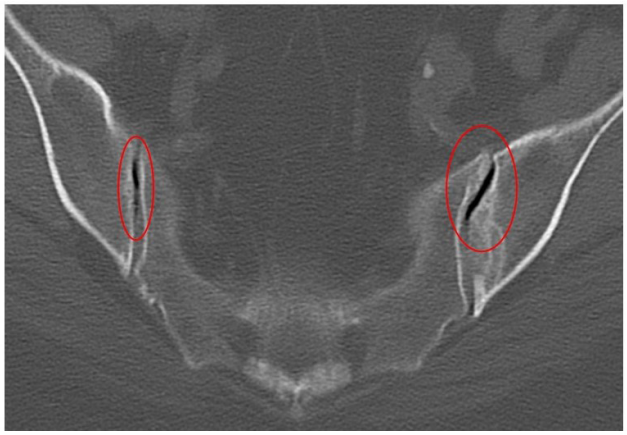
Methods
253 CT scans were retrospectively reviewed from May to January 2020 by two independent reviewers. Axial thin-section images were viewed under the default bone window. Age, sex, presence of VP, presence of sacroiliac fusion hardware, and radiologist subspecialty was recorded. If VP was present, the reading radiologist's note was examined to confirm whether the phenomenon was reported.

Results
VP was present in 214/253 (84.6%) patients. Musculoskeletal radiologists reported the finding in 10/34 (29.5%) patients confirmed to have VP by reviewers. Body radiologists reported the finding in 0/10 (0%) in confirmed cases. Neuroradiologists reported the finding in 1/170 (0.6%) confirmed cases. VP was more common in females with a total of 122 (89.7%) patients than males 92 (78.6%) with an odds ratio of 2.37 (p = 0.017). Average age was 62.48 years in patients with VP and 58.90 in those without, which was not statistically significant (p = 0.52).

Conclusion
Female patients are more likely to have VP within the sacroiliac joints than males. Variations in the rate of VP reporting are seen across radiologist subspecialities. Musculoskeletal radiologists report the finding more often than body or neuroradiologists. If VP suggests sacroiliac joint instability and is clinically significant, then reporting it is more important.

Take Home Message
Vacuum phenomenon suggests sacroiliac joint instability which is clinically significant. This SI joint instability is a potential pain generator so radiologists should be encouraged to report this phenomenon.

Presence of Vacuum Phenomenon



Presence of Vacuum Phenomenon

193. Anterior Vertebral Body Tethering for Adolescent Idiopathic Scoliosis Preserves Spinal Motion Compared to Selective Thoracic Posterior Spinal Fusion

Stephanie Ihnow, MD; Laurel C. Blakemore, MD; Jessica McQuerry, MD; Heather K. Vincent, PhD

Summary
This is a prospective cohort study comparing pre- and post-operative spine motion between patients who underwent thoracic anterior vertebral body tethering (VBT) or selective thoracic posterior spinal fusion (PSF) for the treatment of adolescent idiopathic scoliosis (AIS). Patients who underwent VBT had preserved motion in nearly

all directions with increased motion in trunk flexion and extension at one year postop compared to those undergoing PSF.

Hypothesis
VBT for AIS will preserve more spine motion vs. PSF.

Design
This is a prospective cohort study comparing pre- and 1 year post-operative spine motion between patients who underwent thoracic VBT or selective thoracic PSF for the treatment of AIS.

Introduction
Severe AIS has traditionally been treated with PSF, leading to a loss of spinal motion. Recently, skeletally immature patients with moderate to severe curves have been treated with tethering of the convex side to allow for growth modulation to correct the spinal curvature. This procedure is thought to preserve spine motion.

Methods
Patients with AIS who underwent thoracic VBT or PSF were assessed using a 3-D motion analysis system. Markers were placed on the trunk and pelvis and triplane functional movements (trunk flexion-extension, side bending and rotation; dynamic trunk-to-pelvis rotation during walking) were measured preoperatively and 1-year postoperatively. Mean change was calculated for all parameters. Independent T tests were run for each variable and the mean change. Repeated measure analysis of variance was used assess the response over time.

Results
There were 9 patients in the VBT group (100% F; age 12.6 ± 1.1 yr; BMI 20.5 ± 3.6 kg/m2) and 14 in the PSF group (92.9% F; 14.2 ± 1.3 yr***; 21.7 ± 2.7 kg/m2). Patients in the PSF group saw a decrease in all measured values at one year postop. VBT patients maintained lateral bending but PSF decreased lateral bending, especially toward the left (-1.3 vs. -15.4, p=0.003). The VBT group saw increased forward bending ability whereas PSF decreased trunk flexion and extension (7.1 vs. -11.3, p=0.016). When combining all motions to obtain an arc of motion, VBT appears to better preserve or increases overall motion with lateral side to side bending, increases flexion-extension and tends to preserve more range of motion during trunk rotation than PSF.

Conclusion
Patients with AIS treated with VBT not only had preserved spinal motion at 1 year postoperatively, but VBT appears to increase trunk flexion and extension at one year after surgery compared to those undergoing PSF.

Take Home Message
Thoracic VBT for AIS appears to maintain or increase spinal motion at one year postoperatively compared to selective thoracic PSF.

	VBT (n=9)			PSF (n=14)			ANOVA
	Preop	1-yr Postop	Raw change	Preop	1-yr Postop	Raw change	(p)
Static Position							
Bending Left (°)	35.6 ± 12.3	34.3 ± 5.9	-1.3	40.5 ± 10.2	25.1 ± 8.5	-15.4	**0.003**
Bending Right (°)	36.6 ± 12.5	36.6 ± 8.0	-0.05	34.5 ± 8.5	31.8 ± 8.4	-2.8	0.594
Trunk flexion (°)	50.5 ± 22.0	57.7 ± 9.3	7.1	64.4 ± 8.7	50.3± 17.4	-11.3	**0.016**
Trunk extension (°)	28.1 ± 23.0	30.8 ± 11.9	2.7	30.1 ± 10.3	22.4 ± 8.2	-7.8	0.171
Trunk Left Rotation (°)	42.0 ± 14.5	40.1 ± 5.2	-1.9	37.8 ± 11.9	25.9 ± 11.6	-10	0.083
Trunk Right Rotation (°)	37.7 ± 12.2	34.1 ± 12.8	-3.6	34.8 ± 12.3	26.9 ± 9.9	-7.9	0.404
Walking							
Left rotation (°)	10.9 ± 5.8	11.1 ± 2.3	0.2	10.1 ± 5.1	7.9 ± 4.0	-1	0.323
Right rotation (°)	6.2 ± 3.7	3.7 ± 3.1	-2.4	3.9 ± 3.1	4.9 ± 3.7	1.2	**0.056**
Arcs of motion (all in degrees)							
	Preop	1-yr Postop	Raw change	Preop	1-yr Postop	Raw change	(p)
Lateral bending	72.2 ± 23.6	70.9 ± 11.1	-1.3	74.9 ± 13.6	56.8 ± 15.3	-18.1	**0.045**
Flexion-extension	78.7 ± 37.5	88.5 ± 12.6	**9.8**	94.5 ± 12.9	72.6 ± 19.9	-21.9	**0.015**
Trunk rotation	79.6 ± 25.6	74.2 ± 17.1	-5.4	72.6 ± 22.9	52.9 ± 20.0	-19.7	0.149
Trunk rotation, walking	17.1 ± 5.4	14.8 ± 4.5	-2.3	13.9 ± 4.3	12.9 ± 4.0	-1	0.572

Changes in Spine Motion After VBT vs. PSF

194. Measurable Lumbar Motion Remains One Year Following Anterior Vertebral Body Tethering

Smitha E. Mathew, MBBS; Todd A. Milbrandt, MD, MS; A. Noelle Larson, MD

Summary
Lumbar vertebral body tethering (VBT) results in preserved coronal and sagittal plane motion at 1 year postoperatively without evidence of autofusion.

Hypothesis
Lumbar coronal and sagittal plane motion will be preserved 1-year following lumbar VBT in adolescent idiopathic scoliosis (AIS) patients.

Design
Retrospective review of prospectively collected data

Introduction
VBT is growing in popularity for skeletally immature scoliosis patients due to presumed preservation of spinal motion. No study to date has documented preserved lumbar motion following anterior lumbar instrumentation.

Methods
Patients treated with lumbar VBT underwent standard-of-care low dose flexion extension and lateral bending radiographs 1-year following VBT to assess motion. Coronal motion at 1-year was compared to preop side bending radiographs. Angle subtended by the screws at the upper and lower instrumented vertebra was measured on left and right-bending radiographs to evaluate the coronal arc of motion and compared with preop values over the same levels. At 1-year postop, sagittal Cobb angle was measured over the instrumented levels on flexion and extension radiographs.

