28th IMAST

International Meeting on Advanced Spine Techniques

FINAL PROGRAM

VIRTUAL MEETING
Self-Paced Program: April 21-June 30, 2021
Live Program: April 23-25, 2021

SRS
Scoliosis Research Society

www.srs.org/imast2021

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We are pleased to acknowledge and thank those companies that provided financial support to SRS in 2021. 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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http://srs.brightspace.com

FUTURE EDUCATIONAL EVENTS

56th Annual Meeting
September 22-25, 2021 | St. Louis, Missouri, USA

Spine Deformity Solutions: A Hands-On Course
October 27-29, 2021 | Nijmegen, the Netherlands

Spine Deformity Solutions: A Hands-On Course
November 18-20, 2021 | Singapore, Singapore

29th IMAST
April 6-9, 2022 | Miami, Florida, USA

57th Annual Meeting
September 20-23, 2022 | Sydney, Australia

56th Scoliosis Research Society Annual Meeting

September 22-25, 2021 • St. Louis, Missouri, USA

SRS
Scoliosis Research Society

www.srs.org/am21

CHAIR'S MESSAGE

Dear Attendee,

I would like to personally invite you to the 28th International Meeting on Advanced Spine Techniques that focuses on innovation in spine surgery. We have planned IMAST from the outset to be optimized as a virtual meeting that is both concise and comprehensive. We will experience IMAST live together over three days with just four hours on each day so you can fit this in to your schedule.

Of the 589 submitted abstracts, we have chosen the top 100 to showcase at IMAST. The best clinical and basic science research papers will be presented during the prestigious Whitecloud award-nominated scientific session that opens the meeting on Friday, April 23.

Saturday morning brings you a highly anticipated discussion on "The Bandwagons I Jumped Off" during which some of our preeminent thought leaders reflect on innovative treatments that did not go as they envisioned and share the lessons they learned. There will be six other Instructional Course Lectures on the topics of Minimally Invasive Surgery; Cervical Spine Complications; Robotics, Navigation, and Artificial Intelligence in Pediatric and Adult Patients; Proximal Junctional Kyphosis; and Complications in Vertebral Body Tethering. Be sure to pay special attention to the sessions paired with abstracts for a dynamic delivery of expert opinion and cutting-edge research on the topic.

Other cannot-miss talks will be Jeffrey Gum, MD sharing his "Most Common Complication Using Robotics" (Session 4B), Larry Lenke, MD reporting on "Why [he] Does Fewer VCRs"(Session 3), and Chris Shaffrey, MD assessing "Novel Techniques for PJK Prevention" (Session 4D).

Based on audience feedback, we have expanded to a "Lightning Case Discussion Series" that covers adult deformity, cervical spine, pediatric spine, and spondylolisthesis during Concurrent Sessions 5A-D on Saturday, April 24. Early Career Surgeons will look forward to gathering virtually on Sunday for their special session on topics relevant to those just starting in their spine care careers. In addition to all the education and scientific sessions, each day offers the opportunity to interact with our corporate supporters for both live sessions and on-demand videos and workshops hosted on our online meeting platform, in the Industry Modules.

Attending IMAST will make sure that, despite COVID, you will be updated on the most important innovations in spine surgery that have taken place over the last year.

I am honored to serve as your IMAST Chair. I want to thank Muharrem Yazici, MD; Paul D. Sponseller, MD, MBA; Christopher I. Shaffrey, MD; Lori A. Karol, MD; Peter O. Newton, MD; the IMAST Committee; and the SRS support staff whose leadership and insights have created such a successful meeting. I would also like to thank my colleagues that form the IMAST Leadership Line: Han Jo Kim, MD; Ahmet Alanay, MD; and Stefan Parent, MD for their continued support and guidance in planning this meeting.

With Warm Regards,

David L. Skaggs, MD, MMM
IMAST Committee Chair

SRS ONLINE LEARNING
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GENERAL MEETING INFORMATION

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MEETING DESCRIPTION

The 28th IMAST is a complete web-based 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 both live and self-paced enduring material and 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, you 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.

LANGUAGE

Presentations and course materials will be provided in English.

TECHNOLOGY

Virtual IMAST can be accessed via any electronic device with an internet connection, speakers/headphones, and screen to view and listen to presentations (i.e. Computer, tablet, smart phone).

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 Other (Hybrid) activity, 28th IMAST, for a maximum of 16 *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 are available in the IMAST online platform. After completing the evaluation, your CME certificate will be available to download. To download your CME certificate, login to the virtual meeting platform and select "Awards" from the top of the navigation bar. Navigate to "My Awards," click on each certificate badge and select "Generate Certificate." CME certificates will not be mailed or emailed. The online certificate access is the only source for this documentation. IMAST CME certificates must be claimed by June 30, 2021.

For further instructions, please see the Certificate Guide available on the CME page of the IMAST website (www.srs.org/imast2021/cme-evaluations). Email SRS at cme@srs.org with questions.

EVALUATIONS

Please take time to complete the evaluations for each session you attend. Evaluations allow us to assess whether we have met your needs as a learner and what we can do to improve the next activity. After completing the evaluation surveys, CME and attendance certificates are generated.

SRS MEMBERSHIP

Involvement in the virtual 28th IMAST counts towards SRS membership meeting requirements. Prospective members and new candidate members are encouraged to view the SRS membership section to learn more about membership with SRS, upcoming meetings, and more.

REGISTRATION

Registration for the 28th IMAST is available online at **www.srs.org/imast2021/registration**. The registration cancelation refund deadline is April 20, 2021. The registration deadline/online access cut-off date is June 30, 2021. Please note, learners will not be able to access IMAST after June 30 at 00:00 US Eastern Time.

MEETING ACCESS

Between April 21 and June 30, 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 28th IMAST virtual offering listed under "My Courses"

If you still need to register for the meeting, please visit the IMAST registration webpage (**www.srs.org/imast2021/registration**) for instructions. Please note, online access closes June 30 at 00:00 US Eastern Time.

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ASKING QUESTIONS

Learners will be able to leave questions in the in-course discussion boards for asynchronous communication as well as inquire live using the Q&A webinar feature during live presentations.

LIVE PROGRAM

The live IMAST program, April 23-25, 2021 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. Two additional industry sessions will be presented live the following week on April 28 and April 30, 2021. Join the live sessions by clicking on the webinar links found in the virtual meeting platform. Session links will also be emailed to IMAST registrants one-day before each session begins. All sessions presented live will be recorded and available on-demand for self-paced viewing through June 30, 2021.

SELF-PACED PROGRAM

The self-paced program will be available April 21 through June 30, 2021 on the virtual IMAST platform. E-posters, additional abstract presentations, 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.

WELLNESS LOUNGE

The IMAST Wellness Lounge, located on the home screen of the virtual IMAST platform, is a relaxing space where attendees can take a break, recharge, and get empowered to amplify their wellness. The module includes wellness tips, empowering quotes, healthy recipes, recordings of past meeting wellness-focused sessions, and a discussion board to connect with colleagues.

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.

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 resolved by SRS to ensure that all scientific research referred to, reported, or used in a Continuing Medical Education (CME) activity conforms to the generally accepted standards of experimental design, data collection, and analysis.

MEETING OVERVIEW

| Friday, April 23
Live | Saturday, April 24
Live | Sunday, April 25
Live | April 21-June 30
On-demand |
|---|---|---|---|
| Whitecloud Award-Nominated Papers

Presidential Address

Instructional Course Lectures: MIS and Cervical Complications

Medtronic Live Session | Instructional Course Lecture: Off the Bandwagon

Instructional Course Lectures with Abstracts: Robotics and Navigation, Tethering, PJK

Case Discussions: Spondylolisthesis, Cervical, Adult, Pediatric

Stryker Live Session | Early Career Surgeons Session

DePuy Synthes Live Session | Additional Abstract Presentations

E-Posters

Industry Modules

Recordings of the Live Sessions |

Additional live industry sessions will be hosted by Globus Medical, Inc. on April 28 and Stryker on April 30.

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AUTHOR DISCLOSURES

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If noted, the relationships disclosed are as follows: a – grants/research support; b – consultant; c – stock/shareholder (self-managed); d – speaker's bureau; e – advisory board or panel; f – employee, salary (commercial interest); g – other financial or material support (royalties, patents, etc.)

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08:00-09:55 ET/14:00-15:55 CEST/20:00-21:55 CST

Session 1: Whitecloud Award-Nominated Abstracts
Moderators: Han Jo Kim, MD and David L. Skaggs, MD, MMM

08:00-08:05 Welcome Address
David L. Skaggs, MD, MMM

08:05-08:09 Paper #1: The Trends in Robot-related Complications, Operative Efficiency, Radiation Exposure, and Clinical Outcomes After Robot-Assisted Spine Surgery: A Multicenter Study of 722 Patients and 5,005 Screws From 2015 to 2019
Nathan J. Lee, MD; Ian Buchanan, MD; Eric Leung, BS; Avery L. Buchholz, MD; John Pollina, MD; Ehsan Jazini, MD; Colin Haines, MD; Thomas C. Schuler, MD; Christopher R. Good, MD; Joseph M. Lombardi, MD; Ronald A. Lehman, MD

08:09-08:13 Paper #2: Global Coronal Malalignment after MIS Adult Spinal Deformity Surgery: Multicenter Prospective Assessment of 141 Patients with Minimum 1-year Follow-up
Thomas J. Buell, MD; Vivian Le, MPH; Dean Chou, MD; Robert K. Eastlack, MD; Kai-Ming Gregory Fu, MD; Juan S. Uribe, MD; Gregory M. Mundis, MD; Neel Anand, MD; Pierce D. Nunley, MD; David O. Okonkwo, MD; Richard G. Fessler, MD; Paul Park, MD; Michael Y. Wang, MD; Adam S. Kanter, MD; Christopher I. Shaffrey, MD; Praveen V. Mummaneni, MD; Khoi D. Than, MD; International Spine Study Group

08:13-08:17 Paper #3: Barriers and Knowledge Gaps in Appropriate Postoperative Opioid Use in Spine Patients
Rafa Rahman, MPH; Sara Wallam, BS; Bo Zhang, MD; Rahul Sachdev, BS; Emmanuel McNeely, MS; Khaled M. Kebaish, MD; David B. Cohen, MPH; Sang Hun Lee, MD; Richard L. Skolasky, PhD; Brian J. Neuman, MD

08:17-08:26 Discussion

08:26-08:30 Paper #4: Sanders 2 Skeletal Maturity Patients Have the Greatest Rate and Duration of Post Anterior Tether Scoliosis Correction
Peter O. Newton, MD; Baron Lonner, MD; Kevin M. Neal, MD; Daniel Hoernschemeyer, MD; Firoz Miyanji, MD; Tracey P. Bastrom; Harms Study Group

08:30-08:34 Paper #5: Anterior Spinal Growth Tethering Leads to Asymmetric Growth of the Periapical Vertebrae
Peter O. Newton, MD; Yohei Takahashi, MD, PhD; Yi Yang, MD; Burt Yaszay, MD; Carrie E. Bartley, MA; Tracey P. Bastrom; Carlo Munar, BS

08:34-08:38 Paper #6: Spinal Growth and Cord Breakage Two Years following Vertebral Body Tethering
John B. Hargiss, BS; Todd Milbrandt, MD; D. Dean Potter, MD; A. Noelle Larson, MD

08:38-08:47 Discussion

08:47-08:51 Paper #7: The Harms Study Group Retrospective Comparison Study on Anterior Vertebral Body Tethering (AVBT) versus Posterior Spinal Fusion (PSF) for Primary Thoracic Curves
Peter O. Newton, MD; Stefan Parent, MD, PhD; Firoz Miyanji, MD; Ahmet Alanay, MD; Baron Lonner, MD; Kevin M. Neal, MD; Daniel Hoernschemeyer, MD; Burt Yaszay, MD; Laurel C. Blakemore, MD; Suken A. Shah, MD; Harms Study Group

08:51-08:55 Paper #8: Outcomes of MCGR at >3-Year avg. Follow-up in Severe Scoliosis: Who Undergoes Elective Revision vs. UPROR?
Michelle C. Welborn, MD; Daniel Bouton, MD

08:55-08:59 Paper #9: Early Results of a Novel Growth Rod for Early Onset Scoliosis
Kristopher M. Lundine, MD MSc FRCSC FRACS; Michael B. Johnson, MBBS FRACS

08:59-09:08 Discussion
Moderators: Ahmet Alanay, MD and Stefan Parent, MD, PhD

09:08-09:12 Paper #10: Scoliosis Surgery Normalizes Cardiac Function in AIS Patients
Sarika Kalantre, MD, MBBS; Rachel Gecelter, BS; Jesse M Galina, BS; Aaron M. Atlas, BS; Sayyida Hasan, BS; Terry D. Amaral, MD; Beverly Thornhill, MD; Marina Moguilevtch, MD; *Vishal Sarwahi, MD, MBBS*

* = Non-CME Session

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LIVE PROGRAM FRIDAY, APRIL 23, 2021

Session times are listed in US Eastern Time (ET), Central European Summer Time (CEST), and China Standard Time (CST). Presentation times are listed in ET only.

09:12-09:16 Paper #11: Indications and Timing of Revision Spine Surgery in Adults after Adolescent Surgery for Idiopathic Scoliosis
Andrew Diederich, BS; Jace Erwin, MD; Brandon B. Carlson, MD; Joshua Bunch, MD; Robert Sean Jackson, MD; Douglas C. Burton, MD

09:16-09:20 Paper #12: Primary Benefit of Two-Surgeon Team in AIS Deformity Correction is Reduced Procedure Length
Brandon J. Marshall, BS; Michael G. Read, MD; Andrew Romero, MS, BS; Gary M. Kiebzak, PhD; Suken A. Shah, MD; John F. Lovejoy, MD

09:20-09:29 Discussion

09:29-09:33 Paper #13: Does Patient Frailty Status Influence Recovery Patterns and Ultimate Outcome Following Spinal Fusion for Cervical Deformity?
Katherine E. Pierce, BS; *Peter G. Passias, MD*; Renaud Lafage, MS; Virginie Lafage, PhD; Douglas C. Burton, MD; Alan H. Daniels, MD; Robert K. Eastlack, MD; D. Kojo Hamilton, MD; Robert A. Hart, MD; Han Jo Kim, MD; Themistocles S. Protopsaltis, MD; Alex Soroceanu, ; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; International Spine Study Group

09:33-09:37 Paper #14: The Natural History and Prognosis of Major Neurological Complication in Spinal Deformity Correction Surgery
Yong Qiu, MD; Jie Li, MD; Zhen Liu, MD; Zongshan Hu, PhD; Ziyang Tang, MD; Abdukahar Kiram, PhD; Zezhang Zhu, MD

09:37-9:41 Paper #15: Health-related Quality of Life and Sagittal Balance 2-25 Years after Posterior Transfixation for High-grade Dysplastic Spondylolisthesis
Tom P. Schlösser, MD, PhD; Enrique Garrido, MD, FRCS; Athanasios I. Tsirikos, MD, PhD, FRCS

09:41-09:50 Discussion

09:50-09:55 Live Voting on Whitecloud Award-Nominated Abstracts

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09:55-10:00 ET/15:55-16:00 CEST/21:55-22:00 CST

Break

10:00-10:10 ET/16:00-16:10 CEST/22:00-22:10 CST

Presidential Address
Muharrem Yazici, MD

10:10-10:15 ET/16:10-16:15 CEST/22:10-22:15 CST

Break

10:15-11:00 ET/16:15-17:00 CEST/22:15-23:00 CST

Concurrent Sessions 2A-B: Instructional Course Lectures

2A. Minimally Invasive Surgery for Adult Deformity: When and How
Moderators: Tyler Koski, MD and Juan S. Uribe, MD

Self-Paced Bonus Lecture Evidence Behind MIS
Dean Chou, MD

10:15-10:22 Indications and Applications
Praveen V. Mummaneni, MD

10:22-10:29 Surgical Enabling Technologies for MIS Deformity
Paul Park, MD

10:29-10:36 Discussion

10:36-10:43 Unique Challenges and Limitations of MIS Techniques in ASD Management
Gregory M. Mundis, MD

* = Non-CME Session

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| 10:43-10:48 | Best Case Scenario: Case Presentation |
| | *Juan S. Uribe, MD* |

| 10:48-10:53 | Worst Case Scenario: Case Presentation |
| | *Neel Anand, MD* |

| 10:53-11:00 | Discussion |

2B. My Worst Cervical Complication: Cervical Deformity - Either Creating It or Curing It
Moderators: Rick Sasso, MD and Kota Watanabe, MD, PhD

| 10:15-10:25 | My Worst Surgical Mistake - Resulting in Cervical Deformity |
| | *Todd Albert, MD* |

| 10:25-10:35 | My Worst Surgical Mistake - Correcting Cervical Deformity |
| | *John M. Rhee, MD* |

| 10:35-10:45 | Making Sense of Parameters: Can We Avoid the Lumbar Deformity Assessment Nightmare? |
| | *Alex Vaccaro, MD* |

| 10:45-11:00 | Discussion |

11:00-11:05 ET/17:00-17:05 CEST/23:00-23:05 CST

Break

11:05-12:05 ET/17:05-18:05 CEST/23:05-00:05 CST

Medtronic Live Session*
See page 40 for more information on the industry live sessions.

* = Non-CME Session

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08:00-08:45 ET/14:00-14:45 CEST/20:00-20:45 CST

Session 3: The Bandwagons I Jumped Off
Moderators: Eric Klineberg, MD and David L. Skaggs, MD, MMM

08:00-08:04	Scolitron, Scoliscore, Growing Implants *David L. Skaggs, MD, MMM*
08:04-08:07	Axial Lumbar Interbody Fusion *Isador Lieberman, MD*
08:07-08:10	En Bloc Sacrectomy *Mark Bilsky, MD*
08:10-08:16	Discussion
08:16-08:19	Injections *Hyun Bae, MD*
08:19-08:22	PEEK Implants *Thomas Mroz, MD*
08:22-08:28	Discussion
08:28-08:31	Vertebral Body Staples for Scoliosis *Amer F. Samdani, MD*
08:31-08:34	Why I Do Far Fewer VCRs *Lawrence G. Lenke, MD*
08:34-08:40	Discussion
08:40-08:45	Whitecloud Award Announcement

08:45-8:50 ET/14:45-14:50 CEST/20:45-20:50 CST

Break

08:50-10:10 ET/14:50-16:10 CEST/20:50-22:10 CST

Concurrent Sessions 4A-D: Instructional Course Lectures with Abstracts

4A. Future of Robotics, Navigation, and AI for 2021 and Beyond
Moderators: Han Jo Kim, MD and Rajiv Sethi, MD

08:50-08:58	Where Robotics Needs to Go Beyond 2021: Pros and Cons of Various Systems *Sheeraz Qureshi, MD*
08:58-09:06	Where Navigation Needs to Go Beyond 2021: Pros and Cons of Various Systems *Ronald A. Lehman, MD*
09:06-09:11	Discussion
09:11-09:16	My Most Common Complication Using Robotics *Jeffrey Gum, MD*
09:16-09:21	Discussion
09:21-09:26	My Worst Complication Using Navigation *Themistocles Protopsaltis, MD*
09:26-09:31	Discussion
09:31-09:39	Looking to 2022 and Beyond: Artificial Intelligence and Machine Learning Applications *Christopher Ames, MD*
09:39-09:44	Discussion
09:44-09:48	Paper #16: Assessing Complications Associated with Robotic Spine Surgery Lara Passfall, BS; *Oscar Krol, BA*; Nicholas A. Kummer, BS; Peter G. Passias, MD

* = Non-CME Session

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SATURDAY, APRIL 24, 2021

Session times are listed in US Eastern Time (ET), Central European Summer Time (CEST), and China Standard Time (CST). Presentation times are listed in ET only.

09:48-09:52   **Paper #17: Complication and Revision Rates in Robotic-Guided Posterior Spine Fusions using a Bone-Mounted Robot with Anatomy Recognition Software**
Alexandra E. Thomson, MD; Lindsay Orosz, MS, PA-C; Brandon J. Allen ; Miles T. Guth ; Thomas C. Schuler, MD; Christopher R. Good, MD; Colin Haines, MD; Ehsan Jazini, MD

09:52-09:56   **Paper #18: Is There a Difference Between Navigated and Non-Navigated Robot Cohorts in Robot-Assisted Spine Surgery? A Multicenter, Propensity-Matched Analysis of 2,800 Screws and 372 Patients**
Nathan J. Lee, MD; Ian Buchanan, MD; Eric Leung, BS; Avery L. Buchholz, MD; John Pollina, MD; Ehsan Jazini, MD; Colin Haines, MD; Thomas C. Schuler, MD; Christopher R. Good, MD; Joseph M. Lombardi, MD; Ronald A. Lehman, MD

09:56-10:00   **Paper #19: 90-Day Complication, Revision, and Readmission Rates Associated with Robotic-Assisted Thoracolumbar Fusion Surgery**
Jason I. Liounakos, MD; Christopher R. Good, MD; John Pollina, MD; Colin Haines, MD; Jeffrey L. Gum, MD; Thomas C. Schuler, MD; Ehsan Jazini, MD; Richard V. Chua, MD; Eiman Shafa, MD; Avery L. Buchholz, MD; Martin H. Pham, MD; Michael Y. Wang, MD

10:00-10:10   Discussion

4B. Robotics and Navigation in Pediatric Spine Surgery
Moderators: Daniel J. Hedequist, MD and John (Jack) M. Flynn, MD

08:50-09:00   The History and Evolution of Robotic Spine Surgery
Dennis Devito, MD

09:00-09:05   Discussion

09:05-09:15   The Current State of Robotics and Navigation in 2021 for Pediatric Spine Deformity
Daniel J. Hedequist, MD

09:15-09:20   Discussion

09:20-09:30   Intraoperative Technique of Robotic Assisted Pedicle Screw Placement with Navigation
Roger Widmann, MD

09:30-09:35   Discussion

09:35-09:45   Embracing Robotics in Pediatric Spine Deformity: From Purchase to Practice
Mark A. Erickson, MD

09:45-09:50   Discussion

09:50-09:54   **Paper #20: The Impact of Growing Rod Surgery on Cervical Alignment During the Treatment of Early-Onset Scoliosis: A Retrospective Case Control Study Based on Machine Learning Algorithms**
Bo Han, MD; Yong Hai, MD, PhD; Aixing Pan, MD, PhD

09:54-09:58   **Paper #21: Children with Growth-friendly Spinal Implants Display Impaired Intervertebral Disc Volume and Degeneration**
Sebastian Lippross, MD; Paul Girmond, MS; Katja A. Lüders, PhD; Stefan Lüders, MSc; Friederike Austein, MD; Anna K. Hell, MD

09:58-10:02   **Paper #22: Adolescent Idiopathic Scoliosis Predispose to Early Disc Degeneration- Evidence from Proteomics**
Sri Vijay Anand K S, MS; S. Rajasekaran, PhD, MS, FRCS; Chitra Thangavel, PhD; Dilip Chand Raja Soundarajan, MS; Sharon M. Nayagam, MSc; Ajoy Prasad Shetty, MS (Ortho); Rishi M. Kanna, MS

10:02-10:10   Discussion

4C. Proximal Junctional Kyphosis: Current Thinking and Innovative Solutions
Moderators: Munish Gupta, MD and Eric Klineberg, MD

08:50-08:51   Introduction

08:51-08:59   When is PJK vs. PJF Definition Important and Clinically Meaningful?
Virginie Lafage, PhD

08:59-09:07   Alignment Goals for PJK Prevention: Which Parameters to Use?
Pierre Roussouly, MD, FRCS(C)

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09:07-09:15   When to Stop at Upper Thoracic vs. Lower Thoracic?
Frank Schwab, MD