Results
Of the 68 scoliosis patients who underwent VBT eligible for 1-year follow-up,7 had both thoracic and lumbar VBT on the same day

and 5 had lumbar VBT only, for a total of 12 patients. Mean preop lumbar Cobb angle was 51°±13°.Mean levels instrumented was 8.7(range,5-12),with the lowest instrumented level being L4.Mean preop coronal arc of motion over the instrumented segments was 34°±11°. Mean 1-year postop coronal arc of motion on bending was 13°±7°, with 9 of the 12(75%) having at least 10° coronal arc of motion(Figures 1&2).Patients maintained on average 37% of their preoperative coronal arc of lumbar motion over the instrumented lumbar segments. On flexion-extension lateral radiographs taken at 1-year postoperatively, mean arc of motion was 16°±12° between flexion and extension radiographs.

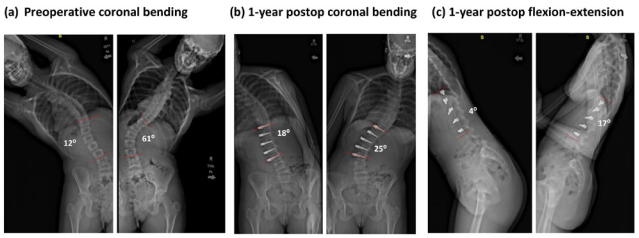
Conclusion

Lumbar VBT resulted in preserved flexion and extension motion at 1-year postop. We also noted coronal plane motion, but this was decreased compared to preop values by approximately 60%.These findings provide proof of concept that sagittal spinal motion is preserved after lumbar VBT in contrast to lumbar fusion where no motion is retained over the instrumented segments.

Take Home Message

In AIS patients who underwent lumbar VBT, there was preservation of flexion and extension motion at 1 year postoperatively. Coronal plane motion was also preserved, but to a lesser extent.

Figure 1: Preoperative coronal bending and 1-year postoperative side bending and flexion-extension



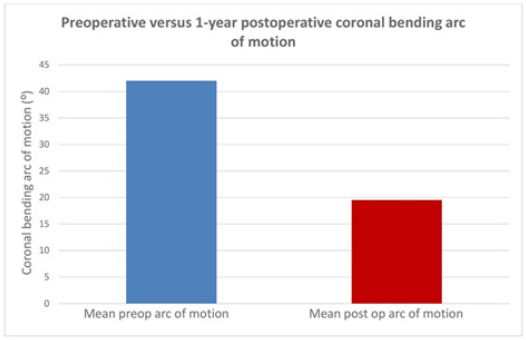
*Cobb angles were determined by the angle formed by the intersection of the lines (marked in red) drawn along endplates of UIV and LIV in (a) and (c) and screws in (b)

a) Preop coronal arc of motion = 61° – 12° = 49°

b) 1-year post op coronal arc of motion = 25° – 18° = 7°

c) 1-year post op sagittal arc of motion = 17° – 4° = 13°

Figure 2: Preoperative versus 1-year postop coronal bending arc of motion



Mean 1-year postoperative coronal arc of motion, though decreased compared to preoperative values, was still present following VBT surgery.

Figures 1 and 2

195. Persistence of Unfused Lumbar Segments Motion One Year Following Vertebral Body Tethering

Smitha E. Mathew, MBBS; Todd A. Milbrandt, MD, MS; A. Noelle Larson, MD

Summary

In contrast to posterior spinal fusion (PSF), coronal arc of segmental motion of the distal uninstrumented lumbar segments following lumbar vertebral body tethering (VBT) was preserved and remains unchanged at 1-year follow-up.

Hypothesis

In adolescent idiopathic scoliosis (AIS) patients undergoing lumbar VBT, coronal arc of motion of the distal uninstrumented lumbar segments will be preserved at 1-year follow-up.

Design

Retrospective review of prospectively collected data

Introduction

VBT, a novel non-fusion surgery for skeletally immature scoliosis patients, is thought to preserve spinal motion. A recent spinal fusion study showed significant increase in coronal motion in the unfused L4 to S1 segments in AIS patients who were fused into the lumbar spine, with the remaining uninstrumented segments showing hypermobility to compensate for the fusion. Literature lacks data on motion of the unfused lumbar segments in AIS patients following lumbar VBT.

Methods

Patients treated with lumbar VBT underwent standard-of-care low dose coronal bending radiographs at 1-year follow-up to assess motion. L3-L4 and L4-L5 intervertebral angles were measured on left and right-bending radiographs to evaluate coronal intervertebral arc of motion and was compared with preop values over the same levels.

Results
Of the 68 AIS patients who underwent VBT eligible for 1-year follow-up, 5 had both thoracic and lumbar VBT on the same day and 5 had lumbar tether only, for a total of 10 patients. Mean preop lumbar Cobb angle was 51°±13°. Mean levels instrumented was 8.7(range, 5-12), with most distal instrumentation level being L4. Coronal-bending radiographs revealed that mean intervertebral arc of motion at L3-L4 changed from 14°±4° preoperatively to 12°±4° at 1-year postoperatively (p=0.95). Mean coronal intervertebral arc of motion at L4-L5 was 11°±5° preoperatively and 8°±4° at 1-year postoperatively (p=0.2) (Fig 1 and 2).

Conclusion
In skeletally immature patients with lumbar VBT, motion in the distal lumbar uninstrumented segments was unchanged at 1-year follow-up. Unlike in patients with spinal fusion to distal lumbar segments, there was no increase in coronal motion. Results of this preliminary study indicate that in contrast to PSF, coronal arc of segmental motion of the distal uninstrumented levels remains unchanged 1-year following lumbar VBT. Further long-term follow up to assess intervertebral motion is warranted.

Take Home Message
In skeletally immature patients with lumbar VBT, coronal arc of motion in the distal lumbar uninstrumented segments remains unchanged at 1-year follow up.

Persistence of Unfused Lumbar Segments Motion One Year Following Vertebral Body Tethering

Figure 1: Preoperative versus 1-year postoperative L3-L4 coronal arc of motion

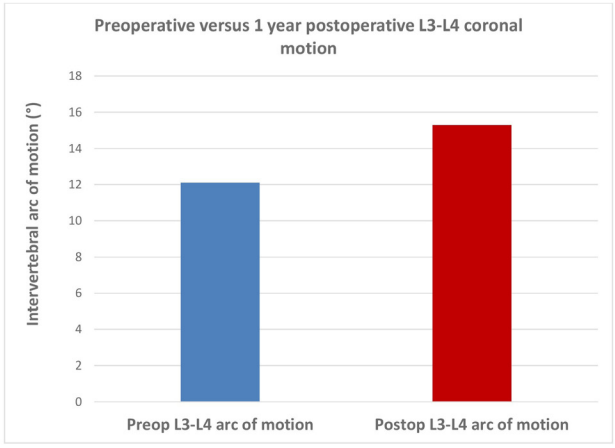


Figure 2: Preoperative versus 1-year postoperative L4-L5 coronal arc of motion

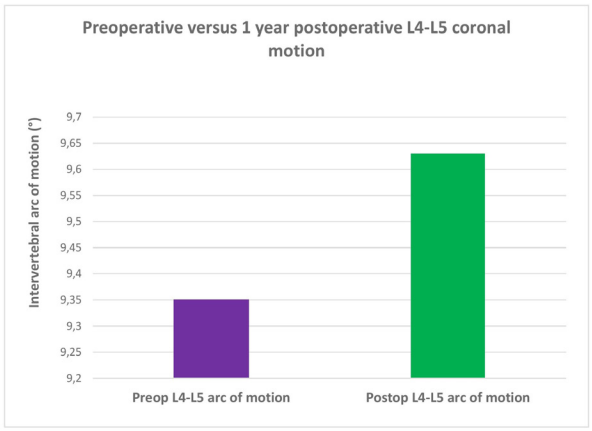


Fig 1 and 2

196. Management of NF-1 Dystrophic Scoliosis Associated with Rib Heads Dislocation into the Spinal Canal in Neurological Intact Patients: A Systematic Literature Review

Martin Estefan, MD, MBBS, FRCS; Gaston Camino Willhuber, MD; Miguel H. Puigdevall, MD; Santiago Tomas Bosio, MD; Ruben A. Maenza, MD

Summary
Dystrophic NF-1 is an entity with broad and bizarre spinal deformity

manifestations. Dislocation of the rib heads into the spinal canal can be present in these cases. The surgical resection vs. non-resection of the rib heads during the corrective scoliosis surgery is still a matter of discussion and concern among surgeons. We found that a posterior corrective surgery using modern spinal instrumentation is possible in neurologically intact patients without the need for rib heads resection.

Hypothesis
We believe that intracranal rib head resection can be avoided in neurologically intact NF-1 patients with dystrophic scoliosis who undergo corrective surgery.

Design
A comprehensive systematic literature search was performed for relevant studies using PubMed, Web of Science, and Scopus databases. Previous publications depicting neurologically intact patients with NF-1 and rib dislocation into the canal were reviewed. Articles reporting individual cases or case series/cohorts with patient-discriminated findings were included.

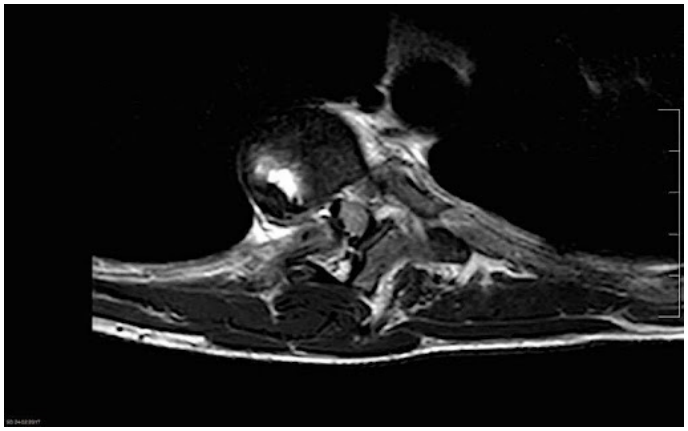
Introduction
The dystrophic NF-1 scoliosis is associated with dysplastic modulation signs. The dislocation of ribs into the spinal canal can be present. Controversy exist in relation to resection vs. not resection of the rib head during the corrective procedure in patients with normal neurology. This systematic review analyzed the clinical outcomes of neurologically intact patients with this condition who underwent corrective surgery.

Methods
A comprehensive systematic literature search was performed for relevant studies using PubMed, Web of Science, and Scopus databases. Previous publications depicting neurologically intact patients with NF-1 and rib dislocation into the canal were reviewed. Articles reporting individual cases or case series/cohorts with patient-discriminated findings were included.

Results
The data collection retrieved a total of 55 neurologically intact patients with NF-1 dystrophic scoliosis and rib penetration into the canal who underwent spinal surgery. Among them, 37 patients underwent surgery without head rib resection and 18 patients with rib excision. No patient presented postoperative neurological deficit except for one case of late postoperative neurological deterioration reported in a patient within situ fusion in which the surgeons ignored the presence of previous spinal cord compression.

Conclusion
Corrective surgery for patients with NF-1 and rib penetration into the canal in neurologically intact patients can be safely performed without the resection of the dislocated rib heads without a higher risk of neurological compromise.

Take Home Message
Patients with scoliosis and NF-1 can present with rib dislocation into the spinal canal. The resection of the rib heads dislocation in neurologically intact patients can be avoided during corrective surgery.



197. What are the Modifiable Risk Factors for Perioperative Blood Transfusion During Posterior Spinal Fusion in Patients with Cerebral Palsy

Ali Asma, MD; Nicholas Gajewski, MD; Denver A. Burton, MD; Armagan C. Ulusaloglu, MD; Petya Yorgova; Paul D. Sponseller, MD, MBA; Amit Jain, MD; Burt Yaszay, MD; Amer F. Samdani, MD; Firoz Miyanji, MD; Suken A. Shah, MD

Summary
Massive blood transfusion (MBT) is correlated to numerous complications including hypothermia and coagulopathy. We checked a prospective database to identify risk factors for MBT.The incidence of MBT in patients with CP undergoing PSF is 26.7%. For every 100 mL increase in blood loss during surgery the risk of requiring perioperative MBT increased by 20%).Lack of antifibrinolytic use, use of a unit rod or hybrid construct, and low preoperative hemoglobin and albumin values represent modifiable risk factors for requiring perioperative MBT.

Hypothesis
There is no modifiable risk factor for perioperative massive blood transfusion during spinal fusion in CP patients

Design
Retrospective cohort

Introduction
Massive blood transfusion (MBT) is correlated to numerous complications including hypothermia and coagulopathy. Little is known regarding the risk factors for perioperative MBT in patients with CP undergoing PSF

Methods
This was a retrospective review of a prospectively collected multicenter cohort of patients with CP who underwent PSF. Perioperative MBT was defined as the administration of allogenic

blood products (packed red blood cells (PRBC), fresh frozen plasma (FFP),platelets, cryoprecipitate) equaling at least half of the patients' preoperative blood volume during the surgical procedure. Cell salvage was excluded from the analysis.

Results

415 patients were included for analysis. The average age at surgery was 14.3 years (SD 2.8 years).87% of patients were GMFCS IV and V. The incidence of MBT was 26.7% (111/415).Univariate logistic regression identified the following significant risk factors for MBT: intraop blood loss,levels fused, lack of antifibrinolytic use, use of a unit rod or hybrid construct, neuromonitoring alert, low preoperative hemoglobin value, and low preoperative albumin value. Preoperative curve magnitude, perioperative curve correction, and duration of surgery were not associated with perioperative MBT. For every 100 mL increase in blood loss during surgery the risk of requiring perioperative MBT increased by 20%.Patients receiving MBT had increased hospital stay (p=0.02) and were more likely to require postoperative ICU (p=0.001).Patients with MBT had a higher rate of surgical site/incision complications compared to w/o MBT(p=0.03); however, the reoperation rate was not different(p=0.46).There was significant decrease in MBT incidence from 2008 (51%) to 2016 (11%) (p<0.001)

Conclusion

The incidence of MBT in patients with CP undergoing PSF is 26.7%. Lack of antifibrinolytic use, use of a unit rod or hybrid construct, and low preoperative hemoglobin and albumin values represent modifiable risk factors for requiring perioperative MBT.

Take Home Message

Optimization of preoperative nutrition status, use of pedicle screw constructs when possible and judicious use of antifibrinolytics when not contraindicated is recommended to reduce the risk of perioperative MBT.

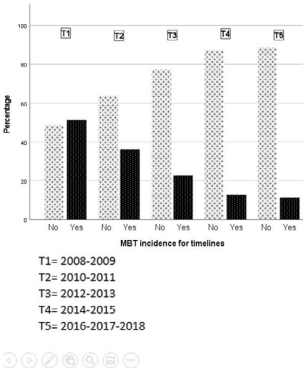


Table 1- Univariate and Stepwise backward multivariate logistic regression analysis results.

		Univariate analysis		Multivariate analysis		
		Odds Ratio	Sig.	Odds Ratio	95% C.I	Sig.
Gender	Female	0.79	0.29			
	Male	Reference	Reference			
Feeding status	Oral feeding	1.02	0.95			
	Oral and G-tube	2.11	0.1			
	G- tube only	0.69	0.59			
	GJ tube only	Reference	Reference			
Coronal major curve angle		1	0.92			
Major curve correction rate		1.001	0.92			
Pelvic obliquity degree		1.01	0.13			
T2-T12 kyphosis degree		0.99	0.1			
Surgery age		1	0.42			
Duration of surgery		1.001	0.23			
Blood Loss during surgery		1.001	<0.001	1.002	1.001-1002	<0.001
Instrumentation type	All pedicle screw	Reference	Reference			
	%60 screw construct	0.62	0.09			0.84
	Hybrid construct	5.35	<0.001	11.65	2.05-66.15	0.006
	Unit rod	13.75	<0.001	5.8	1.05-32.18	0.044
Neuromonitoring alert	Yes	2.1	0.03			
	No	Reference	Reference			
Preoperative hemoglobin value		0.99	0.01			0.33
Preoperative platelet count		1	0.5			
Preoperative albumin value		0.95	0.04			0.85
Number of fused levels		1.79	<0.001			0.45
Antifibrinolytic use	Yes	Reference	Reference			
	No	3.37	<0.001	3.94	1.22-12.65	0.02

Graph and Table

198. Classification of Neurofibromatosis-related Dystrophic or Nondystrophic Scoliosis Based on Image Features Using Bilateral CNN

Zhong He, MD; Xiaodong Qin, PhD; Yu Wang, MD; Bangping Qian, MD; Bin Wang, MD; Zhen Liu, MD; Xu Sun, MD; Jun Jiang, MD; Jun Qiao, PhD; Benlong Shi, PhD; Yong Qiu, MD; Zezhang Zhu, MD

Summary

The proposed Bilateral CNN captured representative features for classifying NF1-S utilizing AP and lateral x-ray images.

Hypothesis

We may classify scoliosis secondary to neurofibromatosis type 1 (NF1-S) using deep learning algorithms (DLAs) and improve the accuracy and effectiveness of classification.

Design

Retrospective study

Introduction

We developed a system that can automatically classify cases of scoliosis secondary to neurofibromatosis type 1 (NF1-S) using deep learning algorithms (DLAs).

Methods

Comprehensive experiments in NF1 classification were performed based on a dataset consisting 211 NF1-S (131 dystrophic and 80 nondystrophic NF1-S) patients. Additionally, 100 congenital scoliosis (CS), 100 adolescent idiopathic scoliosis (AIS) patients, and 114 normal controls were used for experiments in primary classification. For identification of NF1-S with nondystrophic or dystrophic curves, we devised a novel network (i.e., Bilateral convolutional neural network [CNN]) utilizing a bilinear-like operation to discover the similar interest features between whole spine AP and lateral x-ray images. The performance of Bilateral CNN was compared with spine surgeons, conventional DLAs, recently, and T wo-path BCNN which was the extension of BCNN using AP and lateral x-ray images as inputs.