09:15-09:23   Discussion

09:23-09:31   Novel Techniques for PJK Prevention: Do They Really Work?
Christopher Shaffrey, MD

09:31-09:39   Predictive Analytics and PJK Prevention: The Future
Ferran Pellisé, MD, PhD

09:39-09:44   Case 1
Munish Gupta, MD

09:44-09:49   Case 2
Eric Klineberg, MD

Moderators: Owoicho Adogwa, MD and Jean-Charles Le Huec, MD

09:49-09:53   Paper #23: Efficacy of Varying Surgical Approaches on Achieving Optimal Alignment in Adult Spinal Deformity Surgery
Peter G. Passias, MD; Waleed Ahmad, BS; Sara Naessig, BS; Katherine E. Pierce, BS; Khaled M. Kebaish, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Tina Raman, MD; Bassel G. Diebo, MD; Eric Klineberg, MD; Han Jo Kim, MD; Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Shay Bess, MD; Frank J. Schwab, MD; Munish C. Gupta, MD; International Spine Study Group

09:53-09:57   Paper #24: Influences of Osteotomy for Adults Degenerative Scoliosis on Preoperative Proximal Junctional Kyphosis: A Review of 83 Patients
Li Junyu, MD; Lin Haimiao, BS; Yu Miao, MD

09:57-10:01   Paper #25: Consistent and Pathognomonic Modes of Failure Occur at the Proximal Junction Depending Upon the Type of Instrumentation Used: A Two-Step Cluster Analysis to Better Understand Proximal Junctional Failure (PJF)
Jonathan Charles Elysée, BS; Renaud Lafage, MS; Shay Bess, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Munish C. Gupta, MD; Justin S. Smith, MD, PhD; Robert K. Eastlack, MD; Eric Klineberg, MD; Gregory M. Mundis, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

10:01-10:10   Discussion

4D. Vertebral Body Tethering: Go Big or Go Broke
Moderators: Ahmet Alanay, MD; Stefan Parent, MD; Hee-Kit Wong, MD

08:50-08:55   Introduction
Stefan Parent, MD, PhD

08:55-09:02   Complications Following Vertebral Body Tethering: Early vs. Late
Ron El-Hawary, MD

09:02-09:09   Reoperation for Broken Tether
Stefan Parent, MD, PhD

09:09-09:16   Reoperation for Continued Progression: Posterior Spinal Fusion
Peter Newton, MD

09:16-09:26   Discussion

Moderators: Laurel C. Blakemore, MD and Michelle Welborn, MD

09:26-09:30   Paper #26: A Multicenter Comparative Analysis of AVBT to PSF in the Treatment of Lenke 5 Curves
Firoz Miyanji, MD; Baron Lonner, MD; Stefan Parent, MD, PhD; Ahmet Alanay, MD; Daniel Hoernschemeyer, MD; Burt Yaszay, MD; Suken A. Shah, MD; Laurel C. Blakemore, MD; A. Noelle Larson, MD; Lawrence L. Haber, MD; Caglar Yilgor, MD; Kevin M. Neal, MD; Peter O. Newton, MD; Harms Study Group

* = Non-CME Session

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| 09:30-09:34 | Paper #27: Thoracoscopic and Mini-Open Lumbotomy Vertebral Body Tethering for Thoracolumbar/Lumbar Curves: Two to Three Years Follow-up |

Altug Yucekul, MD; Ilkay Karaman, MD; Tais Zulemyan, MS; Gokhan Ergene, MD; Sahin Senay, MD; Sule Turgut Balci, MD; Yasemin Yavuz, PhD; Caglar Yilgor, MD; Ahmet Alanay, MD

09:34-09:38   Paper #28: Lumbar Vertebral Body Tethering (VBT) and Analysis of 1- vs. 2-Cord Construct
Alice Baroncini, MD; Per D. Trobisch, MD

09:38-09:47   Discussion

09:47-09:51   Debate Introduction: Selective VBT
Daniel Hoernschemeyer, MD

09:51-09:55   Double Tether (Both Curves) Produces More Reliable Results
Per D. Trobisch, MD

09:55-09:59   Selective Tether Works Well Even in the Uninstrumented Curve
A. Noelle Larson, MD

09:59-10:01   Audience Vote

10:01-10:10   Conclusion
Ahmet Alanay, MD

10:10-10:15 ET/16:10-16:15 CEST/22:10-22:15 CST

Break

10:15-10:45 ET/16:15-16:45 CEST/22:15-22:45 CST

Concurrent Sessions 5A-D: Lightning Case Discussion Series

5A. Adult Deformity: Use of Adjunctive Instrumentation
Moderator: Tyler Koski, MD

Panelists: Vedat Deviren, MD; Ronald A. Lehman, MD; Patrick Sugrue, MD

5B. Cervical Spine
Moderator: Brian Hsu, MD

Panelists: Michael Fehlings, MD, PhD, FRCSC, FACS; Gabriel Liu, FRCS(Orth), MSC; Justin S. Smith, MD, PhD; Yatsutsugu Yukawa, MD, PhD

5C. Pediatric Spine: Common Problems that Challenge Decision Making
Moderator: Burt Yaszay, MD

Panelists: Ahmet Alanay, MD; Lindsay Andras, MD; Firoz Miyanji, MD, FRCSC; Suken Shah, MD

5D. Spondylolisthesis
Moderator: Jean-Charles Le Huec, MD

Panelists: Kariman Abelin Genevois, MD, PhD; Kazuhiro Hasegawa, MD, PhD; Stefan Parent, MD

10:45-10:50 ET/16:45-16:50 CEST/22:45-22:50 CST

Break

10:50-11:50 ET/16:50-17:50 CEST/22:50-23:50 CST

Stryker Live Session*
See page 40 for more information on the industry live sessions.

* = Non-CME Session

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09:05-10:35 ET/15:05-16:35 CEST/21:05-22:35 CST

Session 6: Early Career Surgeons Session
Presented by the SRS Early Career Surgeon Task Force

09:05-09:10   Welcome and Early Career Surgeon Introduction
Kariman Abelin Genevois, MD, PhD

Team and Practice Building in the Spine World
Moderator: Caglar Yilgor, MD

09:10-09:16   Experience from a High-Functioning Surgical Team
David L. Skaggs, MD, MMM

09:16-09:21   Building a "Spine Center" From Scratch: A SRS Global Outreach Success
Ara Antaranyan

09:21-09:26   Negotiating with the Admins - a Case from Emory
Sandra Hobson, MD

09:26-09:35   Discussion

AIS Surgery is Not Complication-Free
Moderator: Kenny Kwan, BMBCh(Oxon), FRCSEd

09:35-09:40   Case: Mechanical Complication in AIS
Tom Schlösser, MD, PhD

09:40-09:50   Discussion

09:50-09:55   Tips and Tricks on Technical Aspects to Minimize Mechanical Complications
Suken A. Shah, MD

Phone-A-Friend
Moderator: Jaysson T. Brooks, MD

09:55-10:00   Case: Infection in ASD
Ona Lapteva, MD

10:00-10:10   Discussion

10:10-10:15   Tips and Tricks on Technical Aspects to Minimize and Manage Infection
Clément Silvestre, MD

When Things Go Wrong in a "Simple" Case
Moderator: Jeffrey P. Mullin, MD, MBA

10:15-10:20   Case: Severe Radiculopathy after LLIF
Andrés Jaime Aguirre, MD

10:20-10:30   Discussion

10:30-10:35   Tips and Tricks on Technical Aspects to Minimize and Manage Neural Complications
Gregory M. Mundis, MD

10:35-10:40 ET/16:35-16:40 CEST/22:35-22:40 CST

Break

10:40-11:40 ET/16:40-17:40 CEST/22:40-23:40 CST

DePuy Synthes Live Session*

* = Non-CME Session

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ABSTRACTS

There are 22 abstracts, listed below, available on-demand for self-paced viewing only.

Cervical Deformity
Moderator: Jean-Charles Le Huec, MD

Paper #29: 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; Waleed Ahmad, BS; Sara Naessig, BS; Nicholas A. Kummer, BS; Oscar Krol, BA; *Lara Passfall, BS*; Karan Patel, MD; Hesham Saleh, MD; Bassel G. Diebo, MD

Paper #30: Treatment of Cervical Deformity in the Presence of a Secondary Thoracic Deformity: Outcomes Based on Inclusion and Age-adjusted Normalization
Sara Naessig, BS; Peter G. Passias, MD; Waleed Ahmad, BS; Katherine E. Pierce, BS; Renaud Lafage, MS; Virginie Lafage, PhD; Robert K. Eastlack, MD; Han Jo Kim, MD; D. Kojo Hamilton, MD; Themistocles S. Protopsaltis, MD; Alex Soroceanu, MD; Eric Klineberg, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; *Shaleen Vira, MD*; International Spine Study Group

Paper #31: Outcomes Analysis of Staged versus Same-day Patients Undergoing Identical Cervical Deformity Corrective Surgery
Oscar Krol, BA; Peter G. Passias, MD; Lara Passfall, BS; Nicholas A. Kummer, BS; Waleed Ahmad, BS; Sara Naessig, BS

Minimally Invasive Surgery and Innovative Methods
Moderator: Christopher Ames, MD

Paper #32: Novel Artificial Intelligence Algorithm can Accurately and Independently Measure Spinopelvic Parameters
Colin Haines, MD; *Lindsay Orosz, MS, PA-C*; Alexandra E. Thomson, MD; Thomas C. Schuler, MD; Christopher R. Good, MD; Priyanka Grover, MS; Marcel Dreischarf, PhD; Rita Roy, MD; Ehsan Jazini, MD

Paper #33: Lateral Decubitus Single Position Circumferential Fusion (ALIF and PSF) Improves Perioperative Outcomes Compared to Traditional Anterior-Posterior Fusion
Kimberly Ashayeri, MD; Seth Tigchelaar, BS; Brooke K. O'Connell, MS; J. Alex Thomas, MD; Ivan Cheng, MD; Brett Braly, MD; Brian Kwon, MD; Themistocles S. Protopsaltis, MD; Aaron J. Buckland, MBBS, FRCSA

Paper #34: Minimally Invasive Surgery Mitigates but Does not Eliminate Adverse Perioperative Outcomes for Frail TLIF
Sara Naessig, BS; Waleed Ahmad, BS; Katherine E. Pierce, BS; Lara Passfall, BS; Oscar Krol, BA; Nicholas A. Kummer, BS; Bhaveen Kapadia, MD; Laviel Fernandez, MD; Bassel G. Diebo, MD; Peter G. Passias, MD; *Shaleen Vira, MD*

Paper #35: Prone Transpsoas Lateral Interbody Fusion: Multi-Center Clinical Experience
Samuel A. Joseph, MD; Benjamin Ditty, MD; Antoine G. Tohmeh, MD; William Taylor, MD; Luiz Pimenta, MD, PhD

Quality/Safety/Value/Complications
Moderator: Rajiv Sethi, MD

Paper #36: The Effect of a Transdisciplinary Spine Conference on Quality and Safety for Adult Spinal Deformity Surgery
Gregory M. Mundis, MD; *Fernando Rios, MD*; Hani Malone, MD; Bahar Shahidi, PhD; Tina L. Iannacone, BSN; Shae Galli, BS; Robert K. Eastlack, MD

Paper #37: Pre-operative High Frequency Opioid Use Dramatically Increases Complication Rate Within 90 Days, Increases 2 Year Reoperation Rates, and Predisposes to Opioid Dependency Following Adult Spinal Deformity Correction
Peter G. Passias, MD; *Waleed Ahmad, BS*; Katherine E. Pierce, BS; Sara Naessig, BS; Lara Passfall, BS; Nicholas A. Kummer, BS; Oscar Krol, BA; Bassel G. Diebo, MD; Hamid Hassanzadeh, MD

Paper #38: Defining Clinically Relevant Distal Failure In the Treatment of Adult Cervical Deformity: An Improved Definition Based on Functional Outcomes and Need for Reoperation
Peter G. Passias, MD; *Sara Naessig, BS*; Waleed Ahmad, BS; Katherine E. Pierce, BS; Nicholas A. Kummer, BS; Lara Passfall, BS; Oscar Krol, BA; Renaud Lafage, MS; Virginie Lafage, PhD; Themistocles S. Protopsaltis, MD

Miscellaneous
Moderator: Serena Hu, MD

Paper #39: Tip of the Iceberg, Normal Lumbar Bone Density does Not Predict Normal Cervical Bone Density
Yoshihiro Katsuura, MD; Jonathan Charles Elysée, BS; Sachin Shah, BS; Ananth Punyala, MS, BS; Bryan Ang, BS; Sravisht Iyer, MD; Sheeraz Qureshi, MD; Han Jo Kim, MD; Todd J. Albert, MD; Frank J. Schwab, MD; Renaud Lafage, MS; Virginie Lafage, PhD

Paper #40: Lower Hounsfield Units at the Upper Instrumented Vertebrae are Significantly Associated with Proximal Junctional Kyphosis and Failure
Anthony L. Mikula, MD; Jeremy L. Fogelson, MD; Nikita Lakomkin, MD; Zachariah W. Pinter, MD; Matthew K. Doan, BS; Mohamad Bydon, MD; Ahmad Nassr, MD; Arjun Sebastian, MD; Kingsley Abode-Iyamah, MD; Benjamin D. Elder, MD, PhD

Paper #41: Is the Pelvic Incidence a Determinant Factor for Kyphosis Curve Patterns of Ankylosing Spondylitis Patients?
Xiaolin Zhong, MD; Bangping Qian, MD; Yong Qiu, MD

* = Non-CME Session

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Adolescent Idiopathic Scoliosis
Moderator: Kenneth Illingworth, MD

Paper #42: Cervical Sagittal Alignment in Lenke 1 Adolescent Idiopathic Scoliosis and its Alteration with Surgery: A Retrospective, Multi-centric Study
Bhavuk Garg, MS; Nishank Mehta, MS; Anupam Gupta, MS; Ajoy Prasad Shetty, MS (Ortho); Saumyajit Basu, FRCS; Sridhar Jakkepally, MS; Somashekar Doddabhadre Gowda, MS; J. Naresh-Babu, MS; Harvinder Singh Chhabra, MS (Ortho)

Paper #43: Independent Risk Factors for Postoperative Cervical Kyphosis in Lenke Type 1 AIS Patients
Li Junyu, MD; Deng Kaige, MD; *Yu Miao, MD*

Paper #44: T1 Tilt and Clavicle Angle are the Best Predictors of Postoperative Shoulder and Neck Balance in AIS Patients
Vishal Sarwahi, MD, MBBS; Sayyida Hasan, BS; Stephen F. Wendolowski, BS; Rachel Gecelter, BS; Saankritya Ayan, MD; Terry D. Amaral, MD; Beverly Thornhill, MD; Marina Moguilevtch, MD; Jesse M Galina, BS

Pediatric Scoliosis
Moderator: Michelle Welborn, MD

Paper #45: Predictors of Optimal Outcomes of Selective Thoracic Fusion at 5 Years
Amelia Lindgren, MD; Tracey P. Bastrom, ; Carrie E. Bartley, MA; Amer F. Samdani, MD; Suken A. Shah, MD; Firoz Miyanji, MD; Patrick J. Cahill, MD; Vidyadhar V. Upasani, MD; Peter O. Newton, MD; Burt Yaszay, MD

Paper #46: Zero Patient-Controlled Analgesia (PCA) is an Achievable Target for Postoperative Rapid Recovery Management of AIS Patients
Vishal Sarwahi, MD, MBBS; Sayyida Hasan, BS; Aaron M. Atlas, BS; Jesse M Galina, BS; Yungtai Lo, PhD; Terry D. Amaral, MD; Benita Liao, MD; Michelle Kars, MD

Early Onset Scoliosis
Moderator: Lindsay Andras, MD

Paper #48: Myelopathic Patients with Severe Pediatric Spinal Deformity Can Improve Neurologic Function Close to Non-myelopathic Patients by 1-year After Surgery
Meghan Cerpa, MPH; Scott Zuckerman, MD; Lawrence G. Lenke, MD; Zeeshan M. Sardar, MD; Brenda A. Sides, ; Michael P. Kelly, MD; Oheneba Boachie-Adjei, MD; Sumeet Garg, MD; David B. Bumpass, MD; Paul D. Sponseller, MD; Suken A. Shah, MD; Mark A. Erickson, MD; Daniel J. Sucato, MD; Amer F. Samdani, MD; Burt Yaszay, MD; Joshua M. Pahys, MD; Peter O. Newton, MD; Richard E. McCarthy, MD; Munish C. Gupta, MD

Paper # 49: Rod Fracture in Traditionally Growing Rod Technique in Early Onset Scoliosis. When Does it Occur?
Lucas Piantoni, MD; Carlos Tello, MD, PhD; Rodrigo G. Remondino, MD; Carlos A. Moyano, MD; Eduardo Galaretto, MD; Ernesto S. Bersusky, MD; Ida Alejandra Francheri Wilson, MD; Mariano A. Noel, MD

Paper # 50: Mortality in Patients with Neuromuscular Early Onset Scoliosis Undergoing Spinal Deformity Surgery
Hiroko Matsumoto, PhD; Adam N. Fano, BS; Elizabeth T. Herman, BS; Patrick J. Cahill, MD; Brandon A. Ramo, MD; *Benjamin D. Roye, MD*; Michael G. Vitale, MPH; Pediatric Spine Study Group

E-POSTERS
There are 50 e-posters available for your review in the e-poster module.

INDUSTRY MODULES
Learners are encouraged to view the industry modules to learn more about the technological advances our corporate partners offer in the field of deformity care. Each industry module is unique to the supporting company and features on-demand videos, discussion boards, appointment schedulers, and information about live industry sessions.

Industry pages can be accessed by clicking on "Industry Module" from the IMAST home screen.

Available Industry Modules:
DePuy Synthes
Globus Medical, Inc.
Medtronic
NuVasive
Stryker
Zimmer Biomet
ATEC Spine
Pacira BioSciences, Inc.

* = Non-CME Session

INDUSTRY MODULES AND LIVE INDUSTRY SESSIONS

Industry modules can be accessed by clicking on "Industry Module" from the IMAST home screen.

INDUSTRY MODULES

We encourage you to view the industry modules to learn more about the technological advances our corporate partners offer in the field of deformity care. Each industry module is unique to the supporting company and may feature on-demand videos, discussion boards, appointment schedulers, and information about live industry sessions.

Industry modules are available for self-paced viewing from April 21 through June 30, 2021 and are located on the Virtual IMAST platform.

AVAILABLE INDUSTRY MODULES:

DePuy Synthes
Globus Medical, Inc.
Medtronic
NuVasive
Stryker
Zimmer Biomet
ATEC Spine
Pacira BioSciences, Inc.

COMPANY DESCRIPTIONS

DEPUY SYNTHES

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, INC.

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.

MEDTRONIC

Medtronic Cranial and Spinal Technologies (CST), the market leader in spinal implants, robotics, and navigation is redefining cranial and spinal procedures to reduce variability and improve outcomes with the goal of restoring long-term quality of life for more patients. Medtronic is the first company to offer an integrated solution that includes artificial intelligence-driven surgical planning, personalized spinal implants, and robotic-assisted surgical delivery to make patient care more customized.

NUVASIVE

NuVasive (NASDAQ: NUVA) 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.

STRYKER

At Stryker, we are proud to be one of the world's leading medical technology companies, and together with our customers, we are driven to make healthcare better. In addition to offering innovative products and services in the Orthopaedics, Medical and Surgical fields, we are a global leader in Neurotechnology and Spine, specifically focused on providing complex spine and minimally invasive solutions with the goal of helping surgeons achieve three-dimensional Total Body Balance. We offer a comprehensive and diverse product portfolio in this space, including our leading 3D-printed technologies, advanced medical technology for interventional spine procedures, navigation for spine and cranial procedures, and mobile, fan-beam CT imaging both in and out of the operating room. Our rigorously trained sales representatives work hard to support your practice, offer product and procedural consultation and be an active partner in helping you provide your patients with a variety of treatment options.

ZIMMER BIOMET

Zimmer Biomet Spine is a leader in restoring mobility, alleviating pain, and improving the quality of life for patients around the world by delivering surgeons a comprehensive portfolio of quality spine technologies and procedural innovation, best-in-class training, and unparalleled service via a network of responsive team members and sales professionals.

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Industry modules can be accessed by clicking on "Industry Module" from the IMAST home screen.

ATEC SPINE

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.

PACIRA BIOSCIENCES, INC.

Pacira BioSciences, Inc. (Nasdaq: PCRX) is the industry leader in its commitment to non-opioid pain management and regenerative health solutions to improve patients' journeys along the neural pain pathway. The company's long-acting local analgesic, EXPAREL® (bupivacaine liposome injectable suspension) was commercially launched in the United States in April 2012. EXPAREL utilizes DepoFoam®, a unique and proprietary product delivery technology that encapsulates drugs without altering their molecular structure, and releases them over a desired period of time. In April 2019, Pacira acquired the iovera° system, a handheld cryoanalgesia device used to deliver precise, controlled doses of cold temperature only to targeted nerves. To learn more about Pacira, including the corporate mission to reduce overreliance on opioids, visit www.pacira.com.

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Industry modules can be accessed by clicking on "Industry Module" from the IMAST home screen.

INDUSTRY ON-DEMAND VIDEOS

Videos including presentations and demonstrations on topics and technologies selected by the supporting company are available in the industry modules. Videos range from 30-60 minutes in length and may feature new technology, case studies, surgical techniques, complications, and discussions. CME credits are not available for viewing industry videos.

DEPUY SYNTHES

DePuy Synthes Neurosurgical Perspectives in Adult Complex Deformity Webinar
Faculty: Christopher Ames, MD

This session is led by our distinguished faculty, join DePuy Synthes Spine in learning about cervical alignment and classification, and avoiding complications in adult deformity.

DePuy Synthes Evaluation and Treatment Options in Adolescent Spinal Deformity Webinar
Chairman: Suken A. Shah, MD

Faculty: Joshua Pahys, MD; Amer Samdani, MD; Salil Upasani, MD

This session is led by our distinguished faculty, join DePuy Synthes Spine in learning about preoperative planning, differential rod-contouring, vertebral body derotation and strategies for large curves.

GLOBUS MEDICAL, INC.

Advanced Posterior Cervical Applications with ExcelsiusGPS®
Faculty: Peter Douglas Klassen, MD

Join Professor Klassen for a discussion about using ExcelsiusGPS® robotic navigation for advanced clinical applications. He will review his workflow, setup and approach for posterior cervical screw fixation. Attendees will walk away with an in-depth understanding of how to use ExcelsiusGPS® and lessons learned for cervical cases.

Topics Include:
- Why I chose ExcelsiusGPS®?
- Tips for a posterior cervical approach with ExcelsiusGPS®
- Registration process and procedural steps
- Case Review
- Q&A Session

MEDTRONIC

Robotic Pre-Op Planning, Patient-Specific Implants, AI and Predictive Analytics: Setting a New Standard in Spine Surgery
Faculty: Christopher Ames, MD; Daniel Hedequist, MD; Rajiv Sethi, MD; Gregory Poulter, MD

STRYKER

Anterior, Anterolateral, and Lateral Approaches to the Spine: When, Where and Why?
Faculty: Joseph O'Brien, MD, MPH, Robert Lee, BSc MBBS FRCS

Moderator: John Kostuik, MD

Our faculty will discuss what influences them when choosing the right approach to address various spinal deformities in a less invasive way. The three approaches provide different advantages and can each play an important role in your practice.

Intraoperative Imaging and Enabling Technologies: Using Technology to Help Improve Patient Outcomes
Faculty: Martin Gehrchen, MD, PhD, Stephen George, MD

Moderator: John Kostuik, MD

Prof. Martin Gehrchen and Dr. Stephen George will discuss how intra-operative imaging and navigation can help improve surgical outcomes and optimize workflow.

ZIMMER BIOMET

Vertebral Body Tethering – Connecting Indications to Outcomes
Faculty: Amer Samdani, MD; Lawrence Haber, MD; John Braun, MD; Daniel Hoernschemeyer, MD

INDUSTRY MODULES AND LIVE INDUSTRY SESSIONS

Industry modules can be accessed by clicking on "Industry Module" from the IMAST home screen.

INDUSTRY LIVE SESSIONS

Industry live sessions are programmed by the supporting company and include time for audience discussion and Q&A. These industry sessions are scheduled during the live IMAST program and the week following on April 28 and April 30. CME credits are not available for industry sessions.

FRIDAY, APRIL 23, 2021 | 11:05-12:05 ET

Medtronic
Innovations in Enabling Technologies
Faculty: Christopher Good, MD; Jeffery Gum, MD; Ronald Lehman, MD

SATURDAY, APRIL 24, 2021 | 10:50-11:50 ET

Stryker
Intraoperative Imaging and Enabling Technologies: Using Technology to Help Improve Patient Outcomes
Faculty: Martin Gehrchen, MD, PhD, Stephen George, MD

Moderator: Gene Gregerson

Please join us for a supplemental live session where our faculty will take a deeper look into intraoperative imaging and navigation. This session will build on the discussions from the prerecorded webinar, exploring how their workflow has benefited from incorporating technology.

SUNDAY, APRIL 25, 2021 | 10:40-11:40 ET

DePuy Synthes
Pediatric Spinal Deformity – Masters' Techniques and Case Based Discussions
Faculty: Suken A. Shah, MD; Robert H. Cho, MD; Stefan Parent, MD, PhD

WEDNESDAY, APRIL 28, 2021 | 19:00-20:00 ET

Globus Medical, Inc.
A Minimally Invasive Approach to Complex Procedures with ExcelsiusGPS®
Moderator: Mir Hussain, Director Field Applications, INR Globus Medical

Faculty: Richard Frisch, MD; Roland S. Kent, MD

The panel will describe minimally invasive deformity applications for ExcelsiusGPS® and single-position, single-stage robotic spine surgery, as well as strategies for building a strong robotic spine surgery program. Attendees will walk away with an in-depth understanding of how to use ExcelsiusGPS® for complex deformity and single-position cases.

Topics Include:
• Why ExcelsiusGPS®?
• Deformity Applications of ExcelsiusGPS®
• Setup and Workflow of Single-Position Lateral, Single-Stage Robotic Surgery
• Case Review
• Q&A

FRIDAY, APRIL 30, 2021 | 14:30-15:30 ET

Stryker
Anterior, Anterolateral and Lateral Approaches to the Spine: When, Where and Why?
Faculty: Joseph O'Brien, MD, MPH, Robert Lee, BSc MBBS FRCS

Moderator: John Kostuik, MD

Please join us for a live session of case presentations, where our faculty will discuss the pros and cons for each of the MIS approaches. This is a live supplemental session to our pre-recorded webinar and will be coming soon to the IMAST virtual meeting platform.

DON'T MISS THE INDUSTRY LIVE SESSIONS DURING THE PROGRAM.
Friday, April 23, 2021 | 11:05-12:05 ET | Medtronic
Saturday, April 24, 2021 | 10:50-11:50 ET | Stryker
Sunday, April 25, 2021 | 10:40-11:40 ET | DePuy Synthes
Wednesday, April 28, 2021 | 19:00-20:00 ET | Globus Medical, Inc.
Friday, April 30, 2021 | 14:30-15:30 ET | Stryker

PODIUM PRESENTATION ABSTRACTS

The Scoliosis Research Society gratefully acknowledges
Stryker
for their grant support of the IMAST Announcement Board Widget,
Calendar Widget, and Welcome Widget.

PODIUM PRESENTATION ABSTRACTS

1. THE TRENDS IN ROBOT-RELATED COMPLICATIONS, OPERATIVE EFFICIENCY, RADIATION EXPOSURE, AND CLINICAL OUTCOMES AFTER ROBOT-ASSISTED SPINE SURGERY: A MULTICENTER STUDY OF 722 PATIENTS AND 5,005 SCREWS FROM 2015 TO 2019

Nathan J. Lee, MD; Ian Buchanan, MD; Eric Leung, BS; Avery L. Buchholz, MD; John Pollina, MD; Ehsan Jazini, MD; Colin Haines, MD; Thomas C. Schuler, MD; Christopher R. Good, MD; Joseph M. Lombardi, MD; Ronald A. Lehman, MD

Summary

With the arrival of robot-assisted spine surgery nearly twenty years ago, there has been a growing amount of literature that suggests robots are safe and can achieve comparable outcomes to conventional techniques. However, much of this literature is limited by small sample sizes and single-surgeon or single center series. This is the first and largest multicenter study to examine the trends in outcomes and complications after robot-assisted spine surgery over a five-year period.

Hypothesis

We hypothesize that there are significant improvements in clinical outcomes over the last five years

Design

multicenter cohort

Introduction

Existing literature on robot-assisted spine surgery is limited to smaller sizes and the impact on operative and clinical outcomes over time are unclear.

Methods

Adult (≥18 years old) patients who underwent robot-assisted spine surgery from 2015-2019. Perioperative factors were compared across the years of surgery. The minimum follow-up was 90 days after the index surgery. 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

722 adults were included. Mean CCI was 1.5(1.5). 54.4% were female. The mean number of instrumented levels was 3.8(3.4). Most patient and operative factors (e.g., gender, smoking status, total instrumented levels, and pelvic fixation) were similar across years. From 2015-2019, mean time per screw decreased from 7.2 to 5.5 minutes (P=0.004, R2=0.65). Mean fluoroscopy time per screw decreased from 15.2 to 9.4 seconds (P=0.002, R2=0.83). Rates of intraoperative screw exchange for misplaced screw (P=0.0115, R2=0.13) and robot abandonment (P=0.011, R2=0.22) decreased significantly. The incidence of other surgical complications (e.g., dural tear, loss of motor/sensory function, blood transfusion) remained low. Length of stay (LOS) decreased nearly 1 day (P=0.007, R2=0.78), even though mean CCI worsened (P=0.036). 90-day reoperation rates did not change significantly.

Conclusion

Current trends demonstrate that robot screw accuracy, reliability, operative efficiency, and radiation exposure have improved significantly over the last five years. This is likely the result of increased surgeon experience with robots and the recent advances in robotic technology. The 90-day surgical complication rates remain consistently low and the mean length of stay has reduced significantly with time.

Take Home Message

We demonstrate robot screw accuracy, reliability, operative efficiency, and radiation exposure improved significantly from 2015-2019. 90-day complication rates remained low and LOS decreased significantly with time.
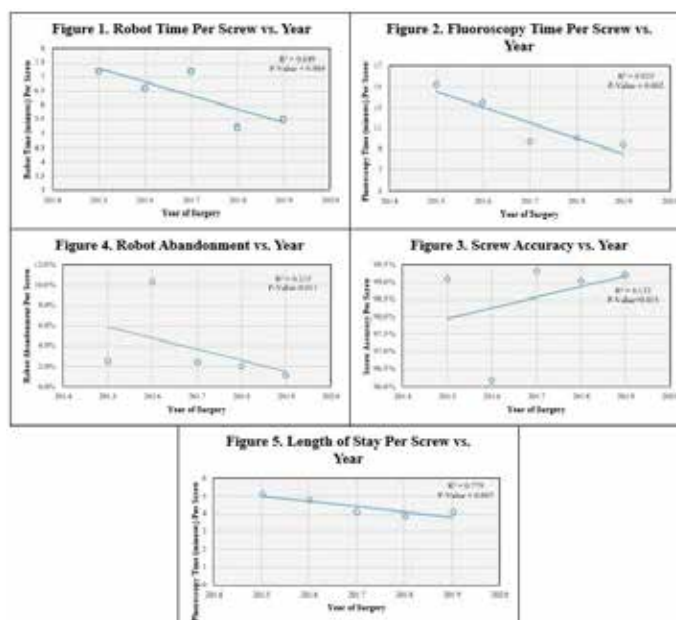
Figure 1. Robot Time Per Screw vs. Year
Figure 2. Fluoroscopy Time Per Screw vs. Year
Figure 4. Robot Abandonment vs. Year
Figure 3. Screw Accuracy vs. Year
Figure 5. Length of Stay Per Screw vs. Year

2. GLOBAL CORONAL MALALIGNMENT AFTER MIS ADULT SPINAL DEFORMITY SURGERY: MULTICENTER PROSPECTIVE ASSESSMENT OF 141 PATIENTS WITH MINIMUM 1-YEAR FOLLOW-UP

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Summary

Recent adult spinal deformity (ASD) studies suggested that postoperative global coronal malalignment (GCM; C7PL-midsacrum≥3cm) might be associated with worse outcomes after traditional open surgery. Few reports focus on GCM after minimally invasive surgery (MIS) for ASD. This study assessed 141 patients treated with MIS techniques and demonstrated

baseline GCM in 35% (n=49), persistent malalignment in 19% (n=27), iatrogenic malalignment in 16% (n=23), and corrected alignment in 16% (n=22). Postop GCM ≥3cm (36%, n=50) was not associated with worse clinical outcomes

Hypothesis
Although GCM may be common after ASD surgery, MIS correction can provide significant clinical benefits despite its occurrence.

Design
Prospective multicenter observational series

Introduction
Few reports focus on GCM after MIS ASD surgery.

Methods
Prospective multicenter MIS ASD data was reviewed. After minimum 1y fu, patients with GCM (≥3cm) were compared to coronally-aligned patients (<3cm).

Results
Of 198 consecutive pts, 141 (71%) achieved 1y fu and were included (age=68±11yr, 68% women, BMI=29±6). 50% had prior spine surgery, 2% were active/past smokers, 21% had osteoporosis, CCI=2.1±1.6, and ASD frailty index=3.4±1.4 (frail). Index MIS op data included: ant-post approach=82%, posterior fused levels=5.3±3.4, no. of interbody fusions=3.2±1.5, op time=6.8±3.7h, and EBL=0.5±0.7L. Overall, 1y postop alignment improved (p<0.05): TL Cobb 22±15º to 16±12º, lumbar Cobb 26±14º to 17±12º, LS Cobb 13±7º to 8±6º, max coronal Cobb 29±15º to 19±13º, SVA 6±6 to 4±5cm, PT 23±10º to 22±9º, PI-LL 15±17º to 6±13º, LL 40±21º to 48±17º, and TK-36±15º to -42±12º. HRQL improved (p<0.05): ODI 46±14 to 26±18, PCS 29±7 to 40±10, SRS22r-Total 2.8±0.6 to 3.5±0.7, Activity 2.8±0.7 to 3.4±0.9, Pain 2.4±0.8 to 3.5±0.9, Appearance 2.6±0.7 to 3.3±1.0, and Satisfaction 2.8±0.9 to 4.2±0.8. Incidence of baseline GCM was 35% (n=49), which was corrected in 16% (n=22), persisted in 19% (n=27), and appeared new (iatrogenic GCM) in 16% (n=23) for overall 1y postop GCM 36% (n=50). Of assessed baseline and op data, univariate results demonstrated postop GCM was associated with older age, increased CCI, worse baseline deformity (preop GCM, lumbar Cobb, SVA), worse baseline SRS Pain, and longer posterior fusions. However, these were not significant after multivariable analysis. Also, postop GCM was not associated with statistically inferior HRQL nor increased rates of complications.

Conclusion
Like with traditional open surgery, current results suggest postop GCM is also common after MIS ASD surgery, with similar overall incidence at baseline and 1y postop (~35%). Despite this, MIS treatment was still associated with significant HRQL improvement.

Take Home Message
Global coronal malalignment is common in patients undergoing ASD surgery. Despite this, the current results demonstrated that MIS ASD treatment was associated with significant clinical improvement at 1-year follow-up.

Global Coronal Malalignment and Minimally Invasive Adult Spinal Deformity Surgery
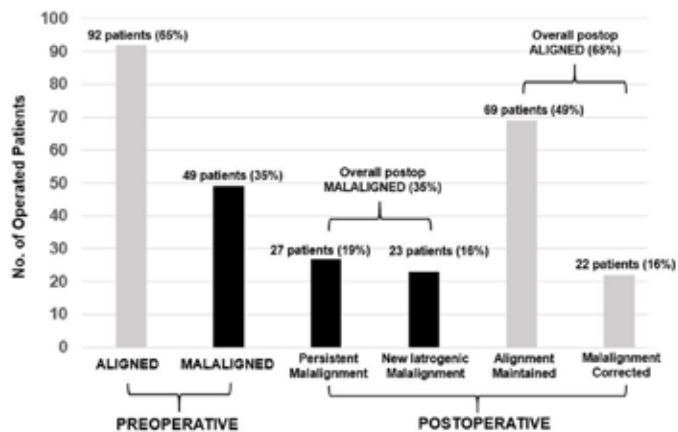
3. BARRIERS AND KNOWLEDGE GAPS IN APPROPRIATE POSTOPERATIVE OPIOID USE IN SPINE PATIENTS

Rafa Rahman, MPH; Sara Wallam, BS; Bo Zhang, MD; Rahul Sachdev, BS; Emmanuel McNeely, MS; Khaled M. Kebaish, MD; David B. Cohen, MPH; Sang Hun Lee, MD; Richard L. Skolasky, PhD; Brian J. Neuman, MD

Summary
We performed a retrospective review of prospectively collected data on 174 adult spine surgery patients at a single institution. Most patients reported barriers to appropriate postoperative opioid use, with associated factors including anxiety and lack of prior postoperative use of opioids. Many patients also faced knowledge gaps, associated with anxiety and lack of opioid use in the prior thirty days. Our results highlight areas that may be addressed through increased education and identifies patients who may benefit from such resources.

Hypothesis
That patients would report high rates of barriers and knowledge gaps in appropriate postoperative opioid use.

Design
Retrospective review

Introduction
Inappropriate postsurgical opioid use puts patients at risk of opioid dependence/abuse. Patient-reported barriers to appropriate postsurgical use are unknown. We sought to identify barriers and knowledge gaps, and associated factors.

Methods
Outcomes included barriers to appropriate postoperative opioid use, comfort with naloxone, and knowledge about safe opioid disposal methods. Multivariable logistic regression identified associated factors. Covariates were patient and surgery characteristics, experience with opioids, patient activation, and PROMIS scores.

Results

Of 174 adult spine surgery patients, the most common barriers were fear of addiction (71%) and concerns about disease progression (43%). Moderate to severe anxiety was associated with fear of distracting the physician (adjusted odds ratio [aOR], 3.8; 95% confidence interval [CI], 1.1–14); non-white/non–African-American race with concern about side effects (aOR, 7.0; CI, 1.7–32); and each 1-year increase in age with increased "desire to be good" (aOR, 1.1; CI, 1.01–1.2). Previous postoperative opioid use was associated with less concern about disease progression (aOR, 0.25; CI, 0.09–0.63) and the need to tolerate pain (aOR, 0.34; CI, 0.12–0.95). Higher educational level was associated with less fear of distracting the physician (aOR 0.30; CI, 0.09–0.97), and knowing someone who became addicted/overdosed with lower odds of "fatalism" (aOR, 0.37; CI, 0.14–0.88). 57% felt neutral/uncomfortable using naloxone. Opioid use during the preceding 30 days was associated with greater comfort with naloxone (aOR, 4.9; CI, 2.1–12). 86% were familiar with safe opioid disposal methods. Anxiety was associated with lower odds of knowing safe disposal methods (aOR, 0.18; CI, 0.04–0.72).

Conclusion

Most spine surgery patients reported at least one barrier to appropriate postoperative opioid use and felt neutral/uncomfortable with naloxone use. Associated factors included anxiety, not having used opioids within the preceding 30 days, and no history of postoperative opioid use.

Take Home Message

Our results emphasize the importance of addressing spine surgery patients' barriers and knowledge gaps in appropriate postoperative opioid use and highlight areas for further education and patients most at-risk.

4. SANDERS 2 SKELETAL MATURITY PATIENTS HAVE THE GREATEST RATE AND DURATION OF POST ANTERIOR TETHER SCOLIOSIS CORRECTION

Peter O. Newton, MD; Baron Lonner, MD; Kevin M. Neal, MD; Daniel Hoernschemeyer, MD; Firoz Miyanji, MD; Tracey P. Bastrom, MA; Harms Study Group

Summary

A multicenter analysis of the segmental rate of scoliosis correction in 71 thoracic idiopathic scoliosis patients with follow-up >2 years demonstrates that there is considerable progressive curve correction after AVBT in Sanders 2 patients (~2 deg/seg/yr x 3yrs), modest additional correction in Sanders 3 patients (<0.5 deg/seg/yr x 2yrs) and little if any correction in patients Sanders 4 or older. The substantial growth of Sanders 2 patients yields potential for large deformity correction as well as greater risk of over-correction.

Hypothesis

The rate of further scoliosis correction induced by a thoracic anterior vertebral body tether (AVBT) will be dependent on skeletal maturity at time of surgery.

Design

Retrospective, multicenter.

Introduction

Harnessing spinal growth with AVBT is proposed as a means of progressively correcting scoliosis. We compared the segmental rate of scoliosis correction based on preop Sanders maturity score.

Methods

Patients with thoracic idiopathic scoliosis who had AVBT and >2years follow-up (6 centers) were analyzed. Between screw angulation of each tethered motion segment was measured at all postoperative time points. We calculated each segment's screw angulation rate of change (degrees/month) between each of the patient's available visits (6, 12, 18, 24, 30, or 36 months). Patients were grouped using preop Sanders stage (2, 3, 4+). Linear mixed models were utilized for non-independent samples.

Results

We analyzed 71 patients (12.8±1.8 yrs) with right thoracic idiopathic scoliosis of 50±10°. Maturity at time of surgery varied from Risser 0-4, Sanders 1-7. A low volume of Sanders 1 (n=3) precluded statistical evaluation. The rate of change for each segment's screw angulation after AVBT declined over the follow-up time and differed significantly based on preop Sanders score (Figure). Scoliosis correction for Sanders 2 patients (n=15) continued for 30 months (-.24,-.32,-.23,-.12,-.05, +.02 deg/level/month at 6- 36 months respectively), [(-) values indicate reduction in scoliosis, p<0.001]. The correction for Sanders 3 patients (n=39) continued until 24 months, with slower rates: -.03,-.06,-.02 and-.02 at 6, 12, 18, 24 months respectively). There was no progressive correction for the Sander 4+ group (n=14). The rate of correction for Sanders 2 was significantly greater than Sanders 3 and 4+ at 6, 12, and 18 months (p<0.05).

Conclusion

There was considerable progressive correction after AVBT in Sanders 2 patients, modest additional correction in Sanders 3 patients, and little if any correction in patients Sanders 4 or older.

Take Home Message

The rate and duration of postoperative thoracic scoliosis correction after AVBT depends on skeletal maturity with the greatest potential for change in Sanders 2 patients (~2 deg/seg/year x 3 years).
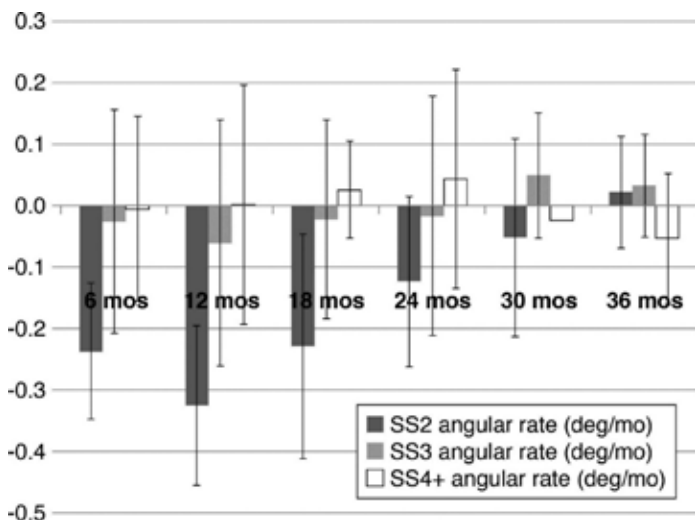
Figure. Segmental correction rate for each Sanders stage (deg/segment/month) for each 6 month period post AVBT (negative values represent decrease in scoliosis)

5. ANTERIOR SPINAL GROWTH TETHERING LEADS TO ASYMMETRIC GROWTH OF THE PERIAPICAL VERTEBRAE

Peter O. Newton, MD; Yohei Takahashi, MD, PhD; Yi Yang, MD; Burt Yaszay, MD; Carrie E. Bartley, MA; Tracey P. Bastrom, MA; Carlo Munar, BS

Summary
This study provides 3D radiological evidence that anterior spinal growth tethering (ASGT) modulates vertebral and disc growth in patients with progressive scoliosis correction.

Hypothesis
ASGT with progressive scoliosis correction is associated with asymmetrical periapical vertebral body growth.

Design
Retrospective

Introduction
ASGT utilizes a flexible cord to limit convex spinal growth in immature scoliosis patients.

Methods
Patients with ASGT for AIS (all Risser 0 at surgery) between 2012-2016, >2 years of follow-up, and 3D reconstructions based on bi-planar images were retrospectively studied. Patients were divided into two groups: progressive scoliosis correction (PC) or not (NPC). From the 3D reconstructions, averages of the 3 apical vertebral and disc heights (Rt, Lt, Ant, Post) and angular measures were made. The rate of change for each measure (mm/mo, deg/mo) from first erect to 2-year follow-up was compared between groups. Patients were excluded if tether breakage or revision surgery occurred.

Results
Fourteen (Risser 0, Sanders 2-3) patients aged 11.4±1.4 years with right thoracic idiopathic scoliosis of 52±9° were included, 7 per group (6F, 1M/group). Mean follow-up was 3.6±1.1 (range 2-5) years. Although vertebral growth occurred in both groups, the PC group increased the convex, left sided vertebral height at 0.13mm/mo compared to just 0.05mm/mo in the NPC group, p=0.001. Right (tethered side) vertebral growth was not different (PC: 0.07mm/mo, NPC: 0.05mm/mo, p=0.2). The rate of change in coronal vertebral wedging was -0.11deg/mo compared to-0.02deg/mo for the PC and NPC groups respectively, p=0.004. The coronal disc angulation also decreased with rates similar to those seen in the vertebrae (PC: -0.12deg/mo, NPC:-0.04deg/mo, p=0.03) and was associated with loss of right (convex) disc height (PC:-0.06mm/mo) with little effect on the concavity (PC:-0.01 mm/mo).

Conclusion
ASGT in immature patients with thoracic scoliosis can asymmetrically modulate the growth of the periapical vertebrae and discs. Progressive reduction in scoliosis after ASGT was associated with faster concave growth rates in the vertebrae and loss of disc height on the convexity. Given the immaturity of the entire cohort, it remains unclear why some patients responded better than others.

Take Home Message
ASGT modulates vertebral and disc growth in patients with progressive scoliosis correction with faster concave growth rates in the vertebrae and loss of disc height on the convexity.

Average Rate of Change for Each Variable Measurements from the First Erect Post-operative Visit to 2-Year Follow-Up				
	PC Group	NPC Group	p-value*	Effect Size
Left Vertebral Height (mm/mo)	0.13	0.05	**0.001**	-0.84
Right Vertebral Height (mm/mo)	0.07	0.05	0.165	-0.39
Anterior Vertebral Height (mm/mo)	0.09	0.03	**0.007**	-0.70
Posterior Vertebral Height (mm/mo)	0.12	0.06	**0.007**	-0.70
Vertebral Kyphosis (deg/mo)	0.03	0.02	0.620	-0.15
Vertebral Cobb (deg/mo)	-0.11	-0.02	**0.004**	-0.73
Left Disc Height (mm/mo)	-0.01	-0.01	0.535	-0.19
Right Disc Height (mm/mo)	-0.06	-0.03	0.209	-0.36
Anterior Disc Height (mm/mo)	-0.04	-0.01	0.805	-0.09
Posterior Disc Height (mm/mo)	-0.05	-0.03	0.535	-0.19
Disc Kyphosis (deg/mo)	-0.004	0.02	0.535	-0.19
Disc Cobb (deg/mo)	-0.12	-0.04	**0.026**	-0.60

*p-value was calculated by Mann Whitney U Test.