Results

In NF1 classification, our proposed Bilateral CNN with 80.36% accuracy outperformed the other seven DLAs ranging from 61.90% to 76.19% with fivefold cross-validation. It also outperformed the spine surgeons (with an average accuracy of 77.5% for the senior surgeons and 65.0% for the junior surgeons). Our method is highly generalizable due to the proposed methodology and data augmentation. Furthermore, the heatmaps extracted by Bilateral CNN showed curve pattern and morphology of ribs and vertebrae contributing most to the classification results. In primary classification, our proposed method with an accuracy of 87.92% also outperformed all the other methods with varied accuracies between 52.58% and 83.35% with fivefold cross-validation.

Conclusion

The proposed Bilateral CNN can automatically capture representative

features for classifying NF1-S utilizing AP and lateral x-ray images, leading to a relatively good performance.

Take Home Message
Deep learning diagnosis system can accurately classify scoliosis

199. Behavior of ≥30º Upper Thoracic Curves After Thoracoscopic VBT for Main Thoracic Curves: A Matched Cohort Analysis

Ahmet Alanay, MD; Altug Yucekul, MD; Atahan Durbas; Ilkay Karaman, MD; Tais Zulemyan, MD; Gokhan Ergene, MD; Sahin Senay, MD; Sule Turgut Balci, MD; Pinar Yalinay Dikmen, MD; Yasemin Yavuz, PhD; *Caglar Yilgor, MD*

Summary
Radiographic and clinical success of VBT surgery was similar for patients having ≥30º UT curves compared to ones having smaller curves. Surgical correction was followed by growth-dependent correction attained during follow-up in the operated main thoracic (MT) and non-operated upper thoracic (UT) and thoracolumbar (TLL) curves. 24 patients who had 34.6º (30º-55º) mean preoperative UT curves, ended up having 20.2º (4º-36º) curves on average. 3 (12.5%) patients had ≥30º UT curve at final follow-up. Pulmonary function and SRS22 self-image increased.

Hypothesis
Thoracic VBT will yield satisfactory results for patients having ≥30º UT curves

Design
Retrospective analysis of prospectively collected data

Introduction
Levels above T5 are challenging to address via VBT due to thoracic cage anatomy. Moreover, performing VBT for Upper Thoracic spine would mean exposing the contralateral lung, which would commonly be on the left side. Thus, it is practically not feasible to address structural or bigger non-structural UT curves while performing VBT for MT curves. This has raised concerns regarding shoulder balance and unpredictable UT curve behavior following surgery.

Methods
Data were collected at preop; at 6w, 1y, 2yrs and latest follow-up. Demographic, peri-op, clinical, radiographic data and complications were analyzed. Patients having ≥30º UT curves (30º-55º) were 1-to-1 matched to patients with <30º UT curves (10º-27º). Curve sizes were compared at each follow-up. Respiratory function was compared between preop, 1-yr and 2-yrs postop. Clinical outcome was assessed by SRS-22r.

Results
48 (46F, 2M) patients with a mean f-up of 32(24-62) months were included. On average, the cohort displayed significant growth potential (mean age 12.2±1.4y, median Sanders 3). 90% of the curves showed Lenke 1 pattern. 81% of patients had thoracic VBT, while the rest had double-curve VBT. All demographic, skeletal maturity and peri-op data were similar between groups (p>0.05). 83% of patients reached skeletal maturity. Preoperative UT and MT curve sizes and flexibilities were different among groups (p>0.05). UT, MT and TLL curves showed significant decrease in each follow-up time point (p<0.05). FEV1% showed significant increase (p=0.024). Pulmonary, mechanical and curve behavior complications rates were similar (p>0.05). Average final follow-up UT curves were 20.2º and 11.9º for UT≥30 and UT<30 groups, respectively. SRS-22-SI and subT scores increased (Fig).

Conclusion
Patients starting with larger UT curves ended up having larger residual curves, although follow-up curve behavior patterns and complication rates were similar compared to patients having smaller preop curves. Pulmonary function and SRS22-SI increased for both groups.

Take Home Message
Satisfactory clinical and radiographic results were achieved after VBT for Lenke 1 patients who had larger and less flexible UT curves preoperatively. All operated and non-operated curves displayed follow-up correction.

	Pre-Operative		6 weeks		12 months		24 months		Latest follow-up	
Preop UT ≥30º group	Mean ± SD	Min-Max	Mean ± SD	Min - Max	Mean ± SD	Min - Max	Mean ± SD	Min - Max	Mean ± SD	Min -Max
UT, Degree	34.6 ± 5.8	30 – 55	24.2 ± 6.3	13 – 37	20.5 ± 6.3	8 – 33	20.0 ± 6.5	8 – 36	20.2 ± 7.0	4 – 36
MT, Degree	55.5 ± 9.7	42 – 77	28.8 ± 7.1	15 – 40	24.0 ± 8.7	2 – 40	22.1 ± 9.7	4 – 43	21.4 ± 11.0	-2 – 43
TLL, Degree	36.6 ± 9.5	25 – 64	19.9 ± 8.5	3 – 39	16.3 ± 10.6	1 – 43	14.8 ± 11.9	-6 – 44	14.1 ± 13.6	-14 – 44

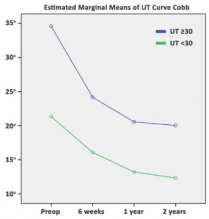
	Pre-Operative		6 weeks		12 months		24 months		Latest follow-up	
Preop UT <30º group	Mean ± SD	Min-Max	Mean ± SD	Min - Max	Mean ± SD	Min - Max	Mean ± SD	Min - Max	Mean ± SD	Min -Max
UT, Degree	21.3 ± 4.5	10 – 27	16.1 ± 5.5	8 – 25	13.2 ± 5.1	3 – 22	12.3 ± 5.7	1 – 22	11.9 ± 5.5	1 – 22
MT, Degree	45.9 ± 8.8	35 – 69	25.7 ± 7.1	13 – 37	20.5 ± 8.4	0 – 37	19.2 ± 11.6	-11 – 41	21.3 ± 12.0	-11 – 41
TLL, Degree	33.1 ± 14.7	12 –70	19.6 ± 8.9	5 – 38	16.7 ± 10.7	0 – 42	16.8 ± 12.2	-7 – 42	17.8 ± 12.0	-7 – 42

	Pre-Operative		12 months		24 months	
Preop UT ≥30º group	n	Mean ± SD	n	Mean ± SD	n	Mean ± SD
FVC% Predicted	24	81.3 ± 15.1	19	81.9 ± 15.3	12	87.8 ± 13.2
FEV1% Predicted	24	80.3 ± 13.0	19	84.9 ± 11.5	12	91.3 ± 13.3