Bold values represent statistical significance.

6. SPINAL GROWTH AND CORD BREAKAGE TWO YEARS FOLLOWING VERTEBRAL BODY TETHERING

John B. Hargiss, BS; Todd Milbrandt, MD; D. Dean Potter, MD; A. Noelle Larson, MD

Summary
At 2 years, cord breakage was noted in 8/23 patients, with a mean of 23 mm in total change in T1-T12 height and 15 mm increase between 1st erect and 2-year follow-up radiographs.

Hypothesis
Cord breakage is common following VBT, but spinal growth continues.

PODIUM PRESENTATION ABSTRACTS

Design
Retrospective case series.

Introduction
Vertebral body tethering is proposed to preserve longitudinal spine growth; however, definitive data is lacking. Further, early reports of VBT have found high rates of cord breakage.

Methods
Patients who underwent VBT with minimum 2-year follow-up were included (mean, 2.6 years). Mean age at surgery was 12.8 (18 females and 5 males). Mean Risser was 0.6 (range, 0-3) and Sanders SMS was 3.3 (range, 2-5). A mean of 7.8 levels were instrumented (range, 6-10). The angle between the screws was measured at each time point. A change in interscrew angle 5 degrees or more was considered a broken cord. T1-T12 and T1-S1 height were measured on preop, 1st erect, 1- and 2-year follow-up.

Results
From first erect standing radiograph to 2 years postop, T1-T12 height increased a mean of 14 mm (p<0.05), and T1-S1 increased a mean of 27 mm (p<0.05). Comparison of screw angle changes by 2 years postop revealed 10 of the 23 patients had cord breakage (43%) with a total of 14 affected vertebral segments. By 3-year follow-up, no additional patients had cord breakage, although additional segments broke. Three revision surgeries were performed for inadequate curve correction (1 retethering, 1 posterior fusion) and symptomatic implants (cord and screw removal). All three patients had broken cords, but it was unclear if tether breakage precipitated the revision surgeries.

Conclusion
Significant spinal growth was noted, despite cord breakage occurring in over one third of patients by 2-year follow-up.

Take Home Message
Although cord breakage occurred in more than 1/3 of patients, there was significant T1-T12 growth following VBT. \
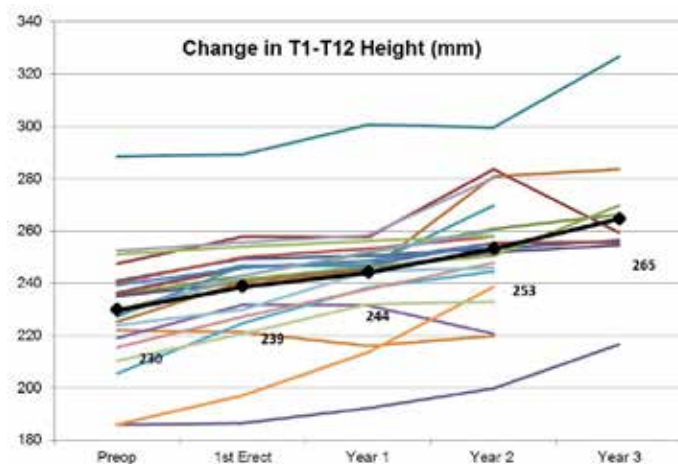
7. THE HARMS STUDY GROUP RETROSPECTIVE COMPARISON STUDY ON ANTERIOR VERTEBRAL BODY TETHERING (AVBT) VERSUS POSTERIOR SPINAL FUSION (PSF) FOR PRIMARY THORACIC CURVES

Peter O. Newton, MD; Stefan Parent, MD, PhD; Firoz Miyanji, MD; Ahmet Alanay, MD; Baron Lonner, MD; Kevin M. Neal, MD; Daniel Hoernschemeyer, MD; Burt Yaszay, MD; Laurel C. Blakemore, MD; Suken A. Shah, MD; Harms Study Group

Summary
122 thoracic AVBT patients were matched to 122 PSF for idiopathic scoliosis utilizing a multicenter database. Curve correction was greater for the PSF cohort and the revision rate was lower (2.5% vs. 16.3%) compared to AVBT group. SRS-22 outcomes were similar at >2 yrs, except that self-image domain median values were lower for AVBT. This may help inform the decision facing patients and families considering AVBT compared to the gold standard, PSF.

Hypothesis
Outcomes of Anterior Vertebral Body Tethering (AVBT) will be comparable to Posterior Spinal Fusion (PSF).

Design
Retrospective, multi-center study.

Introduction
A large, multi-center comparison of the outcomes of AVBT to PSF for thoracic idiopathic scoliosis (IS) is necessary to inform clinicians and patients treatment decisions.

Methods
Cases of thoracic IS who underwent AVBT with a min follow-up of 2 yrs underwent propensity guided matching to PSF patients from a prospective IS database registry. Preop and latest follow-up outcomes were compared.

Results
A total of 122 patients (12.6±1.8 yrs, 84% F, 73% Risser 0) in the AVBT group from 11 surgeons were compared to 122 patients (13.0±1.7 yrs, 92% F, 47% Risser 0) in the PSF group from 25 surgeons. The mean follow-up was similar: 2.6±0.8 yrs for AVBT vs. 2.3±0.5 yrs for PSF. Pre-op, thoracic curves of 48±10° (range 30-71°) for AVBT were lower than 53±8° (range 40-71°) for PSF, p<0.001. Initial % correction was 41±17% vs. 71±12% for AVBT and PSF respectively, p<0.001. At latest follow-up the residual thoracic Cobb was 29±11° in the AVBT group and 18±7° for the PSF group (p<0.001). 74% of AVBT patients had a thoracic curve <35° at latest follow-up compared to 99% of PSF patients, p<0.001. No PSF pts had a residual curve at latest follow-up >50° while 7 (6%) had such after AVBT. Twenty (16.3%) revision procedures (6 PSF, 10 loosen/remove tether, 4 replace/add tether) were performed on 14 (11.5%) AVBT patients vs. 3 revision in 3 PSF patients (2.5%), p<0.01. AVBT patients had lower median preop SRS-22 mental health scores and lower latest follow-up median self-image scores compared to PSF patients (p<0.05, p<0.05), other domains were no different.

Conclusion
At mean follow-up of 2.6 years, AVBT for thoracic IS in 122 pts resulted in correction to <35 deg in 74% of cases with a 16.3% revision rate and an additional 6% with curves >50 deg that may require revision/PSF. This compares to 99% with a residual curve<35 deg and a 2.5% revision rate for the PSF cohort. This may help inform the decision facing patients and families considering these 2 options.

Take Home Message
This multicenter study demonstrates greater residual curve and higher rate of revision surgery in patients with thoracic scoliosis treated with AVBT compared to the gold standard PSF at ~2.5 yrs.

8. OUTCOMES OF MCGR AT >3-YEAR AVG. FOLLOW-UP IN SEVERE SCOLIOSIS: WHO UNDERGOES ELECTIVE REVISION VS. UPROR?

Michelle C. Welborn, MD; Daniel Bouton, MD

Summary
At 3yr avg follow-up 42% of pts were electively revised, 33% were still lengthening, 21% experienced unplanned return to the operating room (UPROR) and 5% were being observed

Hypothesis
Increased preop Cobb, kyphosis, and younger age at implantation would be associated with increased UPROR

Design
IRB approved single site retrospective cohort study

Introduction
Complications associated with MCGR range from 0-100%, avg 44%, with unplanned return to the OR (UPROR) of 9-57% in the reported literature. Decision making around when to perform MCGR remains challenging as many pts experience UPROR and thus never achieve full length of their MCGR. Some patients are electively revised prior to achieving full length due to convenience or skeletal maturity. We defined maximum length as achieving >85% of the maximum length of the elongating portion of the rod with elective revision

Methods
106 MCGR were placed at a single institution between 2014-2020. Exclusion criteria: <1 year follow-up, and previous instrumentation or revision surgery. 48 pt were included 16 in the Halo gravity traction (HGT) group and 32 in the nonHGT group

Results
Ave F/u was 1103 days, 1200 in the HGT group and 1054 days in the nonHGT group. Ave time to revision surgery was 767 days. UPROR was only correlated to male gender p=0.046, 8/10 patients that experienced UPROR were male, all failures to elongate occurred in male patients as did the single rod fracture. We were underpowered to detect a correlation between UPROR and major Cobb p=0.094, flexibility p=0.177 or kyphosis p=0.817. The time to revision surgery based on the actuator length was 831 days for the 90mm length vs. 698 days in the 70mm length but was not significant p=.28, actuator length did not change the rate of UPROR

Conclusion
Complications associated with MCGR remain high. Increased risk of UPROR was associated with male gender. Overall, the average time to revision surgery was 767 days, at >3yr follow-up 21% of patients experienced UPROR, 42% were electively revised to a new MCGR or fusion, 33% were still lengthening and <5% were being observed

Take Home Message
Ave time to revision surgery for MCGR was 767 days. Better knowledge of MCGR outcomes and avg time to revision may improve pt education, surgical timing and decision-making

	n	Ave follow-up in (days)	Average time to revision surgery (days)	UPROR	Max Length achieved*		Elective revision prior to max length		Still lengthening	Lengthening stopped electively
					Revision MCGR	Fusion	Revision MCGR	Fusion		
HGT	16	1200	810.29	4	4	1	1	4	2	0
nonHGT	32	1054	722.69	6	3	3	0	4	14	2
All patients	48	1103	766.74	10	7	4	1	8	16	2

*defined at >85% of potential lengthening achieved. >4.06 cm for 90mm actuator Range (41.5-45.8), >2.28cm for 70mm actuator (25.4-29.5)

9. EARLY RESULTS OF A NOVEL GROWTH ROD FOR EARLY ONSET SCOLIOSIS

Kristopher M. Lundine, MD, MSc, FRCSC, FRACS; Michael B. Johnson, MBBS, FRACS

Summary
Early onset scoliosis represents a complex group of patients that can be very challenging to manage. We have been using a new MIS ratchet-based growth rod since 2017. Our early results demonstrate an average of about 50% correction of the primary Cobb angle with just over 50% of patients showing sustained spinal growth at most recent follow-up. Complications occurred in 39% of our patients with 35% of patients requiring an unplanned return to theatre.

Hypothesis
This study presents the early findings in patients who have had a ratchet-based growth rod placed for treatment of their early onset scoliosis.

Design
Retrospective Case Series

Introduction
Early onset scoliosis is a challenging clinical scenario with many surgical options to consider. Complications are common regardless of implant choice. We began using a new growth rod at our institution in June, 2017. This is a 'ratchet-like' system that allows ongoing spinal growth after implantation without the need for further surgical intervention. This study is a description of our early clinical experience with this technique.

Methods
All patients undergoing surgical correction of their scoliosis with the new growth rod were identified in the surgical database of a single pediatric institution. Patient charts were reviewed to identify demographic data and to assess clinical outcomes including complications. Pre-operative and most recent post-operative radiographs were reviewed to assess curve measurements and spinal growth. Complications were classified according to the modified Clavien-Dindo-Sink system with grade III and above considered a major complication.

Results
31 patients underwent surgical correction of their scoliosis using the ratchet growth rod between June, '17 and Dec., '19. Average age at surgery was 10.5 years and the average clinical follow-up was 21 months. The most common primary diagnosis was Cerebral Palsy (10 patients) and 12 (39%) of the patients were ambulant. Mean cobb angle went from 89 to 46 degrees for an average correction of 48%. Mean increase in thoracic height (T1-12) was 3 cm. There were 15 major complications in 12 patients. 11 patients had a total of 12 unplanned return to theatre cases including 2 deep infections.

Conclusion
This growth rod demonstrated ongoing spinal growth in about 50% of the patients. In this series of 31 patients, 39% experienced a major complication and 35% required an unplanned return to theatre. Many complications resulted in modifications of the original technique to improve safety and prevent future similar complications. This is the largest clinical series of this implant outside of the original center where it was designed.

Take Home Message
This new ratchet-based growth rod can be successful in allowing ongoing growth while correcting the curve in patients with early onset scoliosis.

10. SCOLIOSIS SURGERY NORMALIZES CARDIAC FUNCTION IN AIS PATIENTS

Sarika Kalantre, MD, MBBS; Rachel Gecelter, BS; Jesse M Galina, BS; Aaron M. Atlas, BS; Sayyida Hasan, BS; Terry D. Amaral, MD; Beverly Thornhill, MD; Marina Moguilevtch, MD; *Vishal Sarwahi, MD, MBBS*

Summary
Patients with scoliosis may have a higher incidence of pulmonary hypertension and cardiac disease. A retrospective analysis of patients with AIS having spinal fusion surgery will examine any correlation between severity of scoliosis and estimated right ventricular systolic pressures (RVSP).

Hypothesis
Compared to healthy patients, AIS patients have higher incidence of pulmonary HTN and structural cardiac disease that worsens with increasing curve angle and improves following scoliosis surgery. We hypothesize that scoliosis repair resolves cardiac functional abnormalities.

Design
Retrospective review

Introduction
Spinal deformity in AIS can increase right atrial and ventricular pressures secondary to restrictive lung disease. Pulmonary HTN leading to cor pulmonale is the most feared outcome, however mild pulmonary HTN in AIS patients has been reported in the past. No study has examined these changes, including the improvement of right heart function following scoliosis surgery.

Methods
Group 1: 202 AIS patients undergoing PSF from 2009-2013 at a single institution. Group 2: control patients, 179 healthy, age-matched adolescents. Cobb angle, 2D-echo signs of structural heart disease, aortic root dimensions, tricuspid regurgitant jet velocity (TRV), PFTs, ABG, and patient demographics reviewed. RVSP was estimated using Bernoulli's equation [4(TRV)2] and right atrial pressure. RVSP ≥ 36mmHg is a surrogate marker for pulmonary HTN. All echocardiograms were read by board certified Pediatric Cardiologists. Group 3: 47 AIS patients from Group1 with elevated preoperative TRV underwent corrective PSF. Logistic regression was used to assess for differences in TRV between groups.

Results
Mean preoperative RVSP was significantly elevated in AIS patients (p<0.001) compared to controls (17.25 ± 0.88). 47 (21%) Group1 patients had elevated preoperative TRV (≥ 2.8 m/s) vs. no Group2 patients (p<0.001). Additionally, logistic regression showed AIS patients have an odds ratio of 3.29 for elevated TRV (p=0.007) – an indirect measure of pulmonary HTN. In all Group3 patients, the cardiac function normalized postoperatively (p<0.001). No association was found in Cobb angle, aortic root parameters, or PFTs.

Conclusion
It was found that 21% patients with AIS had elevated TRV while age-matched controls had no TRV abnormalities. RVSP measurements demonstrated mild pulmonary HTN in AIS patients. These abnormal values normalized postoperatively, indicating the benefits of scoliosis surgery on cardiac function in AIS.

Take Home Message
AIS patients have abnormal right heart function which normalizes postoperatively, indicating the medical benefit of PSF in AIS.

11. INDICATIONS AND TIMING OF REVISION SPINE SURGERY IN ADULTS AFTER ADOLESCENT SURGERY FOR IDIOPATHIC SCOLIOSIS

Andrew Diederich, BS; Jace Erwin, MD; Brandon B. Carlson, MD; Joshua Bunch, MD; Robert Sean Jackson, MD; Douglas C. Burton, MD

Summary
81 patients who had surgery in adolescence for idiopathic

scoliosis were examined as adults to identify the timeline and indications for revision surgery. The time from index operation to revision was bimodal. The most common indications were implant malposition, which generally were identified within 15 years post-operation, and subjacent segment degeneration with stenosis, which usually presented over 30 years post-operation. The need for revision had a large impact on quality of life but significant improvements were made after revision surgery.

Hypothesis
Revision surgery for Adolescent Idiopathic Scoliosis (AIS) in adulthood will occur in a bimodal fashion.

Design
Case Series Study

Introduction
Previous studies on adolescent patients treated surgically for idiopathic scoliosis have shown revision usually occurs within three months or more than 5 years after the index operation. It is not clear what the impact, indications for and timeline to revision surgery are in these patients during adulthood.

Methods
421 patients with AIS were seen as adults over a 15-year period. 81 patients who had scoliosis surgery prior to age 18 were identified. This cohort was studied for indications and time from index to revision operation. SRS-22r surveys were collected before and after revision to assess the impact on quality of life.

Results
Of the 81 patients, 18 (22.2%) had a revision surgery. Mean age of the patients requiring revision was 36.1 ± 17.9 (18-70) and mean age at index operation was 14.6 ± 2.0 (12-17). The number of patients requiring revision for each indication and the average and standard deviation of the time from index to revision operation are shown in Table 1. Prior to revision, the average SRS-22r survey Total was 3.04 (1.98-4.24). After revision, SRS Total score and all SRS subcategories showed improvement except for Mental Health. Significant changes were seen with SRS Total, Pain, and Management Satisfaction. Total score, Pain score, and Management Satisfaction score improved by 0.613 (P=.03), 0.99 (P=.004), and 1.6 (P=.007) respectively.

Conclusion
The timeline for revision spine surgery in idiopathic scoliosis is bimodal. The most common indication for revision was implant malposition, which generally presented within 15 years of the initial operation. Subjacent segment degeneration with stenosis was also common and usually presented over 30 years post-operation. Other indications also fit this bimodal pattern. Corrective surgery allowed for large improvements in quality of life, as determined by the SRS-22r survey, with Total, Pain, and Management Satisfaction scores showing significant improvement.

Take Home Message
Patients requiring revision surgery for idiopathic scoliosis

present in a bimodal fashion. Revision surgery in carefully selected patients leads to improved quality of life.

Revision Indication	Number of Patients	Avg Years Post Initial Operation	Standard Deviation
Implant Malposition	4	11.32	2.10
Implant Malposition + Pseudarthrosis	1	3.72	N/A
Implant Malposition + Stenosis	1	19.96	N/A
Pseudarthrosis	3	5.20	3.82
Subjacent Segment Degeneration/Stenosis	4	38.58	13.81
Delayed Deep Wound Infection	2	11.93	7.42
Spondylolisthesis	2	43.27	1.21
Symptomatic Implants	1	3.43	N/A

Table 1

12. PRIMARY BENEFIT OF TWO-SURGEON TEAM IN AIS DEFORMITY CORRECTION IS REDUCED PROCEDURE LENGTH

Brandon J. Marshall, BS; Michael G. Read, MD; Andrew Romero, MS, BS; Gary M. Kiebzak, PhD; Suken A. Shah, MD; John F. Lovejoy, MD

Summary
Adolescent Idiopathic Scoliosis is the most common form of scoliosis in children. Recent literature has focused on the use of two attending surgeons to improve outcomes in surgery. This study retrospectively reviewed 340 cases of AIS with differing surgical teams, including an additional surgeon, physician's assistant, and fellow as first assist. Overall, the two attending surgeons reported better results with respect to procedure length, blood loss, time in hypotension, and early postoperative pain. Other studied variables were similar between groups.

Hypothesis
The two attending teams would have better outcome measures, decreased complications, with less operating room time.

Design
This retrospective review included patients with AIS who underwent posterior spinal fusion (PSF) in our health system.

Introduction
Adolescent Idiopathic Scoliosis (AIS) is the most prevalent form of scoliosis in children. Traditionally these surgeries were performed with a single surgeon with an assistant. Recent studies to improve patient safety, reduce postoperative complications, and increase operating efficiency have focused on the use of two attendings.

Methods
This retrospective review included patients with AIS who underwent PSF in our health system over four years. Patients aged 2 to 17 at the time of surgery with a minimum of 3 months follow-up, and two-person operative team were included. Makeup of surgical team (Attending-Attending, AA; Attending-Physician Assistant, APA; Attending-Fellow, AF) was the primary variable. Secondary variables included patient demographics, preoperative, intraoperative, and postoperative data, complications, and follow-up data.

Results

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Our study reviewed 340 cases of PSF performed on AIS patients. Demographically the patients in each group were similar, except for a lower proportion of Caucasian patients in the AA group, lower ASA in AF, and fewer Medicaid patients in the AF group. Results showed the AA group had shorter procedure times than APA and AF. There were no significant differences in comorbid conditions, preoperative Cobb angle or hemoglobin, correction attained, transfusion requirement. The AF group had shorter length of stay, required fewer pressor medications, and spinal segments fused. The AF group had significantly greater EBL, time in hypotension, fluid administration, reported early pain. No difference in surgical complications was noted between groups. When the AA and APA cases of one surgeon were investigated, patients were found to have significantly reduced procedure time, blood loss, and length of stay for AA cases.

Conclusion

This study suggests that the AA group reports better outcomes in procedure length, EBL, time in hypotension, and reduced early pain.

Take Home Message

We recommend considering the use of two attending surgeon teams as this appears to provide the best metrics relating to blood loss, time under anesthesia, and immediate postoperative pain.

Table 1. Comparison of Significant Variables in Differing Surgical Teams in Treatment of AIS

Variable	Two Attending Surgeons, AA N = 118	One Attending + Fellow, AF N = 157	One Attending + PA, APA N = 59	ANOVA P
Race, % white	55	77	71	<0.0001 AA vs AF, <0.0001 AA vs APA, 0.0145 AF vs APA, NSD
ASA	1.99 ± 0.56	1.74 ± 0.48	1.97 ± 0.52	0.0002 AA vs AF, <0.001 AA vs. APA, NSD AF vs APA, <0.05
Medicaid insurance, %	61.8	10.9	54.2	<0.0001 AA, APA vs AF, <0.0001 AA vs APA, NSD
Procedure time, min	297.5 ± 69.7	381.2 ± 66.8	388.5 ± 73.8	<0.0001 AA vs AF, <0.001 AA vs APA, <0.001 AF vs APA, NSD
Segments fused	12.0 ± 1.4	10.8 ± 2.1	12.6 ± 1.5	<0.0001 AA vs AF, <0.001 AF vs APA, < 0.001 AA vs APA, NSD
EBL, ml	248 ± 138	774 ± 397	300 ± 171	<0.0001 AA vs AF, <0.001 AF vs APA, <0.001 AA vs APA, NSD
% Procedure in hypotension	4.07 ± 3.9	14.8 ± 13.6	3.12 ± 2.8	<0.0001 AA vs AF, <0.001 AF vs APA, <0.001 AA vs APA, NSD
Intraop pressor admin, %	72.0	24.2	71.2	<0.0001 AA vs AF, <0.001 AF vs APA, <0.001 AA vs APA, NSD
Fluid admin, ml	1511 ± 551	2630 ± 827	1863 ± 549	<0.0001 AA vs AF, <0.001 AA vs APA, <0.01 AF vs APA, <0.01
LOS, days	3.23 ± 0.85	2.86 ± 0.90	3.68 ± 0.90	<0.0001 AA vs AF, <0.01 AA vs APA, <0.01 AF vs APA, <0.001

13. DOES PATIENT FRAILTY STATUS INFLUENCE RECOVERY PATTERNS AND ULTIMATE OUTCOME FOLLOWING SPINAL FUSION FOR CERVICAL DEFORMITY?

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Summary

Utilizing a novel area-under-the-curve (AUC) normalization methodology, our analysis establishes objective recovery benchmarks for 3M and 1Y follow-up time points for frailty status. Across frailty scores, patients exhibited postoperatively improved health related quality of life (HRQL) scores. Severely frail patients exhibited significantly better improvement in terms of overall health state.

Hypothesis

Frailty states have unique recovery profiles.

Design

Retrospective.

Introduction

Frailty has been utilized in CD to characterize the influence of preop health state on postop outcomes, and may be an important determinant for impaired recovery after corrective surgery.

Methods

Patients>18yrs undergoing surgery for CD with HRQL data at BL, 3M and 1Y postop intervals were identified. Pts were stratified by the modified CD frailty index scale from 0-1(not frail:<0.3[NF], mild/severe: >0.3[F]). NF and F pts were propensity score matched (PSM) for TS-CL. HRQLs were normalized by dividing BL and postop(3M, 1Y) by BL. Normalized scores(y-axis) were plotted against duration of follow-up(x-axis). AUC was calculated; total area for each follow-up interval was divided by cumulative follow-up, determining overall, time-adjusted HRQL (Integrated Health State [IHS]). IHS was compared between frailty groups.

Results

106 CD pts included (62ys, 66% F, 28 kg/m2). By frailty: 53% NF, 47% F. After PSM for TS-CL (mean: 38.1°), 38 patients remained in each group. At BL, cervical and spinopelvic radiographic parameters were not significant, except for C7-S1 SVA(p=0.007). According to BL HRQLs, F pts displayed worse NDI scores (NF: 36.8 F: 55.4; p<0.001), mJOA (NF: 14.7, F: 12.7; p=0.002), and EQ5D (NF: 0.78, F: 0.69; p<0.001). All frailty groups exhibited BL to 1Y improvement in NDI, EQ5D and NRS Neck Pain (all p<0.001). After HRQL normalization, F pts had more improvement in mJOA scores at 3M(p=0.065), NDI(p=0.096), and EQ5D(p=0.016). IHS-adjusted HRQL outcomes from BL

to 1Y showed a difference in EQ5D scores (NF: 1.02, F: 1.07, P=0.016). No differences were found in the IHS NDI and mJOA between frailty groups (p>0.05). F pts had more postop major complications (31.3%) compared to the NF (8.9%), p=0.004.

Conclusion
While all groups exhibited improved postop disability/pain scores, frail patients recovered better in overall health state. Despite frail patients having more complications, they seem to have overall better patient-reported outcomes, signifying that with frailty severity, patients have more room for improvement postop compared to baseline quality of life.

Take Home Message
Despite frail patients having more complications, they appear to have overall better patient-reported outcomes. With frailty severity, patients have more room for improvement postop compared to baseline quality of life.
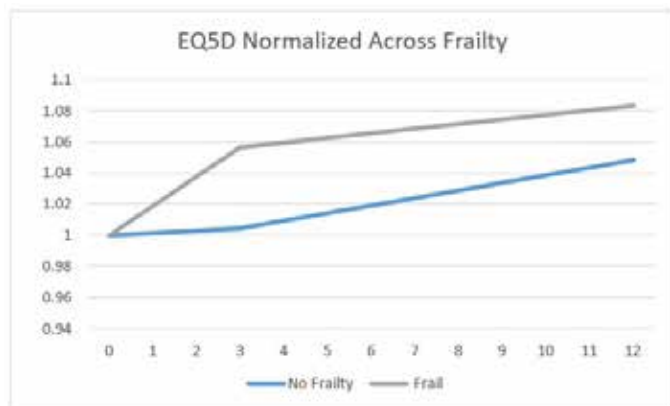
Table 1. EQ5D Scores Normalized and plotted by follow-up time point.

14. THE NATURAL HISTORY AND PROGNOSIS OF MAJOR NEUROLOGICAL COMPLICATION IN SPINAL DEFORMITY CORRECTION SURGERY

Yong Qiu, MD; Jie Li, MD; Zhen Liu, MD; Zongshan Hu, PhD; Ziyang Tang, MD; Abdukahar Kiram, PhD; Zezhang Zhu, MD

Summary
Previous studies have characterized the incidence and risk factors related to perioperative neurological complications (NC). In this study, we review the cases with neurological complication in large spinal deformity patient cohorts and explored it's natural history and outcomes.

Hypothesis
To exam the prognosis of NC after scoliosis correction surgery.

Design
retrospective study

Introduction
Despite the well documented incidence and risk factors of NC in scoliosis correction surgery, there is currently a lack of report on its prognosis and clinical outcomes. We aimed to analyze the natural history and outcomes of NC in scoliosis correction surgery.

Methods
A total of 7851 patients who underwent deformity correction surgery were reviewed. Major neurological complication was identified in 59 patients including complete or incomplete paralysis (28 males and 31 females with average age of 25.0±16.3 years), including 5 with complete paraplegia, 17 with incomplete paralysis, and 37 with incomplete paraplegia. The etiology included 6 idiopathic, 22 congenital, 10 neuromuscular, 4 type I neurofibromatosis (NF1), and 1 Marfan syndrome. Patients were followed to assess the natural outcome of neurological complications.

Results
The incidence of NC was 0.75%. At the final follow-up, 41 patients had complete recovery and 9 patients had partial recovery. The causes included 12 cases with screws misplacement, 12 cases with mechanical injury, 4 cases with ischemic injury, and 3 cases with epidural hematoma. There was no recovery of neurological function in 7 patients, including paraplegia in 2 patients at T10 or T4 level, and 5 patients with incomplete paraplegia. The recovery was significantly associated with etiology(P=0.008). 3 of 4 patients with neurofibromatosis failed to recover during follow-up, which could be related to 2 cases of preoperative neurological deficit (P=0.087). There was no significant correlation between the patient's age at surgery, surgical approach, the use of three-column osteotomy or removal of internal fixation and neurological recovery (P>0.05).

Conclusion
For patients who had NC after scoliosis correction, 88.1% of patients were able to recover during follow-up. Patients with NF1 with preoperative neurological impairment have poor prognosis. Unless there is direct evidence on radiological examination, removal of internal fixation is not recommended.

Take Home Message
Attention should be paid to the poor prognosis of patients with type I neurofibromatosis, or preoperative neurological impairment.

15. HEALTH-RELATED QUALITY OF LIFE AND SAGITTAL BALANCE 2-25 YEARS AFTER POSTERIOR TRANSFIXATION FOR HIGH-GRADE DYSPLASTIC SPONDYLOLISTHESIS

Tom P. Schlösser, MD, PhD; Enrique Garrido, MD, FRCS; Athanasios I. Tsirikos, MD, PhD, FRCS

Summary
High-grade dysplastic spondylolisthesis is a disabling disorder for which many different operative techniques have been described.

Hypothesis
Partial reduction, transfixation without decompression for high-grade dysplastic spondylolisthesis in pediatrics results in satisfactory long-term health-related quality of life and sagittal balance.

Design

Retrospective national cohort study

Introduction

The aim of this study is to evaluate SRS-22r scores, global balance and regional spino-pelvic alignment 2-25 years after surgery for high-grade dysplastic spondylolisthesis using an all-posterior partial reduction, transfixation technique performed in a single institution.

Methods

SRS-22r and full-spine radiographs were collected for the 27 of 28 pediatrics that underwent surgery for high-grade dysplastic spondylolisthesis in a national deformity center. The mean follow-up was 9 years (range 2-25 years). The standard surgical technique was an all-posterior, partial reduction, S1-L5 transfixation screw technique without direct decompression. Parameters for segmental (slippercentage and lumbosacral angle) and regional alignment (PT, SS, L5incidence, LL and TK) and global balance were measured. SRS-22r scores were compared between patients with a balanced and unbalanced pelvis at final follow-up.

Results

SRS-22r domain and total scores improved significantly from preoperative to final follow-up, except for the mental health domain that remained the same. Slip percentage improved from 75±15% to 48±19% and lumbosacral angle from 70±11° to 101±11°. Preoperatively, 35% had global imbalance, at follow-up all were balanced. Preoperatively, 63% had an unbalanced pelvis, at final follow-up 32%. SRS-22r scores were not different in patients with a balanced or unbalanced pelvis. However, postoperative pelvic imbalance as measured by L5 incidence was associated with lower SRS-22r self-image and total scores (P=.029).

Conclusion

In young patients with HGDS, partial reduction and transfixation improves local lumbosacral alignment, restores pelvic and global balance and provides satisfactory long-term clinical outcomes. Higher SRS-22r self-image and total scores were observed in the patients that had a balanced pelvis (L5I<60°) at 2-25 years follow-up.

Take Home Message

In young patients with high-grade spondylolisthesis, partial reduction and transfixation with indirect decompression improves can restore sagittal alignment, with reliable fusion and satisfactory long-term SRS-22r scores.

	Pre-operative	Follow-up	P
SRS-22r scores			
Function	3.5±0.8	4.4±0.6	.003*
Pain	3.2±0.9	4.2±0.7	.002*
Self-image	3.5±0.7	4.2±0.8	.002*
Mental health	4.2±0.6	4.1±1.0	.53
Satisfaction	4.2±0.8	4.7±0.6	.04*
Total	3.7±0.6	4.3±0.6	.002*
Lumbosacral parameters			
Slip%, mean±sd (range)	75±15 (50-100)	48±19 (9-81)	<.001
Dub-LSA (°)(11)	70±11 (50-88)	101±11 (84-125)	.004
Regional spinopelvic parameters			
Pelvic tilt	32±8 (17-51)	28±7 (13-43)	.02
Sacral slope	43±10 (26-60)	55±10 (28-73)	<.001
Pelvic incidence	76±9 (50-92)	84±9 (67-101)	.006
L5 incidence(12)	70±14 (42-95)	52±15 (27-86)	<.001
Level of inflection point	T9±1.4 (T6-T12)	T11±1.0 (T9-T12)	<.001
Lordosis (S1-inflection point)	64±19 (34-105)	77±10 (59-93)	.64
Thoracic kyphosis (T4-T12)	13±13 (-9 - 48)	27±12 (0-44)	.001
Pelvis balanced (PT/SS ratio)(4)	37%	68%	
Pelvis balanced (L5 incidence)(12)	21%	76%	
Global spinopelvic parameters			
T1SPA	-2±7 (-13-+15)	-6±3 (-10 - 0)	.04
SVA(cm)	+4.9±6.4 (-4.8 - +20)	0.7±1.6 (-1.5-4)	.01
Global spinal balance(4)	65%	100%	

Table 1: SRS-22r and sagittal parameters.

16. ASSESSING COMPLICATIONS ASSOCIATED WITH ROBOTIC SPINE SURGERY

Lara Passfall, BS; *Oscar Krol, BA*; Nicholas A. Kummer, BS; Peter G. Passias, MD

Summary

The recent ballooning of the medical device industry has brought forth key advancements to the field of spine surgery. Robot-assisted surgical techniques are being increasingly implemented to increase surgeon accuracy and stamina; however, further investigation of the introductory phase of robot technology on surgical outcomes remains warranted.

Hypothesis

The introductory phase of robot technology is associated with inferior surgical outcomes.

Design

Retrospective

Introduction

The incorporation of robotic technology into spinal surgery has yielded the necessity for surgeons to adapt and learn new techniques before understanding their true impact on clinical outcomes.

Methods

Patients ≥18 years undergoing elective spine surgery with BL to 1-year follow up were isolated in a single-center spine database. Pts were grouped by absence or presence of robotic assistance during operation. Univariate analyses identified differences in perioperative outcomes [op time, estimated blood loss, length of stay], rates of intraoperative [durotomy, massive blood loss] and post-operative [ileus, urinary, neurologic deficit, SSI, mechanical, implant failure] complications, and return to OR within 30 and 90-days.

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Results

8327 patients met inclusion criteria (58yrs, 50% F, 29.0kg/m2) and underwent elective spine surgery (mean levels fused: 3.3, EBL: 441 cc, OpTime: 213 min, LOS: 3.5 days, UIV: T9, LIV: T12). Of these patients, 230 (2.8%) underwent operation with robotic assistance. Compared to a general cohort of elective spine surgery patients, robotic-assisted surgeries had lower levels fused (2.07 vs. 3.3, p<0.001), higher EBL (615 vs. 436 cc, p=0.005), longer OpTime (302 vs. 210 min, p<0.001), and longer LOS (4.5 vs. 3.5 days, p=0.001). Amongst common primary or concurrent diagnoses of pts undergoing robotic spine surgery, 75 pts (32.6%) had DDD, 64 pts (27.8%) HNP, 115 pts (50%) degenerative spondylolisthesis, 118 pts (51.3%) stenosis, and 90 pts (39.1%) had radiculopathy. Overall, robotic patients had significantly higher rates of intra-operative durotomy (6.5% vs. 2.7%, p=0.002), and trended toward higher rate of massive blood loss (12.5% vs. 2.8%, p=0.093). Robotic patients also had higher rate of overall postoperative complication (5.1% vs. 2.4%, p<0.001), DVT (15.0% vs. 2.7%, p=0.004), and ileus (13.0% vs. 2.6%, p<0.001). There were no differences in rate of implant failure or mechanical complication (all p>0.05).

Conclusion

Patients undergoing robotic surgery experience higher rates of intraoperative or postoperative complications, though not mechanical or implant-related ones.

Take Home Message

Robot-assisted procedures are associated with inferior intra- and perioperative outcomes in the introductory phase.

17. COMPLICATION AND REVISION RATES IN ROBOTIC-GUIDED POSTERIOR SPINE FUSIONS USING A BONE-MOUNTED ROBOT WITH ANATOMY RECOGNITION SOFTWARE

Alexandra E. Thomson, MD ; Lindsay Orosz, MS, PA-C ; Brandon J. Allen; Miles T. Guth; Thomas C. Schuler, MD; Christopher R. Good, MD; Colin Haines, MD; Ehsan Jazini, MD

Summary

This multi-surgeon, single center study evaluated complication and revision rates for 228 adults undergoing robotic-guided fusions for deformity and degenerative conditions. 178 surgeries were performed with robotic-guided surgery (RG) and 50 with robotic and navigation integrated surgery (R/N) for a total of 1,741 robotically executed screws. At 1 year follow-up, overall revision rate was 8% (19 patients) with three revisions (2%) related to robotic-guidance (implant malposition). Of the 1741 robotically placed screws, 3 required revision for implant malposition (0.71%).

Hypothesis

Robotic-guided thoracic/lumbar fusions would result in low complication and revision rates.

Design

Retrospective cohort study

Introduction

Robotic-guided surgery is emerging as a reliable and accurate technique for placing posterior spine instrumentation. We sought to evaluate complication rates, revision rates, and intraoperative fluoroscopic use two bone-mounted robotic systems one with robotic-guided surgery (RG) and one with robotic and navigation integrated surgery (R/N).

Methods

A retrospective review of complications and revision surgery for 228 patients treated with robotic-guided fusion (RG n=178, R/N n=50) at a multi-surgeon, single center for a total of 1,741 robotic executed screws. Secondary analysis was conducted between the RG and R/N cohorts evaluating intraoperative fluoroscopic time (seconds), total number of robotic screws, EBL, and VAS.

Results

228 patients had a mean age of 52 years and were 44.7% male. At minimum 1 year follow-up, cumulative revision rate was 8%. Three patients in the RG cohort (2%) and zero in the R/N cohort required revision for misplaced robotic-guided screws. Out of the 1,741 robotically placed screws, 3 required revision for implant malposition (0.71%). At 90 day follow-up, cumulative medical complication rate was 10% (RG =8%, R/N =16%, p=0.099). There was no difference in age, BMI, gender, smoking, and spinal deformity between RG and R/N cohorts (p>0.05). The RG cohort had a lower CCI (RG =1.17, R/N =1.162, p=0.043). Complication and revision rates at 30 day, 90 day, and 1 year follow-up were similar between cohorts (Table 1). R/N cohort had a greater average number of robotic executed screws (6.31, RG =9.43, p=0.028), and a reduced fluoroscopic duration in seconds per screw (6.28, RG =10.85, p=0.000). There was no significant difference in preoperative VAS, postoperative VAS, change in VAS, or EBL.

Conclusion

Robotic-guidance in thoracic/lumbar fusions results in low complication and revision rates. Rate of revision surgery for symptomatic implant malposition was 2% (0.71% rate of implant malposition/screw). R/N reduced intraoperative fluoroscopic duration in lumbar fusions.

Take Home Message

Robotic-guided fusion has low complication and revision rates. Rate of revision surgery for symptomatic implant malposition was 2% (0.71% rate of implant malposition/screw).

Table 1. Cumulative Complication and Revision Rates

	All N=228		RG N=178		R/N N=50		
	N	%	N	%	N	%	P-value
90 Day Follow-up							
Medical Complications	23	10%	15	8%	8	16%	0.099
Revision Surgery	14	6%	11	6%	3	6%	0.632
Robot Related	3	2%	3	2%	0	0%	0.474
1 year Follow-up							
Revision Surgery	19	8%	15	8%	4	8%	0.594
Number Screws Placed	1,741	-	1,254	-	487	-	-
Average # Screws/Surgery	7.6	-	7	-	9.7	-	0.028
Number Screws Revised	3	0.17%	3	0.24%	0	0%	0.083

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18. IS THERE A DIFFERENCE BETWEEN NAVIGATED AND NON-NAVIGATED ROBOT COHORTS IN ROBOT-ASSISTED SPINE SURGERY? A MULTICENTER, PROPENSITY-MATCHED ANALYSIS OF 2,800 SCREWS AND 372 PATIENTS

Nathan J. Lee, MD; Ian Buchanan, MD; Eric Leung, BS; Avery L. Buchholz, MD; John Pollina, MD; Ehsan Jazini, MD; Colin Haines, MD; Thomas C. Schuler, MD; Christopher R. Good, MD; Joseph M. Lombardi, MD; Ronald A. Lehman, MD

Summary

Robot-assisted spine surgery continues to rapidly develop as evidenced by the growing literature in the last few years. Numerous reports demonstrate excellent pedicle screw accuracy and early studies have explored the impact of robot-assisted spine surgery on reducing radiation exposure, length of hospital stay, operative time, and perioperative complications in comparison to conventional freehand technique. This is the first study to compare the outcomes and complications between non-navigated robot-assisted and navigated robot-assisted systems.

Hypothesis

differences in clinical outcomes between cohorts

Design

multicenter cohort

Introduction

In the last decade, computer-assisted navigation has been integrated into robot-assisted platforms to provide surgeons with real-time three-dimensional feedback during spinal instrumentation. It is unclear what the impact these advancements have made on clinical outcomes.

Methods

In this multicenter study, we included adult (≥18 years old) patients who underwent robot-assisted spine surgery with (S) and without navigation (X). A propensity score matching algorithm based on perioperative factors (e.g. demographics, comorbidities, primary diagnosis, prior spine surgery, pelvic fixation, instrumented levels, planned robot screws) was employed to control for the potential selection bias between the two robotic systems. Primary outcomes included operative efficacy (robot time per screw), robot complications, and clinical outcomes with a minimum 1 year follow up.

Results

A total of 372 adult patients were included in this study (186X, 186S). The mean number of instrumented levels was 4.3. The mean number of planned robot screws was 7.8. Similar total operative time and robot time occurred between cohorts. The navigated robot-assisted group achieved significantly shorter radiation time (<0.001) than non-navigated cohort. Furthermore, navigated robot system achieved a significantly lower robot abandonment rate (S: 0% vs. X: 2.2%, p=0.044). The screw accuracy for both robots were excellent (S: 99.6% vs. X: 99.1%, p=0.120). A lower blood transfusion rate was observed for S than X (p=0.018). Other intraoperative complications such as dura tear, motor/sensory deficits, return to the OR during same admission, and LOS was similar between robots (p>0.05). The 90 day complication rates were low and similar between robot cohorts.

Conclusion

In this multicenter, propensity score matching analysis, the navigated robot-assisted group achieved less radiation exposure, lower robot abandonment rate, and reduced blood transfusion rates than the non-navigated robot group. Other factors including operative time, robot time, LOS, and 90day complications were similar.

Take Home Message

The integration of navigation technology into the robot-assisted platforms appears to have reduced radiation exposure, robot abandonment, and blood transfusions.

Table 1. Patient Demographics, Comorbidities, and Perioperative Factors After Propensity Score Matching

	All		X		S		
	N	%	N	%	N	%	P-value
Total # of Patients	372	100%	186	50.0%	186	50.0%	
Female	205	55.1%	107	57.5%	98	52.7%	0.348
Obese (BMI>30Kg/m2)	175	47.0%	87	46.8%	88	47.3%	0.917
CCI, Mean (standard deviation, SD)	1.2 (1.3)		1.2 (1.3)		1.2 (1.3)		0.968
Prior/Current Smoker	24	6.5%	11	5.9%	13	7.0%	0.673
Preoperative Diagnosis							
High Grade Spondylolisthesis	130	34.9%	69	37.1%	61	32.8%	0.788
Degenerative Disc Disease	101	27.2%	50	26.9%	51	27.4%	
Degenerative Scoliosis	79	21.2%	38	20.4%	41	22.0%	
Spinal Stenosis	41	11.0%	18	9.7%	23	12.4%	
Pseudarthrosis, Implant Failure	20	5.4%	11	5.9%	9	4.8%	
Other	1	0.3%	0	0.0%	1	0.5%	
Operative							
Open (vs. Percutaneous)	140	37.6%	74	39.8%	66	35.5%	0.392
Prior Spine Surgery	34	9.1%	18	9.7%	16	8.6%	0.719
Instrumented Levels Per Patient, Mean (SD)	4.3 (3.8)		4.2 (3.9)		4.4 (3.6)		0.546
Pelvic Fixation	57	15.3%	32	17.2%	25	13.4%	0.314
Interbody Fusion	305	82.0%	158	84.9%	147	79.0%	0.146
Planned Robot Screws Per Patient, Mean (SD)	7.8 (6.6)		7.7 (7.1)		8.0 (6.0)		0.759

Table 2. Operative Efficiency and Radiation Exposure by Robot System

	All	X	S	P-value
Operative Time (minutes), Mean (SD)	207 (151)	211 (156)	197 (143)	0.531
Robot Time (minutes), Mean (SD)	46.4 (36.0)	43.9 (34.6)	43.8 (38.3)	0.374
Robot Time Per Screw (minutes/screw), Mean (SD)	6.1 (2.7)	6.1 (3.0)	6.1 (2.3)	0.930
Total Fluoroscopy Time (seconds)	46.3 (36.3)	51.4 (39.4)	41.7 (32.8)	0.013
Fluoroscopy Time per Screw (seconds/screw)	8.7 (8.6)	10.4 (10.1)	7.2 (6.6)	<0.001

Table 3. Robot Technical Errors and Complications By Robot System

	All		X		S		
	N	%	N	%	N	%	P-value
Total # of Executed Robot Screws	2,800	100%	1,355	48.4%	1,445	51.6%	
Exchange of Malpositioned Robot Screw	18	0.6%	12	0.9%	6	0.4%	0.120
Robot Abandonment	4	1.1%	4	2.2%	0	0.0%	0.044
Due To Registration Error	1	0.3%	1	0.5%	0	0.0%	0.317
Due to Unreachable Anatomy	3	0.8%	3	1.6%	0	0.0%	0.082
Other Surgical Complications							
Dural Tear	12	3.2%	7	3.8%	5	2.7%	0.557
Loss of Motor/Sensory Function	2	0.5%	2	1.1%	0	0.0%	0.156
Perioperative Blood Transfusion	28	7.5%	20	10.8%	8	4.3%	0.018
Estimated Blood Loss (mL), Mean (SD)	250 (443)		263 (476)		238 (424)		0.589
Return to Operating Room During Same Index Admission	2	0.5%	2	1.1%	0	0.0%	0.156
Length of Hospital Stay, Mean (SD)	4.4 (2.2)		4.2 (2.0)		4.5 (2.4)		0.199

Table 4. Post-Discharge Outcomes and Complications Requiring Reoperation

	All		X		S		
	N	%	N	%	N	%	P-value
Surgery	17	4.6%	7	3.8%	10	5.4%	0.456
Wound Complication	5	1.3%	4	2.2%	1	0.5%	0.177
Neurologic Deficit	3	0.8%	1	0.5%	2	1.1%	0.562
Implant Failure	3	0.8%	0	0.0%	3	1.6%	0.082
Persistent Symptoms Requiring Decompression	3	0.8%	1	0.5%	2	1.1%	0.562
Screw Malposition	1	0.3%	0	0.0%	1	0.5%	0.317
Dura Fistula	0	0.0%	0	0.0%	0	0.0%	
Other	3	0.8%	1	0.5%	2	1.1%	0.562

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19. 90-DAY COMPLICATION, REVISION, AND READMISSION RATES ASSOCIATED WITH ROBOTIC-ASSISTED THORACOLUMBAR FUSION SURGERY

Jason I. Liounakos, MD; Christopher R. Good, MD; John Pollina, MD; Colin Haines, MD; Jeffrey L. Gum, MD; Thomas C. Schuler, MD; Ehsan Jazini, MD; Richard V. Chua, MD; Eiman Shafa, MD; Avery L. Buchholz, MD; Martin H. Pham, MD; Michael Y. Wang, MD

Summary

A retrospective analysis of a large multicenter database of open and minimally invasive robotic-assisted thoracolumbar instrumented fusion surgeries was performed. Placement of spinal instrumentation utilizing current generation robotic guidance systems was found to be highly accurate and associated with low rates of screw-related complications, revisions, and readmissions within 90 days of surgery.