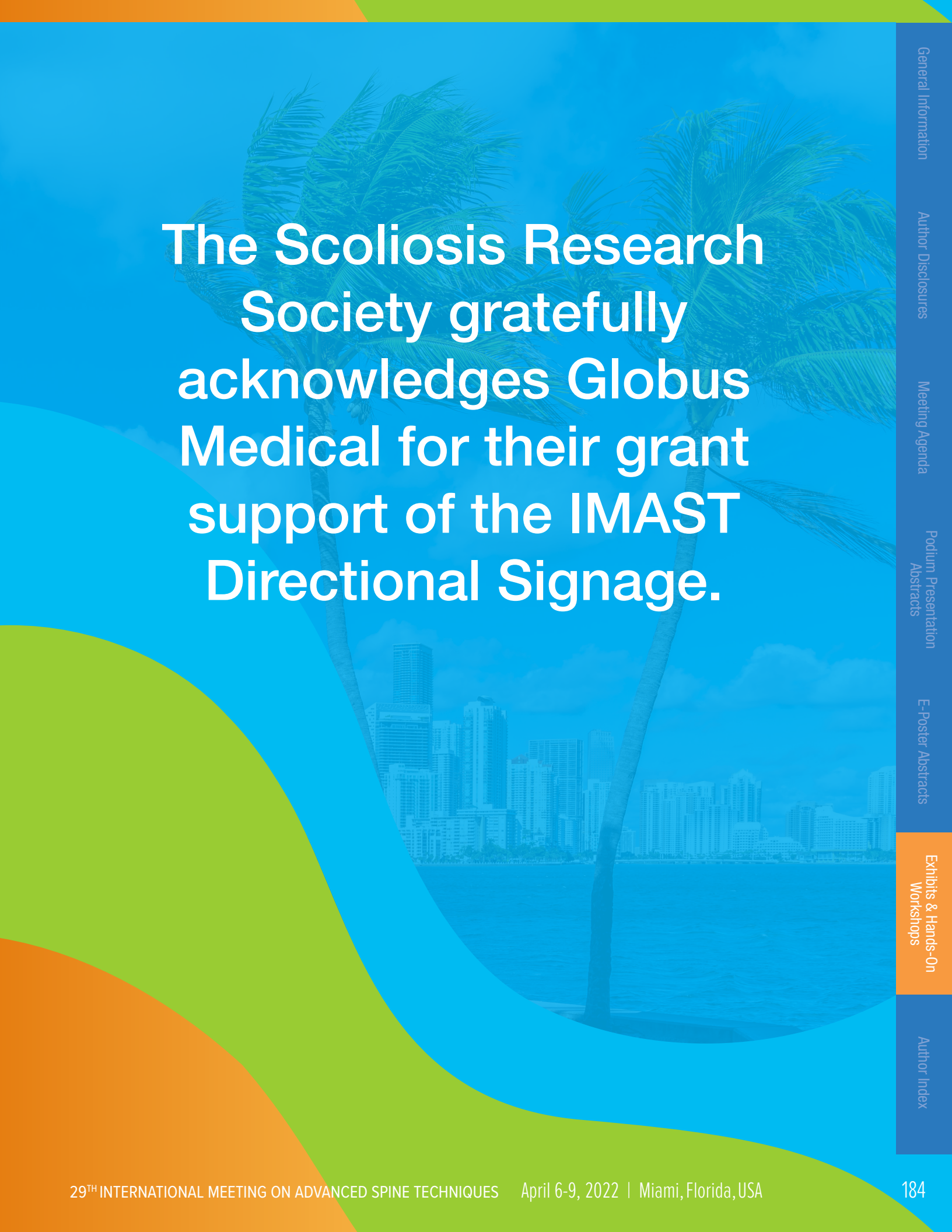
	Pre-Operative		12 months		24 months	
Preop UT <30º group	N	Mean ± SD	n	Mean ± SD	n	Mean ± SD
FVC% Predicted	23	80.6 ± 12.5	22	86.9 ± 13.5	11	87.3 ± 11.6
FEV1% Predicted	23	81.6 ± 12.6	22	89.4 ± 16.8	11	89.9 ± 10.7

	Pre-Operative		Latest follow-up	
Preop UT ≥30º group	n	Mean ± SD	n	Mean ± SD
SRS-22r, SI	20	3.5 ± 0.6	23	3.9 ± 0.7
SRS-22r, Subtotal	20	4.0 ± 0.6	23	4.2 ± 0.5
SRS-22r, Satisfaction	n/a	n/a	23	4.6 ± 0.5

	Pre-Operative		Latest follow-up	
Preop UT <30º group	n	Mean ± SD	n	Mean ± SD
SRS-22r, SI	19	3.4 ± 0.6	24	4.3 ± 0.6
SRS-22r, Subtotal	19	4.1 ± 0.3	24	4.4 ± 0.5
SRS-22r, Satisfaction	n/a	n/a	24	4.5 ± 0.9



Exhibits & Hands-On Workshops



The Scoliosis Research Society gratefully acknowledges Globus Medical for their grant support of the IMAST Directional Signage.

Exhibits and Hands-On Workshops

IMAST EXHIBITORS

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

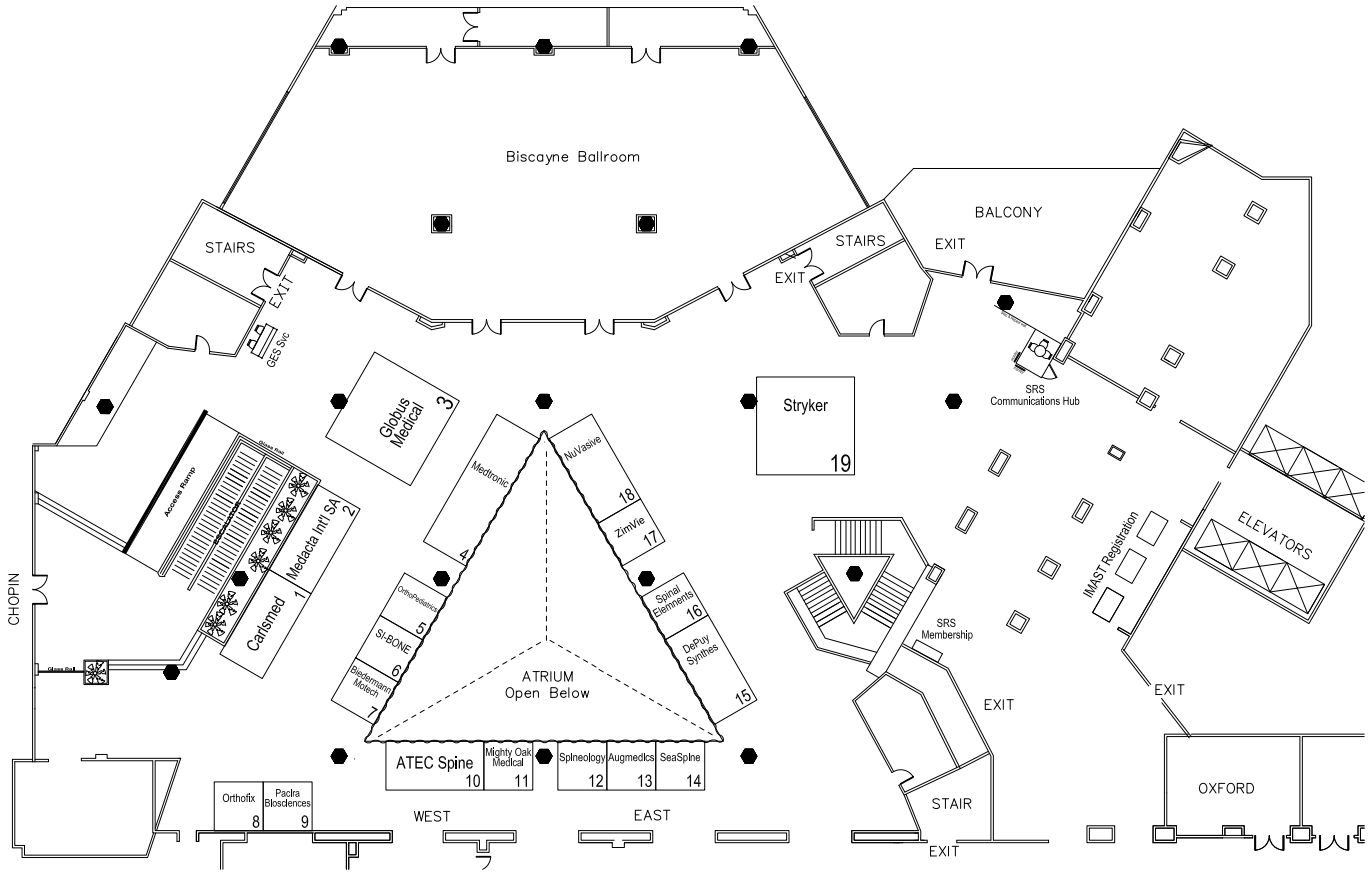
The IMAST Exhibitors are located on Level 2 - Mezzanine of the InterContinental Miami

HOURS:

Wednesday, April 6	17:30 - 19:00
	(Welcome Reception – 17:30 - 19:00)
Thursday, April 7	08:30 - 16:45
Friday, April 8	08:30 - 16:00

Company	Booth #
ATEC Spine	10
Augmedics, INC.	13
BIEDERMANN MOTECH	7
Carlsmed, Inc.	1
DePuy Synthes	15
Globus Medical	3
Medacta International SA	2
Medtronic	4
Mighty Oak Medical	11
NuVasive	18

Company	Booth #
Orthofix	8
OrthoPediatrics	5
Pacira BioSciences, Inc.	9
SeaSpine	14
SI-BONE	6
Spinal Elements	16
Spineology	12
Stryker	19
ZimVie	17



Exhibitor Descriptions

ATEC SPINE – BOOTH #10

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 the Alpha InformatiX™ System to achieve the goals of spine surgery. Our ultimate vision is to be The Standard Bearer in Spine.