Hypothesis

Current generation robotic guidance systems are associated with low screw-related complication, revision, and readmission rates within 90 days of surgery.

Design

Retrospective multicenter case series.

Introduction

Robotics is a major area for research and development in spine surgery today. The high accuracy of robotic-guided placement of spinal instrumentation is documented in the literature. We present the largest case series to date evaluating the 90-day complication, revision, and readmission rates for robotic-assisted spine surgery utilizing the current generation of robotic guidance systems.

Methods

A descriptive analysis of a multicenter database of open and minimally invasive thoracolumbar instrumented fusion surgeries for degenerative thoracolumbar disease performed robotic-assistance. Both overall and screw-related complication, revision, and readmission rates within 90 days of surgery were calculated. These rates were calculated by dividing the number of adverse events by the total number of surgeries performed.

Results

In total, 799 surgical cases met inclusion criteria, including 4838 robotically executed screws with an overall accuracy of 98.9%. The overall intraoperative complication rate was 3.13%, but no screw-related complications were identified intraoperatively. The overall complication rate was 16.1% at 90 days. Five instances of an unrecognized malpositioned screw resulting in a new postoperative radiculopathy (0.626%) were encountered. Medical complications (8.76%) and continued/progressive symptoms unrelated to hardware placement (3.88%) accounted for the bulk of postoperative complications. The overall surgical revision rate at 90 days was 6.63% with 7 screw-related revisions (0.876%). The 90-day readmission rate was 7.13%, but only 2 readmissions were directly related to screw-placement (0.25%).

Conclusion

Current generation robotic guidance systems are associated with a high degree of accuracy – resulting in exceedingly low instances of intraoperative and postoperative screw-related complications, surgical revisions, and readmissions within 90 days.

Take Home Message

Robotic-guided placement of spinal instrumentation is highly accurate and associated with low 90-day complication, revision, and readmission rates attributed to instrumentation placement.

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Table 1:

Patient and Surgical Characteristics	
Number of Surgical Cases	799
Age (mean ± SD)	57.59 ± 12.86 years
Gender	
Male	341 (42.68%)
Female	458 (57.32%)
ASA (median)	3
BMI (mean ± SD)	29.50 ± 5.62
Instrumentation Technique	
Open	305 (38.17%)
Percutaneous	494 (61.83%)
Levels Instrumented per Case (mean ± SD)	3.09 ± 2.90
Total Number of Screws Placed	4838
Accuracy	98.9%
Complications, Revisions, Readmissions	
Intraoperative Complications	25 (3.13%)
Implant-Related	0 (0%)
Durotomy	21 (2.63%)
Other	4 (0.50%)
Complications at 90 Days	146 (16.1%)
Malpositioned Screw	5 (0.626)
Hardware Failure	3 (2.05%)
Continued/Progressive Symptoms	31 (21.2%)
Surgical Site Infection	21 (14.4%)
Postoperative Hematoma/Seroma	8 (5.48%)
Proximal Junctional Failure	2 (1.34%)
Medical	70 (47.9%)
Other	6 (4.11%)
Surgical Revision within 90 Days	53 (6.63%)
Implant-Related	7 (0.876%)
Readmissions	57 (7.13%)
Implant-Related	2 (0.25%)

ASA: American Society of Anesthesiologists; BMI: Body mass index; SD: Standard deviation

20. THE IMPACT OF GROWING ROD SURGERY ON CERVICAL ALIGNMENT DURING THE TREATMENT OF EARLY-ONSET SCOLIOSIS: A RETROSPECTIVE CASE CONTROL STUDY BASED ON MACHINE LEARNING ALGORITHMS

Bo Han, MD; Yong Hai, MD, PhD; Aixing Pan, MD, PhD

Summary

We aimed to analyze the cervical sagittal alignment change following the growing rod treatment in early-onset scoliosis (EOS) and identify the risk factors of sagittal cervical imbalance after growing-rod surgery with the method of machine learning. The cervical sagittal alignment was significantly affected by the growing rod surgery in EOS. PJK and the early insertion of growing rod would lead to cervical sagittal imbalance.

Hypothesis

There will be the cervical sagittal alignment change following the growing rod treatment in early-onset scoliosis (EOS) and some risk factors of sagittal cervical imbalance after growing-rod surgery with the method of machine learning.

Design

Retrospective case control study

Introduction

To our knowledge, this is the first study that focused on the cervical balance following the growth friendly surgical treatment in EOS patients.

Methods

The impact of thoracolumbar spinal parameters and surgical strategy on the cervical sagittal parameters was analyzed using t-test and χ2 test. The machine learning methodology of a sparse additive machine (SAM) was applied to identify the risk factors that caused the cervical imbalance. The algorithm was trained and validated on the data sets. Each model was trained on an 80% sample of the dataset and the prediction was validated by the remainder of the data to determine the accuracy of the post-training model.

Results

46 EOS patients were enrolled in this study (32 male and 14 female). The mean thoracic curve Cobb angle was 67.00±22.74 degrees. The mean age at the first operation was 8.5 ±2.6yrs. The mean follow-up was 34.48±20.87 months. Compared with the pre-operative data, CL, T1 slope and C2-7 SVA increased in the final follow-up (P<0.05). The CL and T1 slope increased more significantly in the group of patients who had proximal junctional kyphosis (PJK) compared with the patients without PJK (P<0.05). The location of the upper instrumented vertebrae (UIV) and single/dual growing rod had no significant influence on the sagittal cervical parameters (P>0.05). According to the SAM analysis, the occurrence of PJK, times of lengthening, age at last follow-up, age at 1st operation, and the follow-up time were identified as the risk factors of cervical sagittal imbalance during the treatment of growing rod surgery.

Conclusion
The cervical sagittal alignment was significantly affected by the growing rod surgery in EOS. PJK and the early insertion of growing rod would lead to cervical sagittal imbalance.

Take Home Message
The cervical sagittal alignment was significantly affected by the growing rod surgery in EOS. PJK and the early insertion of growing rod would lead to cervical sagittal imbalance.

21. CHILDREN WITH GROWTH-FRIENDLY SPINAL IMPLANTS DISPLAY IMPAIRED INTERVERTEBRAL DISC VOLUME AND DEGENERATION

Sebastian Lippross, MD; Paul Girmond, MS; Katja A. Lüders, PhD; Stefan Lüders, MSc; Friederike Austein, MD; Anna K. Hell, MD

Summary
We examined the effect of growth friendly spinal implants (GFSI) on the intervertebral discs of children with SMA and scoliosis by using MRI. MRI data showed a volume reduction and disc degeneration of lower lumbar intervertebral discs in scoliotic children after continuous spinal distraction with GFSI.

Hypothesis
The treatment of children suffering from scoliosis with growth friendly spinal implants has negative effects on the volume and degeneration of the intervertebral discs.

Design
Prospective Study

Introduction
Growth friendly spinal implants (GFSI) have become a standard of care for early onset scoliosis (EOS). GFSI are generally accepted, however possible complications like heterotopic ossification and autofusion make balancing the risks and complications challenging. Little is known about the effect of GFSI on the morphology of vertebrae and discs. We conducted a prospective study to evaluate intervertebral disc volume and disc degeneration.

Methods
-Prospective non-randomized cohort study of 24 scoliotic non-ambulatory children with spinal muscular atrophy (SMA)-Cohort I (n=12) with bilateral GFSI (rib to pelvis fixation, analyzed after an average of 5.2 (+/- 2.0) years); Cohort II (n=12) without prior surgery-Intervertebral disc volume (IDV) measured by manual drawing of disc circumference and subsequent software-based volume calculation-Intervertebral space volume (ISV) was determined by measuring distances between vertebral landmarks-Intervertebral disc degeneration (IDD) was graded according to Pfirrmann et al.

Results
In cohort I, there were no significant changes of intervertebral disc volume in the lower thoracic and lumbar spine after 5.2 years of GFSI treatment. Comparing age- and disease-matched data of GFSI treated versus untreated patients there was a significantly higher lumbar vertebral disc volume in untreated children in comparison to treated children. Age- and disease-matched patients (GFSI (I) vs. no GFSI (II)) showed significantly more intervertebral disc degeneration after GFSI therapy in comparison to untreated individuals despite more severe scoliosis in the latter group.

Conclusion
MRI data showed a volume reduction and disc degeneration of lower lumbar intervertebral discs in scoliotic children after continuous spinal distraction with GFSI. These effects were confirmed in the same subjects before and after a 5.2-year treatment course as well as in age- and disease-matched surgically untreated controls.

Take Home Message
Volume reduction and disc degeneration of lower lumbar intervertebral discs in scoliotic children after continuous spinal distraction with GFSI.
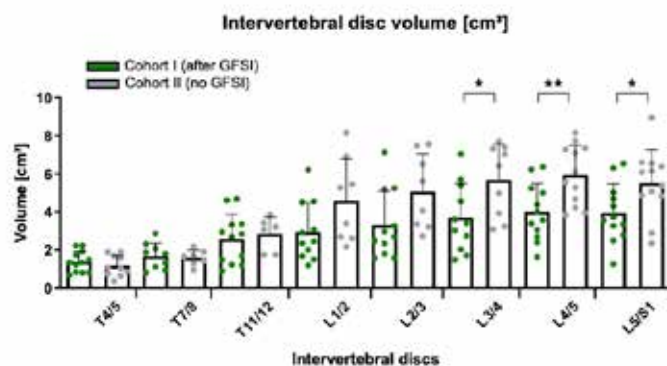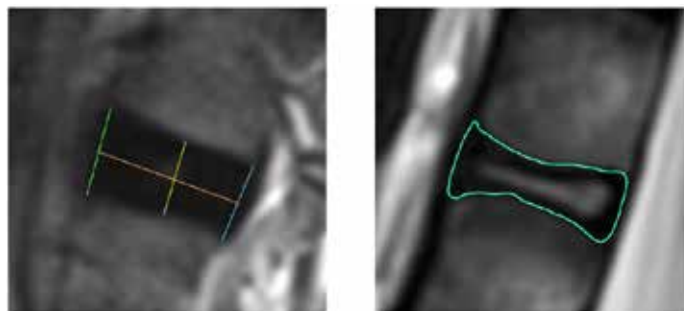
Volume: GFSI vs. NO GFSI

22. ADOLESCENT IDIOPATHIC SCOLIOSIS PREDISPOSE TO EARLY DISC DEGENERATION: EVIDENCE FROM PROTEOMICS

Sri Vijay Anand K S, MS; S. Rajasekaran, PhD, MS, FRCS; Chitra Thangavel, PhD; Dilip Chand Raja Soundarajan, MS; Sharon M. Nayagam, MSc; Ajoy Prasad Shetty, MS (Ortho); Rishi M. Kanna, MS

Summary
Abnormal loading of intervertebral discs predisposes to early disc degeneration in adolescent idiopathic scoliosis. A

comparative proteomic analysis of scoliotic discs with normal control discs from voluntary organ donors revealed increased inflammatory markers, oxidative stress response proteins in scoliotic discs, which are either absent or downregulated in control discs indicating altered metabolism that could lead to disc degeneration

Hypothesis
Abnormal loading, intrinsic to deformity, alters the metabolism of the intervertebral disc and predispose to early disc degeneration

Design
Comparative proteomic analysis of scoliotic discs and MRI normal control discs from brain dead voluntary organ donors

Introduction
Adolescent idiopathic scoliosis often presents with complaints of back pain. However, the relationship between scoliosis and back pain remains unclear. Animal studies in scoliotic models have shown disc degeneration, but human studies in this regard are lacking. Recently, chronic persistent inflammation i.e., inflammation, due to absence/downregulation of regulators have been implicated in disc degeneration. We performed a proteomic analysis of scoliotic discs and compared it with normal discs to explore for evidence of degeneration

Methods
After appropriate ethical clearance, eight L4-L5 discs (Nucleus pulposus) from eight MRI normal voluntary organ donors (ND group) and eight discs from three patients who underwent anterior deformity correction surgery for adolescent idiopathic scoliosis (SD group) were harvested and subjected to tandem mass spectrometry and bioinformatic analysis to identify the protein function, class, biological process and pathways involved

Results
Tandem mass spectrometry identified a total of 235 proteins in ND and 438 proteins in the SD group. Inflammatory proteins (C3, C1S), and oxidative stress response proteins (Peroxiredoxin-2,6, Catalase, Myeloperoxidase, Apolipoprotein E) were found to be up-regulated in SD. Whereas anti-inflammatory proteins SERPIN G1, complement inhibitor clusterin and vitronectin were downregulated in SD group. The significant biological process includes cellular oxidant detoxification, positive regulation of reactive oxygen species and complement activation in SD group and positive regulation of NF-KappaB transcription activity and negative regulation of endopeptidase activity in ND group.

Conclusion
Our study has documented numerous pro-inflammatory proteins and oxidative stress response proteins indicating altered metabolism in scoliotic discs which could predispose to early disc degeneration.

Take Home Message
Evidences for inflammatory and oxidative stress in scoliotic discs, looking normal in MRI, indicate that scoliosis predispose to early disc degeneration and could be an important cause for back pain.
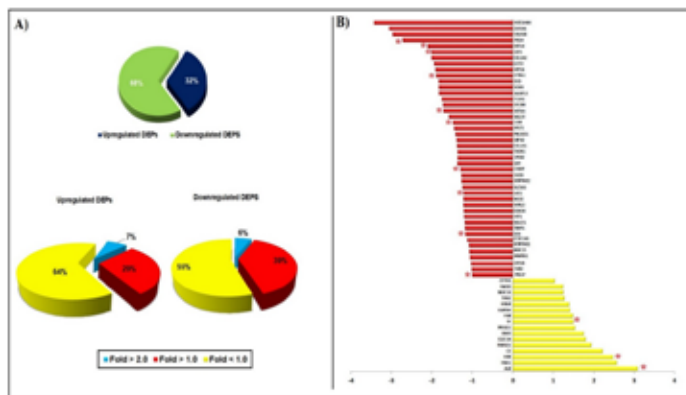
Differentially expressed proteins

23. EFFICACY OF VARYING SURGICAL APPROACHES ON ACHIEVING OPTIMAL ALIGNMENT IN ADULT SPINAL DEFORMITY SURGERY

Peter G. Passias, MD; Waleed Ahmad, BS; Sara Naessig, BS; Katherine E. Pierce, BS; Khaled M. Kebaish, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Tina Raman, MD; Bassel G. Diebo, MD; Eric Klineberg, MD; Han Jo Kim, MD; Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Shay Bess, MD; Frank J. Schwab, MD; Munish C. Gupta, MD; International Spine Study Group

Summary
The Roussouly, SRS-Schwab, and GAP Score classification systems encompass alignment criteria that are predicated on normal variation in spinal shape and deformity severity. This study sought to identify the impact of surgical approach on meeting realignment goals in adult spinal deformity (ASD). The results demonstrated that in patients undergoing corrective surgery for ASD without prior fusions, similar global realignment can be achieved with different surgical approaches.

Hypothesis
Various surgical approaches can optimize alignment

Design
Retrospective

Introduction
We sought to identify the impact of surgical approach on meeting realignment goals in ASD.

Methods
ASD patients with primary fusion incorporating the ilium, BL and 2Y radiographic data were included. Patients were categorized by: 1) Roussouly types 2) SRS-Schwab 3) GAP Score. Means comparison tests compared outcomes for different surgical approaches, inter-body usage, and osteotomies for patients that met alignment goals. Patients that met their Roussouly type at

2Y or showed improvement in GAP Score were categorized as improving in Spinal Shape or distribution of lumbar lordosis.

Results

338 primary ASD patients (64.3yrs, 80%F) were included. At 2Y, 49.7% of patients improved in GAP proportionality, 15.7% of patients that mismatched at BL matched Roussouly Type and 37% improved in SRS-Schwab PT, 49.7% SVA, and 61.5% PI-LL. Combined approaches were most effective for improvement in Schwab PT(p=0.037). Improved Schwab PT patients underwent more ALIFs at L5-S1 vs. TLIF(p=0.043). Controlling for BL SVA, patients that improved in PI-LL at L5 underwent increased rates of a SPO(p=0.037). Patients that underwent a posterior-only approach and showed significant improvement in spinal shape or distribution of lordosis had higher rates of TLIFs, specifically at L3-L4, L4-L5, and L5-S1(all p<0.05). Overall, patients that achieved optimal alignment goals according to improvement in Spinal Shape, distribution of lumbar lordosis, or improvement in deformity had higher rates of a combined approach, interbody usage at L4-L5 and L5-S1, and SPO at L3.

Conclusion

Patients undergoing ASD realignment can achieve optimal lumbar shape and proportion with a combined or a posterior only approach. ALIFs at L4-S1 were likely to achieve this goal with the added benefit of mitigating elevated pelvic tilt. Posterior procedures achieving similar alignment required a TLIF at L3-S1 in addition to facet and complete facet resection at L3-4.

Take Home Message

Patients without prior fusions undergoing ASD surgery can achieve global realignment with various approaches. Consideration of additional surgery and risk on an individual is inherent to the decision of approach.

24. INFLUENCES OF OSTEOTOMY FOR ADULTS DEGENERATIVE SCOLIOSIS ON PREOPERATIVE PROXIMAL JUNCTIONAL KYPHOSIS: A REVIEW OF 83 PATIENTS

Li Junyu, MD; Lin Haimiao, BS; Yu Miao, MD

Summary

Controversies remain on the effect of osteotomy for adult degenerative scoliosis (ADS) on postoperative proximal junctional kyphosis (PJK). This study proved that osteotomy was associated with PJK,and Smith-Petersen Osteotomy (SPO) could be better for its maintenance of spinal reconstruction balance.

Hypothesis

Osteotomy will influence the occurrence of postoperative PJK in ADS patients.

Design

This is a retrospective study. The ADS patients with orthopedic operation were grouped into Pedicle Subtraction Osteotomy (PSO) group (18 cases),Smith-Petersen osteotomy (SPO) group (33 cases) and non-osteotomy group (32 cases).

Introduction

ADS is treated effectively with osteotomy in the elderly. The correlation between osteotomy and PJK is not clear yet.

Methods

We retrospectively identified 83 ADS patients with orthopedic operation in Peking University Third Hospital from Oct.2008 to Nov.2019, grouped. We compared the baseline data, occurrence of PJK and spinal-pelvic parameters at perioperative period and the last follow-up.

Results

The mean age of 15 males and 68 females was 61.4 years. The SPO group and PSO group had no statically significant difference in sex, BMI and Cobb's angle except age(p>0.05). The occurrence of PJK was similar in the 2 groups(p>0.05). Compared with SPO group, SS at the last follow-up in PSO group was larger significantly (p<0.05). A minimal 2-year follow-up showed that PI-LL were significantly smaller than that in PSO group(p<0.05). The incidence of PJK in osteotomy group (combined SPO and PSO group) was higher significantly than that in non-osteotomy group(p<0.05), as well as LL at any time. Compared with non-osteotomy group, PT was greater after the operation but was smaller at the last follow-up in osteotomy group. During the follow-up, the changes of PT and TK in osteotomy group were larger than those in non-osteotomy group, while the changes of LL in non-osteotomy group were greater.

Conclusion

Osteotomy is associated with occurrence of PJK in ADS. Patients with SPO could maintain better spinal-pelvic parameters in follow-up time.

Take Home Message

With the similar influence on PJK between SPO and PSO, SPO could be better for ADS patients for its maintenance of spinal reconstruction balance.

25. CONSISTENT AND PATHOGNOMONIC MODES OF FAILURE OCCUR AT THE PROXIMAL JUNCTION DEPENDING UPON THE TYPE OF INSTRUMENTATION USED; A TWO-STEP CLUSTER ANALYSIS TO BETTER UNDERSTAND PROXIMAL JUNCTIONAL FAILURE (PJF)

Jonathan Charles Elysée, BS; Renaud Lafage, MS; Shay Bess, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Munish C. Gupta, MD; Justin S. Smith, MD, PhD; Robert K. Eastlack, MD; Eric Klineberg, MD; Gregory M. Mundis, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

Summary

Cluster analysis of ASD patients undergoing extension of fusion for PJF demonstrated 4 different UIV failure modes based upon UIV instrumentation: 1) no vertebra fracture with vertebral dislocation (UIV type= 90% screw, 6% Hook), 2) UIV screw= UIV fracture screw with erosion into UIV+1, 3) UIV hook= UIV-

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1 fracture and 4) UIV+1 fracture (UIV type=96.9% screw). PJF prophylaxis should account for these failure modes to further prevent PJF rather than move the failure to an adjacent vertebra.

Hypothesis
Consistent fracture patterns occur at the proximal vertebrae resulting in PJF based upon the instrumentation used in long ASD constructs.

Design
Retrospective review of multicenter database of ASD patients

Introduction
Different prophylactic techniques have been implemented to prevent PJF following ASD surgery, however, PJF remains problematic. Understanding modes of failures and identifying failure patterns will further help prevent PJF.

Methods
Radiographs of surgically treated ASD patients enrolled in a prospective multicenter database were reviewed for extension of fusion for PJF due to instrumentation failure and/or vertebral fracture at the UIV-1, UIV, and UIV+1 based on Genant classification. Proximal junctional angle (PJA) was measured, and PJF patterns were evaluated using an unsupervised AI approach (Two-step cluster analysis). Clusters were then compared in terms of instrumentation type and failure patterns.

Results
146/151 patients were identified (66±9 years). Cluster analysis revealed excellent results with a Silhouette of 0.9, and identified 4 patterns: "Small" (Mild to No fracture, 59.4%, PJA=23˚), "UIV+1 Fracture" (8.4%, PJA=36±14˚), "UIV Fracture" (22.4%, PJA=36±12˚), and "UIV-1 Fracture" (5.6%, PJA=41±14˚ from UIV-1 to UIV+1). No differences were found in sagittal alignment before revision surgery between the 4 groups in PI, PT, PI-LL, TPA or SVA (p>0.1). Comparison of fracture patterns showed differences in UIV instrumentation type, with UIV hook= UIV-1 fractures (50% versus < 10%), UIV screw=UIV fractures (62.5%); and an additional 50% of UIV fractures and UIV screw erosion into the UIV+1 inferior endplate. "Small" demonstrated the largest rate of translation between UIV and UIV+1 (13.3%).

Conclusion
Failure patterns of the proximal vertebrae are associated with specific UIV instrumentation. These modes of failure explain why current methods to prevent PJF or not consistently effective. Further research for PJF prophylaxis should account for these failure modes to further prevent PJF rather than move the failure to an adjacent vertebra.