AUGMEDICS INC – BOOTH #13

21 S Evergreen Ave. Suite 230
Arlington Heights, IL 60005 USA
www.augmedics.com

Augmedics (Chicago, IL) is an augmented reality surgical navigation pioneer that aims to improve surgery outcomes with cutting edge AR technologies that solve unmet clinical needs and instill technological confidence in the surgical workflow. The medtech company's FDA-cleared revolutionary xvision Spine System®, the first augmented reality guidance system, allows surgeons to "see" the patient's anatomy through skin and tissue as if they have "x-ray vision," and to accurately navigate instruments and implants during spine procedures. Augmedics has received numerous honors, including being named a 2021 Index Awards Finalist, a Fast Company World Changing Ideas Awards 2021 Finalist, and one of Time Magazine's Best Inventions of 2020. For more information, visit www.augmedics.com

BIEDERMANN MOTECH – BOOTH #7

7620 NW 25th St. Unit 3&4
Doral, FL 33122 USA
www.biedermann.com

Since 1916 Biedermann has been working in synergy with world-class surgeons to solve clinical challenges through the development of next-generation technology. Specializing in spine since the 1980s has allowed us to become a leader in spinal innovation, bringing life-changing technology to the world through specialist surgeons. Biedermann is a mid-sized, international, family-owned, and operated group of companies with headquarters in the Black Forest, Germany (Villingen-Schwenningen) and the USA (Miami). Our focus is on the development, production, and distribution of innovative implants and instruments for spinal and extremity surgery. We research, develop, manufacture, and distribute high-quality implant systems in collaboration with healthcare professionals, technology partners, and scientific institutions, with the goal of achieving improved clinical outcomes.

CARLSMED, INC. – BOOTH #1

1800 Aston Ave. Suite 100
Carlsbad, CA 92008 USA
www.carlsmed.com

Carlsmed's mission is to improve outcomes and decrease the cost of healthcare for spine surgery and beyond. The company's aprevo® devices are designed to improve the standard of care for the surgical treatment of patients with adult spinal malalignment. Carlsmed uses patient data and proprietary digital technologies to create optimal surgical plans and personalized aprevo® spine fusion devices for each patient. The Carlsmed® aprevo® devices are FDA cleared and have been granted FDA Breakthrough Designation, an industry first for any implanted device, and are commercially available in the U.S.

DEPUY SYNTHES – BOOTH #15

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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.

GLOBUS MEDICAL – BOOTH #3

2560 General Armistead
Audubon, PA 19403 USA
www.globusmedical.com

Globus Medical, a leading musculoskeletal solutions company is driving significant technological advancements across a complete suite of products ranging from spinal, trauma and orthopedics therapies to robotics, navigation and imaging. Founded in 2003, Globus' single-minded focus on advancing spinal surgery has made it the fastest growing company in the history of orthopedics. Globus is driven to utilize superior engineering and technology to achieve pain free, active lives for all patients with musculoskeletal disorders.

Exhibitor Descriptions

MEDACTA INTERNATIONAL SA – BOOTH #2

Strada Regina
6874 Castel San Pietro
Switzerland
www.medacta.com

Medacta is specialized in the design, production, and distribution of innovative orthopedic products, as well as in the development of accompanying surgical techniques. Established in 1999 in Switzerland, Medacta is active in joint replacement, spine surgery, and sports medicine.

Medacta is committed to improving the care and well-being of patients and maintains a strong focus on healthcare sustainability. Medacta's innovation, forged by close collaboration with expert surgeon globally, began with minimally invasive surgical techniques and has evolved into personalized solutions for every patient.

Through the M.O.R.E. Institute, Medacta supports surgeons with a comprehensive and tailored educational program.

MEDTRONIC – BOOTH #4

710 Medtronic Parkway
Minneapolis, MN 55432 USA
www.medtronic.com

We lead global healthcare technology. Our Mission — to alleviate pain, restore health, and extend life — unites a global team of 90,000+ people. Transforming the lives of two people every second, every hour, every day. Medtronic. **Engineering the extraordinary.**

MIGHTY OAK MEDICAL – BOOTH #11

750 W Hampton Avenue, Suite 120
Englewood, CO 80110 USA
www.mightyoakmedical.com

Mighty Oak Medical brings accuracy, efficiency and simplicity to your operating room with FIREFLY® Technology.

ACCURACY: FIREFLY®'s patented FDA cleared & CE-Marked patient-specific guides test at 99.7% for screw placement accuracy. FIREFLY® affixes to the vertebra and is not affected by intersegmental motion during surgery. FIREFLY® patient-specific guides provide mechanical constraint to repeatably achieve the highest accuracy at every level.

EFFICIENCY: Our team of engineers works with you, the surgeon, to predetermine the screw sizes and trajectories that achieve maximal pedicle fit and fill; knowing this valuable information in advance of surgery typically increases OR efficiency by reducing screw placement and screw insertion time. There is no need for reference arcs, multiple registrations or leaving the room for intra-operative imaging.

SIMPLICITY: The concierge presurgical planning process provides you with the anatomical information and analytics needed to execute your plan quickly and confidently in the OR. You will receive an anatomically exact and autoclavable 3D printed bone model for simulation and test fitting your guides either before or while you are in surgery. With the plan displayed on a monitor in the OR, the entire surgical team is synchronized and ready for the surgeon at each pedicle insertion point. The efficiency, coordination and satisfaction is akin to a successful Formula 1 racing pit stop.

FIREFLY® is compatible with essentially all screw systems and is cleared for use with no intraoperative radiation. Visit us at Booth #11 to experience the accuracy, efficiency and simplicity that FIREFLY® will bring to your operating room.

NUVASIVE – BOOTH #18

7475 Lusk Blvd.
San Diego, CA 92121 USA
www.nuvasive.com

NuVasive is the leader in spine technology innovation, with a mission to transform surgery, advance care, and change lives. The Company's less-invasive, procedurally integrated surgical solutions are designed to deliver reproducible and clinically proven outcomes. The Company's comprehensive procedural portfolio includes surgical access instruments, spinal implants, fixation systems, biologics, software for surgical planning, navigation and imaging solutions, magnetically adjustable implant systems for spine and orthopedics, and intraoperative neuromonitoring technology and service offerings. With more than $1 billion in net sales, NuVasive has approximately 2,700 employees and operates in more than 50 countries serving surgeons, hospitals, and patients. For more information, please visit www.nuvasive.com.

ORTHOFIX – BOOTH #8

3451 Plano Parkway
Lewisville, TX 75056 USA
www.orthofix.com

Orthofix Medical Inc. is a global medical device company with a spine and orthopedics focus. The Company's mission is to deliver innovative, quality-driven solutions as we partner with health care professionals to improve patient mobility. Headquartered in Lewisville, Texas, Orthofix's spine and orthopedics products are distributed in more than 60 countries via the Company's sales representatives and distributors. For more information, please visit www.Orthofix.com or visit Booth #8 at IMAST.

Exhibitor Descriptions

ORTHOPEDIATRICS – BOOTH #5

2850 Frontier Drive
Warsaw, IN 46582 USA
www.orthopediatrics.com

Founded in 2006, OrthoPediatrics is an orthopedic company focused exclusively on advancing the field of pediatric orthopedics. As such it has developed the most comprehensive product offering to the pediatric orthopedic market to improve the lives of children with orthopedic conditions. OrthoPediatrics currently markets 37 surgical systems that serve three of the largest categories within the pediatric orthopedic market. This offering spans trauma and deformity, scoliosis, and sports medicine/other procedures. OrthoPediatrics' global sales organization is focused exclusively on pediatric orthopedics and distributes its products in the United States and 45 countries outside the United States.

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. Pacira has three commercial-stage non-opioid treatments: EXPAREL® (bupivacaine liposome injectable suspension), a long-acting, local analgesia 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, visit www.pacira.com.

SEASPINE – BOOTH #14

5770 Armada Drive
Carlsbad, CA 92008 USA
www.seaspine.com

SeaSpine® is a global medical technology company focused on the design, development and commercialization of surgical solutions for the treatment of patients suffering from spinal disorders. SeaSpine has a comprehensive portfolio of orthobiologics, spinal instrumentation and surgical navigation system solutions to meet the varying combinations of products that spine surgeons need to perform fusion procedures on the lumbar, thoracic and cervical spine. SeaSpine's orthobiologics products consist of a broad range of advanced and traditional bone graft substitutes that are designed to improve bone fusion rates following a wide range of orthopedic surgeries, including spine, hip, and extremities procedures. SeaSpine's spinal instrumentation portfolio consists of an extensive line of products to facilitate spinal fusion in minimally invasive surgery (MIS), complex spine, deformity and degenerative procedures. SeaSpine currently markets its products through a network of independent sales agents in the United States and through stocking distributors in over 30 countries worldwide.

SI-BONE – BOOTH #6

471 El Camino Real, Suite 101
Santa Clara, CA 95050 USA
www.SI-BONE.com

SI-BONE, Inc. is a medical device company dedicated to solving musculoskeletal disorders of the sacropelvic anatomy. Founded in 2008, the company pioneered the surgical treatment of the SI joint with the iFuse Implant System.

Minimally invasive SI joint surgery is the current medical standard of care for SI joint fusion to treat sacroiliac joint dysfunction. The iFuse Implant System, a minimally invasive surgical (MIS) option, is designed to provide immediate sacroiliac (SI) joint stabilization and allow long-term fusion.

Current products, including applications in spinal deformity and SI joint trauma, have expanded the company's scope within the sacropelvic space. The iFuse Implant's unique triangular geometry provides immediate stabilization, while the 3D printed porous surface facilitates bone ingrowth and ongrowth.

With more than 65,000 procedures, 2,600+ treating surgeons and 100+ publications, iFuse is the leading choice in the surgical treatment of sacropelvic disorders.

SPINAL ELEMENTS – BOOTH #16

3115 S Melrose Drive, Suite 200
Carlsbad, CA 92010 USA
www.Spinalelements.com

Spinal Elements is a privately held technology-driven company headquartered in Carlsbad, California. As a leading designer, developer, and manufacturer of innovative medical devices used in spinal surgical procedures, Spinal Elements combines its differentiated MIS Ultra technologies, instrumentation, and biologics to create positive surgical outcomes that exceed surgeon and patient expectations. The company markets a complete portfolio of advanced spinal implant technologies.

Exhibitor Descriptions

SPINEOLOGY – BOOTH #12

7800 3rd Street North, Suite 600
St. Paul, MN 55128 USA
www.spineology.com

At Spineology, we are dedicated to transforming spine surgery by providing innovative, anatomy-conserving technologies for surgeons and their patients. Our proprietary mesh technology is used in the OptiMesh and Duo implants, which expand in three dimensions to create large footprints and allow placement of anatomy-conforming interbody fusion devices through very small incisions. This technology preserves spinal anatomy, increases procedural efficiency, and accelerates patient recovery.

STRYKER – BOOTH #19

600 Hope Parkway
Leesburg, VA 20175 USA
www.strykerspine.com

Stryker is one of the world's leading medical technology companies and, together with its customers, is driven to make healthcare better. The company offers innovative products and services in Medical and Surgical, Neurotechnology, Orthopaedics and Spine that help improve patient and hospital outcomes. More information is available at www.stryker.com.

ZIMVIE – BOOTH #17

10225 Westmoor Drive
Westminster, CO 80021 USA
https://www.zimvie.com/en

ZimVie Spine is dedicated to enhancing the quality of 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, fusion devices, and comprehensive spinal fixation for adult and pediatric complex spine, ZimVie offers minimally invasive focused procedural solutions and a complete suite of biologics solutions.

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. Descriptions of the Hands-On Workshops can be found begining on page 191

*Please note: CME credits are not available for Hands-On Workshops.

HOWs are located on Level 2 - Mezzanine of the InterContinental Miami

SCHEDULE

	THURSDAY, APRIL 7	FRIDAY, APRIL 8
Morning	**07:30 - 08:30**	**07:30 - 08:30**
Escorial / Alhambra	DePuy Synthes	Pacira BioSciences, Inc.
Michelangelo / Raphael		Mainstay Medical
Sandringham	SI-Bone	
Windsor	SeaSpine	
Lunch	**13:15 - 14:15**	**12:30 - 13:30**
Escorial / Alhambra	Medtronic	DePuy Synthes
Michelangelo / Raphael	Stryker	Stryker
Sandringham	NuVasive	ATEC Spine
Windsor	Globus Medical	Globus Medical
Afternoon	**18:00 - 19:00**	
Michelangelo / Raphael	Stryker	
Sandringham	OrthoPediatrics	
Windsor	Globus Medical	

Hands-On Workshop Descriptions

THURSDAY, APRIL 7, 2022 – 07:30 - 08:30

DePuy Synthes
Escorial / Alhambra

Advanced Techniques in the Management of Complex Adult Spinal Deformity
Discussing the benefits and challenges associated with current treatment options for the correction of Complex Adult Spine highlighting Adult Deformity, MIS, and Tumor.
Faculty: Eric O. Klineberg, MD (Moderator), Neel Anand, MD, Daniel Sciubba, MD

SI-Bone
Sandringham

Latest Evolution in Spinopelvic Fixation
Come join us to hear David Polly Jr., MD discuss the latest evolution in spinopelvic fixation and SI joint fusion for adult spinal deformity. Topics include complications, biomechanics, latest publications, iFuse Bedrock surgical technique tips and a case review discussion. The workshop includes a hands-on Simulator demonstration following the discussion.
Faculty: David W. Polly, Jr., MD

SeaSpine
Windsor

Fact vs. Fiction – The Data Behind Bone Grafting Options
With all the bone grafting options available for spinal fusion, how does one begin to sift through the data to separate fact from fiction? Does the data stack up to clinical experience? How does one determine what is appropriate graft for their patients?
Please join the surgeon panel as they discuss the various bone grafting categories, such as autograft, Infuse, Cellular Allografts, and DBMs. Each surgeon will focus on the key scientific and clinical data supporting each category while discussing their own clinical experiences for their more complex deformity cases.
Faculty: Gregory Mundis Jr., MD, Justin S. Smith, MD, Frank Vizesi, PhD

THURSDAY, APRIL 7, 2022 – 13:15 - 14:15

Medtronic
Escorial / Alhambra

The Importance of Global Sagittal Alignment in ASD and AIS Patients: How Predictive Models Can Help Achieve Patient Specific Goals
Sagittal alignment is the most dominant radiographic predictor of patient outcomes. Achieving harmonious alignment of key spinopelvic parameters is a key goal of spinal deformity surgery as it can help prevent postoperative complications such as proximal junctional kyphosis. This applies to both pediatric and adult patients. By leveraging the power of data, A.I and predictive modeling, Medtronic helps surgeons visualize postoperative compensatory mechanisms most likely to occur, and their impact on the patient's global alignment. In this session, the faculty will discuss their experience using these technologies in AIS and ASD patients.
Faculty: Christopher Ames, MD and Afshin Aminian, MD

Globus Medical
Windsor

REFLECT™, A Non-Fusion Technique for Adolescent Idiopathic Scoliosis
Open to surgeons practicing outside of USA only!
Faculty: Juan C. Rodriguez-Olaverri, MD, PhD

NuVasive
Sandringham

The Pulse Platform – A Case Review of Pulse in My OR
In a single expandable platform, Pulse integrates multiple enabling technologies to improve workflow, reduce variability and increase the reproducibility of surgical outcomes. Hear from Dr. Juan Uribe, Barrow Neurological Institute on how he's adopted the Pulse system into his practice. From one level XLIF's to large complex deformity cases, Pulse enables a more efficient workflow with various technologies in just one platform. Join the Pulse workshop to see Dr. Uribe's case presentation and ask questions live on the new technology.
Faculty: Juan Uribe, MD

Stryker
Michelangelo / Raphael

Current Trends in Imaging: Workflow, Image Quality and Best Use Scenarios
In this workshop, our panel will discuss the recent advances of imaging in spine surgery and workflow considerations. The expert panel will cover scenarios that may benefit from the use of intraoperative imaging.
Faculty: William Accousti, MD, Laurel C. Blakemore, MD, CEO, Jose Valerio-Pascua, MD

Hands-On Workshop Descriptions

THURSDAY, APRIL 7, 2022 – 18:00 - 19:00

Stryker
Michelangelo / Raphael

3-Dimensional Deformity Correction Utilizing Mesa® 2 Deformity Spinal System, Rail™ 4D Technology and Differential Rod Contouring

Rod flattening and not achieving your desired derotation can be a major challenge in pediatric deformity. Join our faculty as they share techniques to help address difficult correction maneuvers for complex spinal pathologies.

Faculty: Laurel C. Blakemore, MD, CEO, Brad Culotta, MD, Ryan Goodwin, MD

Globus Medical
Windsor

How a Robotics Program Goes From Acquisition to 100+ Cases Successfully

This discussion will cover a comprehensive overview of acquiring new disruptive technology, how it is incorporated into the workflow for procedures, and advancing into successful robotics program.

Faculty: Brandon Bert Carlson, MD, MPH

OrthoPediatrics
Sandringham

ApiFix Procedure: Non-Fusion Treatment for AIS

Please join Dr. Ron El-Hawary and Dr. Geoffrey Haft at this workshop as they will cover patient selection, surgical technique overview, procedure tips & tricks, clinical outcomes, and case reviews. This workshop will also include models, implants, and instruments for hands-on demonstration.

Faculty: Dr. Ron El-Hawary, Dr. Geoffrey Haft

FRIDAY, APRIL 8, 2022 – 07:30 - 08:30

Pacira BioSciences, Inc.
Escorial / Alhambra

Innovative Pain Management Techniques for Treating Adult and Pediatric Spine Patients

Faculty: Dr. Peter Newton, Dr. Mike Wang, and Dr. Ravi Bains

Mainstay Medical
Michelangelo / Raphael

Advanced Restorative Neurostimulation's Permanent Role in the Future of Spine Surgery

Current guideline recommended treatments for non-surgically indicated mechanical chronic low back pain (CLBP) are generally palliative and have limited durability and efficacy. While the etiology CLBP is multifactorial, there are a subset of patients where a deficit motor control of the multifidus muscle leads to functional instability and prolonged pain. Physical therapy targeting motor control, thereby alleviating pain, is beneficial in moderately affected patients. However, patients who are more severely impacted do not tend to benefit from these conservative techniques.