Take Home Message
Vertebral fractures leading to PJF have distinct failure patterns that are consistently associated with specific upper vertebrae instrumentation. Understanding these failure patterns will improve prophylaxis techniques and improve PJF prevention.
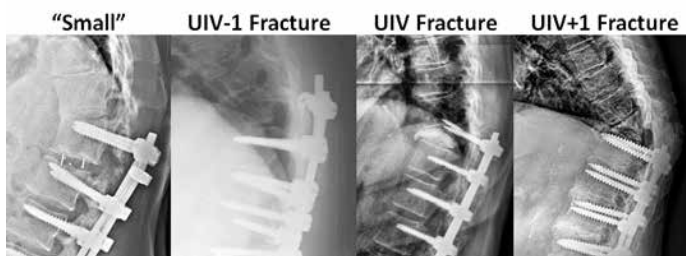
"Small" UIV-1 Fracture UIV Fracture UIV+1 Fracture

26. A MULTICENTER COMPARATIVE ANALYSIS OF AVBT TO PSF IN THE TREATMENT OF LENKE 5 CURVES

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Summary
This multicenter, retrospective review demonstrated radiographic and functional outcomes equivalence between anterior vertebral body tethering (AVBT) and posterior spinal fusion (PSF) in the treatment of IS at minimum 2 yr f/u. This may potentially be at the added risk of a significantly higher revision surgery rate which emphasizes the need for improved patient selection when discussing AVBT with patients and families.

Hypothesis
Clinical and radiographic outcomes of AVBT will be comparable to PSF in Lenke 5 curves

Design
Multicenter, comparative, retrospective analysis

Introduction
Reports of AVBT have shown an acceptable safety and efficacy profile; however, comparison to standard instrumented fusion is important to help guide treatment decisions, improve patient selection, and ultimately understand the role of AVBT in the treatment of idiopathic scoliosis (IS).

Methods
Following IRB approval, consecutive cases of patients treated with AVBT for Lenke 5 curves with ≥2-yr f/u were identified. Demographic, clinical, and periop data were obtained from chart review. Radiographs were measured by an independent observer. Patients were matched for sex and age distribution with PSF patients treated for Lenke 5 curves from a prospective surgical IS database.

Results
19 AVBT patients were compared to 36 PSF. Mean age and preop Risser were similar(p=0.07).Mean preop major coronal Cobb (MCC) was similar between groups(AVBT/PSF:42.5±5.8°/45.6±6.5°;p=0.099) as was first erect MCC (AVBT/PSF:17.8±7.9°;16.6±6.3°;p=0.57).Blood loss(p=<0.001) and OR time(p=0.002) were significantly lower in AVBT, however no difference in LOS was noted(p=0.13).At most recent

f/u(MRF) MCC had a slight increase in both groups (AVBT/PSF:22.9±9.3°/20.3±8.8°;p=0.32).Lumbar prominence improved mean 70.5%(AVBT) and 76.1%(PSF)(p=0.25).LIV distribution was significantly different with L3(47.4%) followed by L2(26.3%) being more common in AVBT compared to L3(58.3%) followed by L4(30.6%) being more common in PSF. There was no significant difference in curves <35° at MRF between groups (AVBT/PSF:84.2%/90.9%; p=0.66). SRS scores improved in all domains with no difference between groups(p>0.05). Revision surgery was significantly higher in AVBT (26.3%) compared to PSF (13.9%) (p=0.039).

Conclusion

AVBT demonstrated equivalent curve correction and HRQoL outcomes compared to PSF in Lenke 5 curves at ≥2 yr f/u. Although a significantly higher revision surgery rate to PSF, AVBT can be considered an alternative to PSF with the potential of motion preservation in the lumbar spine. Further f/u remains critical in assessing the true benefits of AVBT in the surgical treatment of IS.

Take Home Message

AVBT demonstrates equivalent curve correction and HRQoL outcome scores to PSF in Lenke 5 curves at minimum 2-yr f/u.

Patient Demographics	AVBT (N=19)	PSF (N=36)	p-value
Mean Age at Surgery (yrs)	12.4 ± 1.3	12.7±1.7	0.47
Gender	M= 4; F= 15	M=6; F=30	
Risser Grade	2.1± 1.6(0-4)	2.5+/-1.5(0-5)	0.07
Outcome Variables	AVBT (N=19)	PSF (N=36)	
Mean OR Time (min)	194.7±60.8	280.9±94.3	0.002*
Mean EBL (cc)	155.3±99.5	665.8±394.2	<0.001*
Length of Stay (days)	4.6±2.8	3.8±1.3	0.13
Clinical Success (Major Cobb ≤35°) (%)	84.2%	90.9%	0.66

*p-value denotes significant difference

Radiographic Measures	AVBT (N=19)			PSF (N=36)			p-value
	Pre-op	First Erect	MRF	Pre-op	First Erect	MRF	
Mean Major Thoracolumbar/Lumbar Cobb (°)(Range)	42.5±5.8 (31-53)	17.8±7.9 (1-32)	22.9±9.3 (6-44)	45.6±6.5 (35-61)	16.6±6.3 (5-30)	20.3±8.8 (2-44)	0.32
T2-T12 Kyphosis (°)	31.1±15.0	29.6±15.8	32.1±14.6	33.4±11.4	37.5±13.2	41.4±11.8	0.02*
Lumbar Lordosis (°)	-59.8±9.2	-53.8±11.8	-59.1±10.7	55.1±13.4	-54.4±12.3	-60.8±12.3	0.63
Surface Measurements	Pre-op	First Erect	MRF	Pre-op	First Erect	MRF	
Lumbar Prominence (°)	15.6±4.4		4.6±3.2	12.5±5.4		2.97±3.7	0.25
SRS Outcome Scores	Pre-op		MRF	Pre-op		MRF	
Pain	4.04±0.7		4.3±0.8	4.01±0.7		4.17±0.7	0.51
Self-Image	3.13±0.7		4.6±0.5	3.34±0.7		4.43±0.5	0.36
General Function	4.02±0.7		4.5±0.4	4.6±0.7		4.35±0.5	0.56
Mental Health	4.1±0.9		4.4±0.6	3.84±0.9		4.05±0.8	0.46
Total	3.83±0.7		4.48±0.3	3.89±0.5		4.28±0.5	0.34

*p-value denotes significant difference

Complications Requiring Revision Surgery (N)	AVBT (N=19)	PSF (N=36)
Tether Removal for Overcorrection	2	
Tether Replacement for Tether Failure	1	
Conversion to PSF	2	
Revision PSF for Pseudarthrosis		2
Hardware Irritation		2
Neurological		1

27. THORACOSCOPIC AND MINI-OPEN LUMBOTOMY VERTEBRAL BODY TETHERING FOR THORACOLUMBAR/LUMBAR CURVES: TWO TO THREE YEARS FOLLOW-UP

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Summary

This study reports a single-center experience of 11 patients that had undergone vertebral body tethering for thoracolumbar/lumbar (TL/L) curves (7 of whom also had a same-day staged Thoracic VBT). At the end of a mean of 28 months follow-up (24-36), 1 (14%) thoracic tether and 5 (%45) thoracolumbar tethers were broken; 1 patient (9%) had a revision surgery. Average time to break was 22.7 (6.1-33.8) months. All patients reached skeletal maturity. Last follow-up mean main curve Cobb was 25.2°.

Hypothesis

VBT is safe and effective for TL/L Curves

Design

Retrospective analysis of prospectively collected data

Introduction

Thoracoscopic VBT has been reported to be safe and effective for Main Thoracic (MT) Curves. There is little information about the outcomes of VBT for TL/L curves.

Methods

Demographic, perioperative, clinical, radiographic data and complications were recorded. Surgical and total follow-up correction percentages were calculated. Descriptive statistics are given.

Results

11 patients (10F, 13.3±1.2 years) with a mean follow-up of 28 (24-36) months were included (1 Lenke 6C, 5 Lenke 5C, 1 Lenke 3C and 4 Lenke 1C). Five (50%) patients were premenarchal; median Sanders: 5 (3-7), median Risser: 3 (0-5). Seven patients had a Double VBT addressing both MT and TL/L curves, while 4 patients had a thoracolumbar VBT only. The mean preoperative TL/L curve Cobb was 50.4° (40-70°). A mean of 9.2 (5-11) levels were tethered. LIV was L3 in all but 1, although EV was below L3 in 5 cases. Three patients had a double-row VBT at thoracolumbar levels. Mean surgical time was 454±135 min. Mean EBL was 123±49 ml. Mean postoperative TL/L curve Cobb was 20.5° (5-34°). Following initial surgical correction related gain in height, patients grew 3.8 cm (0-8) on average. Last f-up TL/L curve Cobb was 23.7° (8-42°). On the latest follow-up 73% of the MT curves and 64% of the TL/L curves were below 30°. Mechanical complications were 6 tether breakages, 1 in the thoracic and 5 in the lumbar areas. Average time to break was 22.7 (6.1-33.8) months. For LIV=L3 patients, breakage rate was 33% when EV was at L3, and 75% when EV was lower than L3. One patient was converted to a posterior fusion keeping the anterior instruments in place in a patient that had a double row.

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No pulmonary complications were observed. SRS-22 subtotal increased from a mean of 3.69 to 4.23 with a mean satisfaction score of 4.5/5.

Conclusion
Thoracolumbar/Lumbar Vertebral Body Tethering resulted in <30° curves in 64% of the cases at 2-3 years follow-up. Tether breakage rate was lower (14%) for thoracic applications, and higher (45%) for thoracolumbar applications.

Take Home Message
VBT applications for TL/L curves resulted in high tether breakage rate at a mean of 22.7 months follow-up. Technical considerations such as LIV selection and/or double row applications warrants investigation.

28. LUMBAR VERTEBRAL BODY TETHERING (VBT) AND ANALYSIS OF 1- VS. 2-CORD CONSTRUCT

Alice Baroncini, MD; Per D. Trobisch, MD

Summary
This study analyzed the radiographic outcome after VBT in 34 patients with the lowest instrumented vertebra at L3 or L4. Subanalysis included the comparison of a 1- and a 2-Cord-Construct. We observed an increased rupture rate compared to the literature after thoracic VBT, which can be reduced with a 2-Cord-Construct.

Hypothesis
VBT for thoracolumbar and lumbar curves will be successful albeit a high rupture rate. A 2-Cord-Construct can reduce the incidence of early cord ruptures compared to a 1-Cord-Construct.

Design
Retrospective Study

Introduction
Several studies have shown good to excellent results after thoracic VBT but there is a paucity of studies analyzing the results after VBT for thoracolumbar and lumbar scoliosis. As we have observed a high early rupture rate after lumbar VBT, we have changed our technique and now instrument lumbar spines in a 2-Cord-Technique. The aim of this study was to analyze the differences of these two techniques with respect to radiographic outcome.

Methods
All 37 consecutive patients who underwent VBT between 1/2018 and 8/2019 with the lowest instrumented vertebra at L3 or L4 and who had a 1-year follow-up were analyzed. Inclusion criteria were skeletal immaturity and a curve magnitude between 35° and 75°. Coronal and sagittal parameters before VBT, at the 1st standing x-ray and at the 1-year follow-up were compared. A cord rupture was defined as change of the angulation between 2 adjacent screws of more than 5°.

Results
Data from 34 patients (14.5 ± 1.5 years, 5 males) were available.

14 patients had a 2-cord construct. Thoracic and lumbar Cobb angles improved significantly at the 1-year follow up. Neither of the constructs had a kyphotic effect on lumbar lordosis. 20 patients showed signs of a cord rupture below T12: 16/65 segments with 1-cord and 7/48 segments with 2-cord construct ruptured (Odds Ratio 1.7; 95% Confidence Interval 0.64 – 4.42; p = 0.3). Loss of correction in patients with cord rupture was 11.6° ± 5.1°. Two patients (5.8%) required revision surgery, both had a 1-cord construct.

Conclusion
Rupture rate after lumbar VBT was high, but loss of correction and need for revision surgery was limited. The use of a 2-cord construct can decrease the rupture rate. Lumbar VBT did not have a kyphotic effect on lumbar lordosis, even with the use of 2 cords.

Take Home Message
Rupture rate after lumbar VBT is high, but decreases with 2-Cord-Constructs. Loss of correction and revision surgery are limited. Lumbar VBT does not have a kyphotic effect on lumbar lordosis.

29. BASELINE MYELOPATHIC SEVERITY IS AN INDEPENDENT DETERMINANT OF ADVERSE OUTCOMES, COMPLICATIONS, AND FUNCTIONAL RECOVERY FOLLOWING ADULT CERVICAL DEFORMITY CORRECTIVE SURGERY

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Summary
This study sought to investigate the relationship between myelopathy and neck function severity at baseline and examine how the ratio of severity impacts outcomes following cervical deformity (CD) surgery. Patients who report more myelopathy severity over neck disability have an increased risk for poor neurologic outcomes and distal junctional kyphosis.

Hypothesis
Baseline myelopathy severity will impact postoperative outcomes.

Design
Retrospective cohort study of a single-surgeon CD database

Introduction
Little is known of the impact of myelopathy severity in CD patients on patient-reported outcomes when taking into account symptomatic presentation

Methods
CD patients with baseline HRQLs and radiographic follow-up(1Y). 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

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myelopathy severity weighed more than neck disability, and vice versa. Severe and Not Severe myelopathy groups were PSM for cSVA. Univariate analyses determined 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). Ratio 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, 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 1Y 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.

Ratios of mJOA to NDI (Mean: 0.64±0.31)	
More impacted by their neck disability over their myelopathy severity (ratio < 1)	72.8%
Equal severity of NDI and mJOA	17.6%
More impacted by their myelopathy severity over their neck disability (ratio > 1)	2.9%

Percentages of the cohort meeting thresholds for ratios of mJOA to NDI

30. TREATMENT OF CERVICAL DEFORMITY IN THE PRESENCE OF A SECONDARY THORACIC DEFORMITY: OUTCOMES BASED ON INCLUSION AND AGE-ADJUSTED NORMALIZATION

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Summary

Recently, the relationship between thoracolumbar malalignment and cervical deformity (CD) progression has been well described. Consequently, surgical management now aims to address these secondary thoracolumbar drivers. However, the impact of not addressing secondary drivers on patient(pt) outcomes is not well understood. This study investigates differences in outcomes among CD pts in regards to inclusion of the secondary thoracic driver in the fusion construct. Failure to include the secondary driver resulted in alignment deterioration as well as worse back and neck pain.

Hypothesis

Patients whose fusion construct does not include the secondary driver will have worse outcomes.

Design

Retrospective

Introduction

There is a paucity in the literature regarding the relationship of failing to treat the secondary driver and outcomes.

Methods

CD pts with Baseline and 1Year(1Y) HRQL and radiographic data were isolated by their primary driver apex, which is classified by spinal region and determined by a panel of spine deformity surgeons, to be Cervical/Cervical Thoracic Junction(C). Pts were identified for their presence/absence of significant thoracic sagittal malalignment that was a secondary contributor to their cervical deformity(T). These pts were then divided into two groups: 1)inclusion of the entire thoracic driver in the surgical fusion(TDriver-No vs TDriver-Yes), and 2)inclusion of the thoracic driver apex in the fusion(TApex-No vs TApex-Yes). Means comparison tests assessed differences in surgical and radiographic factors between groups.

Results

65 pts (61yrs, 69%F) were included (86.2% C). 12.5% (7) of these C pts were T. By Ames modifiers, T pts were more moderately deformed(p=0.02). 11.6%(13) of CD pts did not included the entire thoracic deformity in the fusion construct while 88.4%(99) did. Specifically, 5.4% (3)of primary C pts were TDriver-No. Table 1 displays significant HRQL differences and complications in T driver pts at 3M and 2Y. TDriver-No had reciprocal increase in T4-T12 kyphosis (-33.2 to-40.8; p=0.005). TApex-No did not display improvement in global or spino-pelvic alignment(p>0.05). Sub analysis identified pts who had their thoracic kyphosis included in the fusion and matched their ideal age adjusted. At 2Y these pts had lower NDI scores than those that were not matched and excluded their thoracic deformity (33.4% vs 37.8%; p=0.04).

Conclusion

Patients who did not have their secondary thoracic sagittal deformity included in the fusion construct, had worse neck and back pain and developed malcompensation at 3M post-operatively which didn't resolve by 1 year.

Take Home Message

Inclusion of the secondary thoracic deformity is a crucial factor for proper alignment as well as quality of life post-operatively.

HRQL at 3M			
	TDriver-Yes	TDriver-Not	p-value
NSR-Neck Pain	4.0	7.6	P<0.05
NDI	41.2	56.4	
HRQL and Complications at 2Y			
	TDriver-Yes	TDriver-Not	p-value
NSR-Back	4.7	7.3	P<0.05
Cardiopulmonary	1.9%	33.3%	
Vascular	5.7%	33.3%	
Complication Total	15.1%	66.7%	

HRQLs and complications at 3M and 2Y for patients with and without fusion construct including the secondary thoracic abnormality.

31. OUTCOMES ANALYSIS OF STAGED VERSUS SAME-DAY PATIENTS UNDERGOING IDENTICAL CERVICAL DEFORMITY CORRECTIVE SURGERY

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Summary

Surgical intervention aimed at addressing adult cervical deformity (ACD) is an invasive and complex procedure that surgeons often elect to perform on different days. Staged procedures are becoming increasingly prevalent, however, there has been paucity in literature on the effect that intervals between procedures have on outcomes. Our study demonstrates staged patients had improved short term and long-term outcomes in a variety of HRQL metrics, including IHS adjusted EQ5D, with less utilization of osteotomies.

Hypothesis

To determine differences in outcomes between Staged and Same-Day surgery patients.

Design

Retrospective cohort study

Introduction

Staged procedures are becoming increasingly prominent, however, there is lack of literature on benefits of interval surgeries. Our goals are to broaden understanding of outcome differences between Staged and Same-Day patients.

Methods

Inclusion criteria: operative CD patients (Cervical kyphosis>10°, with cSVA>4cm or CBVA>25°) and >18yrs undergoing either staged or same-day procedures. Univariate, and bivariate analysis was used to determine significant differences in surgical, radiographic, and clinical factors and outcomes. IHS adjusted EQ5D was used to determine overall recovery kinetics.

Results

91 CD patients met inclusion criteria (58.3yrs, 46% Female, 28.3 kg/m2). Overall, 10 (14.2%) of these patients underwent staged procedures, while 82 (40%) underwent same-day combined approach. Staged patients were correlated with a lower number of osteotomies (r=-.31, p<0.05) and trended towards having lower overall complications (26% vs 1%, p=119) and lower neuro complications ((8% vs 0, p=.169). At 6W, Staged patients trended towards a lower NDI Score (44 vs 60.44, p=67). At 3M, Staged patients trended towards a higher mJOA score (16 vs 14, p=0.057). At 6M, Staged patients had a lower NSR-Back pain (3 vs 6), and higher SWAL Physical (95 vs 84, both p<0.05). At 1Y, Staged patients had a lower NSR-Back Pain (3 vs 8), lower NSR-Neck Pain (7 vs 3), lower NDI score (23 vs 43), higher SWAL Desire to Eat (96 vs 66), SWAL Eat Duration (90 vs 66), lower EQ5D (6 vs 9), and higher EQ5D VAS (80 vs 62, all p<0.05). Staged patients had a lower IHS adjusted EQ5D up to 1Y (.9 vs 1, p<0.05). Controlling for BL deformity, number of osteotomies and levels fused, patients who were staged had a lower IHS adjusted EQ5D, (p<0.05).

Conclusion

Staged procedures have become more prevalent as surgeons aim to decrease perioperative adverse events and improve patient outcomes. Our analysis shows staged patients had superior short- and long-term outcomes while undergoing less osteotomies, possibly decreasing overall complication rates.

Take Home Message

This analysis demonstrates staged patients had superior short- and long-term outcomes while undergoing less osteotomies, possibly decreasing overall complication rates.

32. NOVEL ARTIFICIAL INTELLIGENCE ALGORITHM CAN ACCURATELY AND INDEPENDENTLY MEASURE SPINOPELVIC PARAMETERS

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Summary

The analysis of sagittal alignment by measuring spinopelvic parameters has been widely adopted among spine surgeons globally. The currently available spine measurement software programs require users to identify several landmarks prior to calculating parameters, making them time consuming and more reliant upon user experience. This study evaluates and demonstrates that an algorithm based on artificial intelligence (AI) can independently determine spinopelvic parameters. This allows for precise radiographic measurement without time-intensive human input.

Hypothesis

The novel, fully automatic method will have a high agreement with human measurements for lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS).

Design

Evaluation of the inter-rater reliability and mean error between radiographic measurements of the AI algorithm and expert human raters.

Introduction

Preoperative and postoperative sagittal plane assessment is crucial in both spinal deformity and degenerative pathologies. Sagittal malalignment is a well-established cause of poor patient reported outcomes. There is a growing need for an automated analysis tool that measures pelvic parameters with speed, precision and reproducibility without relying on user identified landmarks. A new AI algorithm has been developed to measure important radiographic parameters independently.

Methods

From a total of 200 lateral lumbar radiographs (preoperative and postoperative images from 100 patients undergoing fusion) five independent observers (4 spinal surgeons, 1 senior researcher) digitally measured LL, PI, PT and SS. Their parameters were compared with AI algorithm generated parameters. Mean error (95% confidence interval, standard deviation) and inter-rater reliability were assessed using two-way mixed, single-measure intraclass correlation (ICC). ICC values larger than 0.75 were considered excellent (Ciccetti, Psychol. Assess. 1994).

Results

The novel algorithm's spinopelvic parameter ICC values were excellent in 98% of preoperative and in 95% of postoperative radiographs (PreOp range: 0.85–0.92, PostOp range: 0.81–0.87). Exemplarily, mean errors are smallest for the PI (PreOp:-0.5° (95%-CI:-1.5°–0.6°; Fig. 1); PostOp: 0.0° (-1.1°–1.2°)) and largest for LL (1.3° (0.3°–2.4°); 3.8° (2.5°–5.0°)).

Conclusion

Novel AI algorithm automated spinopelvic parameter measurements from spine radiographs have a high degree of accuracy comparable to digital measurements by experts. This algorithm can improve physician workflow efficiency and reduce inter-rater and intra-rater measurement errors.

Take Home Message

Advancements in artificial intelligence can accurately and reliably measure spinopelvic parameters independently. Novel AI algorithms can increase efficiency and reduce inter-expert and intra-expert measurement errors.
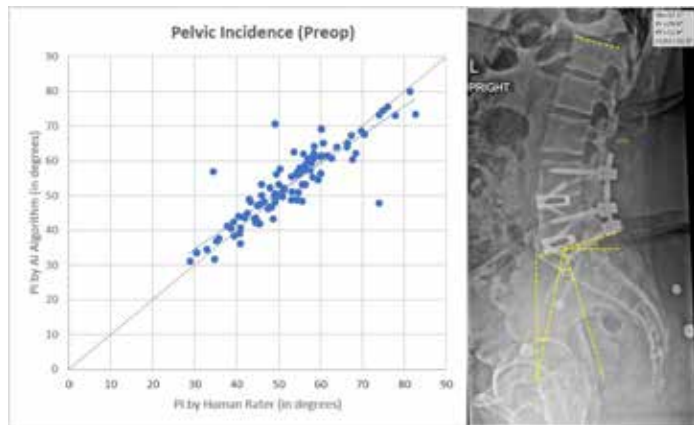
Fig. 1: Correlation plot for Pelvic Incidence and visualization of all parameters.