ReActiv8 Restorative Neurostimulation stimulates the medial branch of the dorsal ramus aiming to restore motor control in severely impacted CLBP patients by electrically inducing contractions of the multifidus. The efficacy and durability of ReActiv8 has been demonstrated in multiple clinical studies of more than 380 patients, with some cohorts reaching follow-up of up to 4 years.

This session introduces ReActiv8 therapy, including clinical evidence, mechanism of action, and patient selection.

Faculty: Dr. Juan Uribe, Dr. Greg Mundis and Dr. Chris Gilligan

Hands-On Workshop Descriptions

FRIDAY, APRIL 8, 2022 – 12:30-13:30

Globus Medical
Windsor

Robotic-Assisted Deformity Correction with a Focus on MIS Deformity Correction
Dr. Kent will discuss his clinical experience utilizing ExcelsiusGPS® for MIS deformity correction. The attendees will gain perspective on how ExcelsiusGPS® is used in MIS deformity correction, where screw placement is crucial.
Faculty: Roland Kent, MD

Stryker
Michelangelo / Raphael

Imaging of Challenging Procedure Types: Pediatric Deformity, Adult Deformity and CT Junction
Join our faculty as they discuss new data on image quality and the differences between fan beam CT and cone beam imaging. Our expert panel will also discuss challenging cases where surgeons have benefited from the use of this technology.
Faculty: Nader S. Dahdaleh, MD, Stephen G. George, MD, Jason E. Lowenstein, MD

DePuy Synthes
Escorial / Alhambra

Advanced Techniques in the Management of Complex Pediatric Deformity
Discussing the management of Pediatric Spinal Deformity highlighting 3D Prediction, Planning and Evaluation, and Sagittal Plane Restoration in AIS.
Faculty: Suken Shah, MD (Moderator); Robert Lark, MD; A. Noelle Larson, MD; Stefan Parent, MD, PhD

ATEC Spine
Sandringham

PTP – Prone Transpsoas: The Evolution of Lateral Surgery
PTP advanced applications to address complex pathology and procedures.
Faculty: Vedat Deviren, MD, Daniel Cavanaugh, MD, Gurvinder Deol, MD

Author Index

The Scoliosis Research Society thanks our ASLS Directed Research Partners, DePuy Synthes, Globus Medical, Medtronic, NuVasive, Stryker and ZimVie.

Author Index

Key: 1-75 = Paper Presentations; 100-200 = E-Posters; CC = Cases & Cocktails; Education Sessions: S3A-C, S4A-C, S7A-C, S8A-C, S9, S10, S11

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About SRS

Founded in 1966, the Scoliosis Research Society is an organization of medical professionals and researchers dedicated to improving care for patients with spinal deformities. Over the years, it has grown from a group of 37 orthopaedic surgeons to an international organization of more than 1,400 health care professionals.

MISSION STATEMENT

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

MEMBERSHIP

SRS is open to orthopaedic surgeons, neurosurgeons, researchers, and allied health professionals who have a practice that focuses on spinal deformity. Visit www.srs.org/professionals/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), Worldwide 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.

DEI STATEMENT

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 difference 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.

SOCIETY OFFICE STAFF

Ashtin Neuschaefer, CAE - Executive Director
Sinais Alvarado, MA - Education Manager
Erica Bowring - Membership & Development Manager
Grace Donlin - Meetings Manager
Danielle Gioia, PhD - Senior Education & Instructional Design Manager
Courtney Kissinger - Senior CME & Education Manager
Laura Pizur - Program Manager
Michele Sewart, PMP - Senior Communications Manager
Leah Skogman, CMP - Senior Meetings Manager
Shawn Storey - Website & Digital Content Manager

SCOLIOSIS RESEARCH SOCIETY

555 East Wells Street, Suite 1100
Milwaukee, WI 53202
Phone: 414-289-9107
Fax: 414-276-3349
www.srs.org

SOCIAL MEDIA

Join the conversation surrounding IMAST by including #SRSIMAST22 in your social media posts.

@srs_org

@ScoliosisResearchSociety

@srs_org

linkedin.com/company/srs_org

SRS 2023 Meetings

58TH ANNUAL MEETING

September 6-9, 2023

Seattle, Washington USA

Abstract Submission Opens: **November 1, 2022**

Advanced Registration Opens: **April 25, 2023**

Scoliosis Research Society

Save the Date

30th International Meeting on Advanced Spine Techniques

March 22-25, 2023 • Dublin, Ireland

SAVE THE DATE

Abstract Submission Opens:
August 1, 2022
Advanced Registration Opens:
December 7, 2022

SRS
Scoliosis Research Society

www.srs.org/imast2023

Program-at-a-Glance

Wednesday, April 6, 2022		
14:00 - 20:00	Registration Open	Mezzanine
17:30 - 19:00	Welcome Reception & Exhibitor Viewing	Mezzanine
19:15 - 20:45	Cases & Cocktails Sessions	1) Escorial / Alhambra, 2) Michelangelo / Raphael, 3) Sandringham / Windsor, 4) Balmoral
Thursday, April 7, 2022		
06:30 - 18:00	Registration Open	Mezzanine East
07:30 - 08:30	*Hands-On Workshops with Breakfast	1) Escorial / Alhambra, 2) Sandringham, 3) Windsor
08:30 - 09:00	Coffee & Exhibit Viewing	Mezzanine
09:00-11:15	Session 1: Whitecloud Nominees & Presidential Address	Versailles Ballroom
11:15 - 11:55	Refreshment Break & Exhibit Viewing	Mezzanine
11:55 - 13:00	Concurrent Sessions 2A - 2B: Abstract Presentations	2A: Trianon Ballroom 2B: Biscayne Ballroom
13:00 - 13:15	Lunch Pick-Up	Grand Ballroom Foyer
13:00 - 14:15	Exhibitor Viewing	Mezzanine
13:15 - 14:15	*Hands-On Workshops	1) Escorial / Alhambra, 2) Michelangelo / Raphael, 3) Sandringham, 4) Windsor
14:45 - 16:15	Concurrent Sessions 3A - 3C: ICLs	3A: Trianon Ballroom 3B: Biscayne Ballroom 3C: Chopin Ballroom
16:15 - 16:45	Refreshment Break & Exhibit Viewing	Mezzanine
16:45 - 17:45	Concurrent Sessions 4A - 4B: ICLs	4A: Trianon Ballroom 4B: Biscayne Ballroom 4C: Chopin Ballroom
18:00 - 19:00	*Hands-On Workshops with Beverages & Snacks	1) Michelangelo / Raphael, 2) Sandringham, 3) Windsor

WIRELESS INTERNET

Network = SRS Meeting
Password = IMAST2022

Friday, April 8, 2022		
07:00-17:00	Registration Open	Mezzanine
07:30 - 08:30	*Hands-On Workshops with Breakfast	1) Escorial / Alhambra, 2) Michelangelo / Raphael
08:30 - 09:00	Coffee & Exhibit Viewing	Mezzanine
09:00 - 10:10	Concurrent Sessions 5A - 5B: Abstract Presentations	5A: Trianon Ballroom 5B: Biscayne Ballroom
10:10 - 10:50	Refreshment Break & Exhibit Viewing	Mezzanine
10:50 - 12:15	Concurrent Sessions 6A - 6B: Abstract Presentations	6A: Trianon Ballroom 6B: Biscayne Ballroom
12:15 - 12:30	Lunch Pick-Up	Grand Ballroom Foyer
12:15 - 13:30	Exhibitor Viewing	Mezzanine
12:30 - 13:30	*Hands-On Workshops	1) Escorial / Alhambra, 2) Michelangelo / Raphael, 3) Sandringham, 4) Windsor
14:00 - 15:30	Concurrent Sessions 7A – 7C: ICLs	7A: Trianon Ballroom 7B: Biscayne Ballroom 7C: Chopin Ballroom
15:30 - 16:00	Refreshment Break & Exhibit Viewing	Mezzanine
16:00 - 17:00	Concurrent Sessions 8A - 8C: ICLs	8A: Trianon Ballroom 8B: Biscayne Ballroom 8C: Chopin Ballroom
Session 8C: Early Career Surgeon session supported, in part by, Medtronic, Globus Medical, and ZimVie		
17:00	Early Career Surgeon Social	Bayfront Ballroom A
Early Career Surgeon Social is supported by Medtronic		
Saturday, April 9, 2022		
08:00 - 13:00	Registration Open	Mezzanine
09:00 - 10:15	Session 9: Bandwagon vs Pendulum Swing	Versailles Ballroom
10:30 - 11:30	Session 10: Current Trends in the Management of Thoracolumbar Spine Trauma	Versailles Ballroom
11:30 - 11:45	Walking Break & Lunch Pick Up	Versailles Foyer
11:45 - 13:15	Session 11: Lunch with the Experts	Versailles Ballroom
Session 11: Lunch with the Experts session is supported, in part by, ZimVie		
13:15	Adjourn	
*Denotes Non-CME Session		