33. LATERAL DECUBITUS SINGLE POSITION CIRCUMFERENTIAL FUSION (ALIF & PSF) IMPROVES PERIOPERATIVE OUTCOMES COMPARED TO TRADITIONAL ANTERIOR-POSTERIOR FUSION

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Summary

Lateral decubitus single position anterior-posterior (AP) fusion utilizing anterior lumbar interbody fusion and percutaneous posterior fixation (SPS) is a novel, minimally invasive surgical technique. This multicenter retrospective cohort study demonstrated that compared to traditional AP fusion requiring repositioning (FLIP), the SPS cohort had significantly lower operative time, blood loss, length of stay and rates of ileus with similar radiographic outcomes.

Hypothesis

SPS improves perioperative outcomes compared to FLIP patients.

Design

Multicenter retrospective cohort study

Introduction

Single position AP fusion with anterior or lateral interbodies has been shown to be a safe, effective technique to treat of lumbar degenerative disease. This study directly compares perioperative outcomes of SPS v FLIP for degenerative pathologies.

Methods

Retrospective analysis of primary ALIFs with bilateral percutaneous pedicle screw fixation between L4-S1 over 5 years at 5 institutions. Patients were grouped as FLIP or SPS. Outcome measures: levels fused, inclusion of L4-L5, L5-S1, radiation dosage, OpTime, estimated blood loss (EBL), length of stay (LOS), perioperative complications. Radiographic analysis included lumbar lordosis (LL), pelvic incidence (PI), and PI-LL mismatch. Measures were compared using independent samples t-tests and chi-squared analyses, significance set at p<0.05. Cohorts were propensity matched (PSM) for levels fused.

Results

321 patients: 124 SPS, 197 Flip were identified. PSM was performed due to differences between groups in levels fused, and proportion involving L4-5, yielding 248 patients: 124 SPS, 124 FLIP. The SPS cohort demonstrated significantly reduced OpTime, EBL, LOS, and rate of perioperative ileus. Radiation dose and perioperative complications including vascular injury, retrograde ejaculation, abdominal wall, neurological, or wound complications, or VTE were similar. No difference was seen in 90 day return to OR. Similar results were noted in subanalyses of single-level L4-L5 or L5-S1 fusions. On radiographic analysis the SPS cohort had greater changes in LL and PI-LL mismatch. (Fig 1)

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Conclusion
LALIF SPS is a safe, novel technique that improves operative efficiency, reduces blood loss, length of stay and rates of postoperative ileus.

Take Home Message
Single position lateral ALIF with percutaneous posterior fixation improves operative efficiency, EBL, LOS, rate of ileus, and maintains safety compared to supine ALIF with prone percutaneous pedicle screws between L4-S1.

Perioperative Outcomes in Single Position Lateral ALIF SPS versus Flip AP Fusion		SPS (N=124)	FLIP (N=124)	p-value
Demographics	Age (years)	55.3±12.7	53.9±12.6	0.373
	Gender (%F)	54%	49%	0.448
	BMI	30.2±5.1	29.0±5.2	0.094
	Diabetes	14%	11%	0.583
	Smoker	13%	26%	0.031
	Levels Fused	1.1±0.3	1.1±0.3	1.000
	L4-L5 Included (%)	15%	21%	0.251
	L5-S1 Included (%)	96%	91%	0.122
Procedural Outcomes	Operative Time (min)	133.0±77.4	261.8±91.7	<0.001
	LOS (days)	2.1±1.3	3.5±1.4	<0.001
	EBL (mL)	120.4±217.1	224.3±244.0	0.001
	Radiation Dose (mGy)	39.8±31.7	37.5±35.9	0.719
	Preop LL	56.2±12.1	56.9±12.2	0.905
	Postop LL	60.3±11.7	57.0±11.7	0.028
	Change LL	4.2±11.1	0.1±8.0	0.005
	Preop PI-LL Mismatch	4.1±11.4	4.3±9.3	0.454
	Postop PI-LL Mismatch	-0.7±11.7	4.4±9.3	0.001
	Change PI-LL Mismatch	4.7±8.7	0.0±7.3	0.001
Complications	Ileus	0.0%	6.5%	0.005
	Neuropraxia	1.7%	0.8%	0.532
	Persistent Motor Deficit	0.0%	1.7%	0.166
	Abdominal Bulge	0.8%	2.4%	0.338
	Vascular Injury	1.7%	1.7%	0.960
	Retrograde Ejaculation	0.0%	0.8%	0.328
	Wound Complication	1.7%	1.7%	0.960
	Surgical Site Infection	0.9%	0.0%	0.347
	DVT/PE	0.8%	0.8%	0.972
Returns to OR	Return to OR within 90 days	4.2%	5.6%	0.614
	Central Decompression	0.0%	0.8%	0.328
	Foraminal Decompression	1.7%	2.4%	0.692
	Neurological Deficit	0.0%	0.8%	0.328
	Irrigation and Debridement	0.8%	0.0%	0.328
	Hematoma Evacuation	0.0%	0.8%	0.328
	Instrumentation Revision	1.7%	2.4%	0.692

34. MINIMALLY INVASIVE SURGERY MITIGATES BUT DOES NOT ELIMINATE ADVERSE PERIOPERATIVE OUTCOMES FOR FRAIL TLIF

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Summary
Frailty is an increasingly recognized characteristic that has been validated across many studies as influencing operative risk. Utilization of frailty indices can allow for its identification of which spine patients may be too high risk for surgical intervention. This may be especially useful when it comes to surgeries that are minimally invasive and are supposed to have decrease perioperative outcomes.

Hypothesis
Frail patients will benefit from MIS procedures.

Design
Retrospective.

Introduction
Adverse outcomes for Frail TLIF undergoing MIS surgery has to be identified.

Methods
Included: pts who underwent lumbar spine procedure from a single-center database. Pts were stratified based on approach (Open[OP] and Minimally invasive Surgery [MIS]). Frailty was calculated for each resultant group by using 30 variables with a validated method (Searle et al.). Based on these scores, pts were categorized as not frail [NF]: <0.09, frail[F]: 0.09-0.18, and severe frailty [SF] >0.18. Groups were controlled for surgical invasiveness. Chi-squared tests identified the relationship between complications and length of stay among frailty states given surgical approach (OP vs MIS). These patients were propensity score matched for levels fused. Univariate analyses identified hospital acquired complication rates (HACs) based on frailty groups and other surgical factors. Logistic regression analysis identified the association between frailty, approach, and postoperative outcomes.

Results
1300 TLIF spine patients were isolated (59yrs, 29.3kg/m2). After PSM for levels fused, there were 338 pts each for MIS and OP. MIS pts were older (56.1 vs 53.3; p<0.05) than OP pts. OP pts underwent more posterior approaches and less anterior approaches than MIS pts (p<0.05). By surgical factors: MIS and OP patients had similar LOS (3 vs 2.9days) and EBL (282.8 vs 251.5cc) but differed by Op time (195.7 vs 247.1; p<0.05) respectively. Further breakdown by frailty displayed statistical significance between MIS and OP patients with MIS pts having more F(16% vs 12%) and SF pts (4.3% vs 1.9%) than OP (all p<0.05). FMIS patients had lower postop neurologic complications as compared to FOP pts (4.63% vs 14.8%). However, SFMIS patients had more post-operative complications than SFOP pts (55.2% vs 23.1%) and increased a pt's likelihood of being SFMIS by 5.4x's (all p<0.05).

Conclusion
When frailty status is taken into account, TLIF MIS patients benefit from this procedure type in terms of having lower postop neurologic complications However, F patients suffer more from other post-op complications.

Take Home Message

Minimally invasive surgery can be utilized for creating optimal patient outcomes, however, further research needs to investigate how this approach can better outcomes within surgery specific confines.

35. PRONE TRANSPSOAS LATERAL INTERBODY FUSION: MULTI-CENTER CLINICAL EXPERIENCE

Samuel A. Joseph, MD; Benjamin Ditty, MD; Antoine G. Tohmeh, MD; William Taylor, MD; Luiz Pimenta, MD, PhD

Summary

The prone transpsoas (PTP) technique allows for single-position combined anterior and posterior column procedures while capitalizing on the advantages of lateral lumbar interbody fusion (LIF). Multi-center clinical experience of 120 procedures demonstrated feasibility, identified efficiencies of prone single-position surgery, and prescribed technique requirements including optimization of patient positioning and maintenance of orthogonal exposure for lateral access. With these learnings in mind, outcomes can be expected to be similar to those reported for lateral decubitus LIF experience.

Hypothesis

Instrumented lateral interbody fusion can be performed safely and efficiently in prone position.

Design

Prospective multi-center observational collection of peri-op outcomes.

Introduction

Lateral interbody fusion (LIF) is traditionally performed in lateral decubitus, requiring prone repositioning for posterior procedures or modifying traditional posterior techniques to be done in lateral. The benefits of lateral anterior column access may be achievable with the patient prone, allowing for concomitant posterior techniques in a more familiar single-position setting.

Methods

Prone transpsoas (PTP) access was outlined and vetted by a group of LIF-experienced spine surgeons. Early clinical experience included prospectively capturing case details to assess feasibility, efficiencies, hurdles. The surgical technique is consistent with prior LIF descriptions, apart from prone positioning on a Jackson frame-type bed using a procedure-specific positioner and retractor system.

Results

More than 600 PTP cases have been performed to date. Peri-op data was collected in 120 consecutive cases from 22 surgeons. Patient size varied (BMI 21-46, mean 33). Procedures totaled 176 levels (1-4/case), 68% inclusive of L4-5. Docking was between the posterior 4th and 3rd quadrants of the disc, guided by trEMG, and with continued plexus monitoring via saphenous SSEP. Exposure was achieved in an average 18 min; retraction time averaged 25 min. Fixation was via perc pedicle screws (65%), open pedicle screws (24%), other (11%). No re-positioning was required. In some cases, posterior work was performed concurrent with PTP. Concomitant procedures facilitated by prone position included direct decompression (37%), treatment at L5-S1 (18%), revision of posterior instrumentation (7%), and osteotomy/bony releases (9%). PTP procedure time, blood loss, and length of stay were consistent with lateral decubitus experience.

Conclusion

Initial multicenter clinical experience suggests that PTP is not only feasible but creates efficiencies by allowing for single-position surgery maximizing both anterior and posterior column access and corrective techniques, with perioperative outcomes consistent with lateral decubitus experience.

Take Home Message

Prone transpsoas LIF is shown by multi-center experience to be a safe and efficient technique for single-position circumferential correction. Learnings included need for procedure-specific positioner and retractor.

36. THE EFFECT OF A TRANSDISCIPLINARY SPINE CONFERENCE ON QUALITY AND SAFETY FOR ADULT SPINAL DEFORMITY SURGERY

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Summary

This study compares complication rates of patients with Adult Spinal Deformity (ASD) who underwent an operation requiring ≥6 levels of fusion or ≥3 in a patient with multiple comorbidities, reviewed preoperatively by a Transdisciplinary Spine Committee (TDSC) against a matched cohort who did not, demonstrating lower 30-day infection and surgical failure rates, shorter length of stay in the intensive care unit (ICU), and lower 1-year infection rates for those reviewed in the TDSC

Hypothesis

Implementing a preoperative TDSC decreases complications in the treatment of ASD

Design

Retrospective review of a prospective consecutive database

Introduction

Surgical treatment for ASD carries a high risk of morbidity. Complications occur in up to 90% of these operations and often involve >1 per surgery. Revision rates range from 10%-40% by 1 year. Since 2017, patients at our institution considered for ASD surgery have been reviewed by a TDSC. This consists of a multidisciplinary group responsible for the perioperative care of the patient. Surgical interventions and patient suitability are discussed. Once the decision to proceed with surgery is made, patients are followed prospectively to evaluate for perioperative morbidity

Methods

81 consecutive patients discussed on TDSC who underwent ASD surgery between 2017-18 at a single institution were compared to a matched cohort of 48 consecutive patients from prior to implementing TDSC who underwent surgery in 2015-16. Univariate and multivariate regressions were used to evaluate complication rates between groups with and without adjusting for demographic and surgical covariates

Results

There were no differences in age, gender, Charlson Comorbidity Index (CCI) and surgical profiles between the post- and preTDSC groups. Univariate analysis demonstrated lower 30-day complication rates for the post- vs. preTDSC groups (25.9% vs 47.9%, p=0.016), driven by lower infection (0% vs 18%, p=0.001) and lower surgical failure rates (5.2% vs 18.8%, p=0.03). Length of stay (LOS) in the ICU was also lower in the postTDSC group (3.6[3.3] days vs 1.2[1.8] days, p<0.01). Lower 1-yr infection rates in the postTDSC group were also found (p=0.015). When significant outcomes were adjusted for covariates of age, CCI and levels fused, all relationships retained significance (p<0.05)

Conclusion

Using unbiased data reduction methods from univariate modeling to develop customized adjusted multivariate logistic/linear regression models, the implementation of a TDSC resulted in a significant reduction in the 30-day surgical failure rates by 76%, a reduced LOS in the ICU by 1.2 days, and a reduction in a 1-year infection rate by 80%

Take Home Message

The implementation of a preoperative TDSC improves outcomes and decreases complication rates early postoperatively for patients undergoing correction of ASD

37. PRE-OPERATIVE HIGH FREQUENCY OPIOID USE DRAMATICALLY INCREASES COMPLICATION RATE WITHIN 90 DAYS, INCREASES 2 YEAR REOPERATION RATES, AND PREDISPOSES TO OPIOID DEPENDENCY FOLLOWING ADULT SPINAL DEFORMITY CORRECTION

Peter G. Passias, MD; *Waleed Ahmad, BS*; Katherine E. Pierce, BS; Sara Naessig, BS; Lara Passfall, BS; Nicholas A. Kummer, BS; Oscar Krol, BA; Bassel G. Diebo, MD; Hamid Hassanzadeh, MD

Summary

With a heightened focus on prescription narcotic use in the United States there has been an increased concern amongst surgeons on preoperative and postoperative usage. Our results demonstrate that adult spinal deformity patients (ASD) patients with high frequency opioid usage preoperatively trend towards high complication rates within 90-days of surgery and need for reoperations at two years.

Hypothesis

High frequency preoperative opioid usage will result in worse outcomes.

Design

Retrospective review

Introduction

There is paucity in the literature on outcomes of preoperative and prolong opioid usage in ASD patients.

Methods

ASD patients undergoing a fusion were isolated using the PearlDiver database between the years 2008-2013. Patients were stratified by pre-op opioid use 3 months prior to surgery: 1)High Frequency(>4 refills); 2)Low Frequency(1-3 refills); 3) Opioid Naive. Means comparison tests compared differences in demographics, complications, and reoperation rates. Logistic regression assessed the odds of complication and reoperations associated with preoperative frequency and prolonged opioid use (3 to 6 months postop), controlling for age, sex, and comorbidities.

Results

7,661 ASD patients were isolated. 2,342 patients were high frequency pre-op opioid users, 2,247 low frequency pre-op opioid users, and 3,072 opioid naïve. At BL, high frequency pre-op opioid users had higher rates of obesity, diabetes mellitus, CHF, COPD, hypertension, smoking and alcohol use (all p<0.001). Compared to opioid naïve patients, low frequency pre-op opioid users had higher rates of 90-day complications associated with hematoma and transfusion(p<0.05). High frequency pre-op opioid users relative to naïve opioid users had significantly increased 90-day complication rates including pulmonary embolism, pneumonia, hematoma, and transfusions. High frequency opioid use was associated with increased odds of wound disruption (1.74[1.22-2.51]) and hospital readmission (1.42[1.22-1.64], both p<0.05). Additionally, high frequency opioid usage preop followed by prolonged opioid use postop was associated with increased odds of reoperations at 2Y relative to low frequency (1.67[1.34-2.10]) and opioid naïve patients (1.83[1.40-2.42], both p<0.001).

Conclusion

Patients with high frequency preoperative opioid use are at increased risk of major complications within 90-days of surgery, prolonged use postoperatively, and increased risk of reoperations within two years.

Take Home Message

During pre-operative risk assessment, providers should consider the effect of pre- and post-operative opioid usage on outcomes.

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Table. 1 90-Day Post-Operative Complication Rates

	High Frequency Opioid Use n = 2,342	Low Frequency Opioid Use n = 2,247	Opioid Naive n = 3,072	High Frequency Opioid Users vs. Opioid Naive Adjusted OR (95% CI)	P-value	Low Frequency Opioid Users vs. Opioid Naive Adjusted OR (95% CI)	P-value
DVT	17 (0.72%)	9 (0.40%)	16 (0.52%)	1.63 (0.79-3.37)	0.182	0.80 (0.33-1.79)	0.591
Pulmonary Embolism	80 (3.4%)	42 (1.9%)	63 (2.1%)	1.56 (1.09-2.24)	0.014	0.91 (0.61-1.35)	0.647
MI	12 (0.51%)	22 (0.98%)	17 (0.55%)	0.89 (0.39-1.93)	0.765	1.82 (0.96-3.53)	0.069
Pneumonia	224 (9.6%)	116 (5.2%)	172 (5.6%)	1.51 (1.21-1.90)	<0.001	0.93 (0.73-1.20)	0.590
UTI	519 (22.2%)	419 (18.6%)	564 (18.4%)	1.36 (1.17-1.57)	<0.001	1.03 (0.89-1.19)	0.703
AKI	158 (6.7%)	124 (5.5%)	159 (5.2%)	1.33 (1.04-1.71)	0.025	1.10 (0.50-1.41)	0.480
Wound Disruption	84 (3.6%)	49 (2.2%)	59 (1.9%)	1.74 (1.22-2.51)	0.002	1.15 (0.78-1.70)	0.477
Hematoma	100 (4.3%)	84 (3.7%)	87 (2.8%)	1.60 (1.17-2.19)	0.004	1.43 (1.05-1.95)	0.023
Transfusion	176 (7.5%)	145 (6.5%)	166 (5.4%)	1.68 (1.33-2.13)	<0.001	1.31 (1.03-1.65)	0.026
Death	12 (0.5%)	18 (0.80%)	18 (0.59%)	1.17 (0.52-2.51)	0.698	1.52 (0.77-3.00)	0.221
Readmission	506 (21.6%)	376 (16.7%)	499 (16%)	1.42 (1.22-1.64)	<0.001	1.04 (0.89-1.21)	0.614

DVT, Deep Vein Thrombosis; MI, Myocardial Infarction; UTI, Urinary Tract Infection; AKI, Acute Kidney Injury.

Values in bold denote significance determined as p<0.05

38. DEFINING CLINICALLY RELEVANT DISTAL FAILURE IN THE TREATMENT OF ADULT CERVICAL DEFORMITY: AN IMPROVED DEFINITION BASED ON FUNCTIONAL OUTCOMES AND NEED FOR REOPERATION

Peter G. Passias, MD; _Sara Naessig, BS_; Waleed Ahmad, BS; Katherine E. Pierce, BS; Nicholas A. Kummer, BS; Lara Passfall, BS; Oscar Krol, BA; Renaud Lafage, MS; Virginie Lafage, PhD; Themistocles S. Protopsaltis, MD

Summary
Given that the widely used definitions for distal junctional kyphosis (DJK) has been relatively under-analyzed in terms of accuracy, sensitivity, and specificity, this study utilized true positive and true negative calculations to determine the ability of different angular change measures to predict DJK failure. The study found that a proposed 15.3° angle resulted in a DJK patient population that was more clinically meaningful than previous measures and enhanced the specificity and accuracy of predicting DJF defined by reoperation and HRQLs.

Hypothesis
A new threshold angle will more accurately capture patients experiencing DJK

Design
Retrospective

Introduction
The widely used definition for distal junctional kyphosis includes the change in kyphosis between the lower instrument vertebra (LIV) and LIV-2 to be >10°

Methods
CD patients evaluated at 1Y follow up for DJK. DJK was defined by the patient's DJK angle(DJKA) >10° change in kyphosis between LIV and LIV-2 and a>10° index angle. Sensitivity (true positive[TP]/TP+false negative[FN]), precision (true

negative[TN]/(TN+False Positive[FP]), and accuracy (TN+TP/TN+TP+FN+FP) metrics were calculated from angular changes above and below the lower instrumented vertebrae (LIV) from pre- to postop. Ability of these angular changes to predict different types of DJK failure(DJKF) [1] reoperation for DJK 2) not meeting MCID for either NDI or Eq5D] was compared against ΔDJKA>10° and ΔDJKA>20°

Results
160 CD patients were included (57yrs, 29.1 kg/m2, 51.8%F); 18% developed DJK. Previously used criteria of >10° to identify DJKF for outcome 1 demonstrated a sensitivity 50%, specificity 64.4%, and accuracy 63.2%. Outcome 2 sensitivity was 55%, specificity 75.8%, and accuracy 67.3%. If the ΔDJKA was increased to 15.3, the predicted sensitivity for DJKF defined by reoperation was 50%, specificity 86.6% and accuracy 83.6%. When DKF was defined by HRQLs the sensitivity was 35%, specificity 96.5%, accuracy 71.4%. The new cut off had greater ability to identify true positives than the 20° cutoff (45.8% vs 27.1%) and true negatives when compared to the 10° (39.2% vs 34.2%). 40.6% of patients with a DJKA>10° was not clinically meaningful. Increasing the angle to 15.3° resulted in 35.7% not clinically meaningful.

Conclusion
The newly established cut off for DJK failure (ΔDJKA>15.3°) demonstrated greater sensitivity, specificity, and precision than the previously established criteria of 10° when analyzing distal junctional kyphosis failure as described by reoperations or clinical deterioration

Take Home Message
A modified cutoff value for DJK may be able to capture patients suffering from this complication better than previous measures.

39. TIP OF THE ICEBERG: NORMAL LUMBAR BONE DENSITY DOES NOT PREDICT NORMAL CERVICAL BONE DENSITY

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Summary
We compare the Hounsfield units of the cervical spine to the lumbar spine and found that 92% of patients with an osteoporotic cervical spine have a normal lumbar spine. However, if the cervical spine was normal, the lumbar spine tended to be normal as well.

Hypothesis
That cervical and lumbar bone quality measures are distinct and should be evaluated independently

Design
Retrospective single center study

Introduction
The Hounsfield unit (HU) is a measurement of x-ray beam

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attenuation in computer tomography (CT) scans and have shown strong correlation to Dual energy x-ray absorptiometry (DEXA), the current standard for measurement of bone density. Unlike DEXA, hounsfield units may be opportunistically assessed on preoperative CT scans for osteoporosis screening. While the lumbar spine has been well studied using this technique, difference in the biomechanics of loading between the cervical spine and lumbar spine poses the question of whether lumbar HU can be correlated to cervical HU

Methods
In addition to basic demographics and clinical information, HU measurements were collected by three independent reviewers at C2, C4, C7, T1, L1, L2, L3, L4 and S1 within a sagittal region of interest Z (ROI) in the vertebral body. These were compared and correlated to BMD as measured by DEXA scans.

Results
182 patients were included. Interrater reliability was excellent between the three reviewers for all measurements. Linear regression analysis showed a significant association between lumbar and cervical HU (r-square: 0.436; std error: 37.3). Hounsfield units of the spine were strongly associated with DEXA of the spine, however not to the radius or hip. Interestingly 92% of patients with an osteoporotic cervical spine have a non-osteoporotic lumbar spine while only 1.3% of patients that have a non-osteoporotic cervical spine have an osteoporotic lumbar spine

Conclusion
A region of the spine can be a good predictor of overall bone quality however, it is not specific enough to predict the bone quality in another spinal region. The lumbar spine cannot be used as a predictor of bone quality in the cervical spine. However, if the cervical spine is normal, it is likely that the lumbar spine is normal as well. Planned fusion surgeries on the cervical spine should not use lumbar DXA or HU as a surrogate for cervical bone quality. Finally, future studies should evaluate if the cervical spine can be used as an early indicator for osteoporosis screening

Take Home Message
A region of the spine can be a good predictor of overall bone quality however, it is not specific enough to predict the bone quality in another anatomic region.
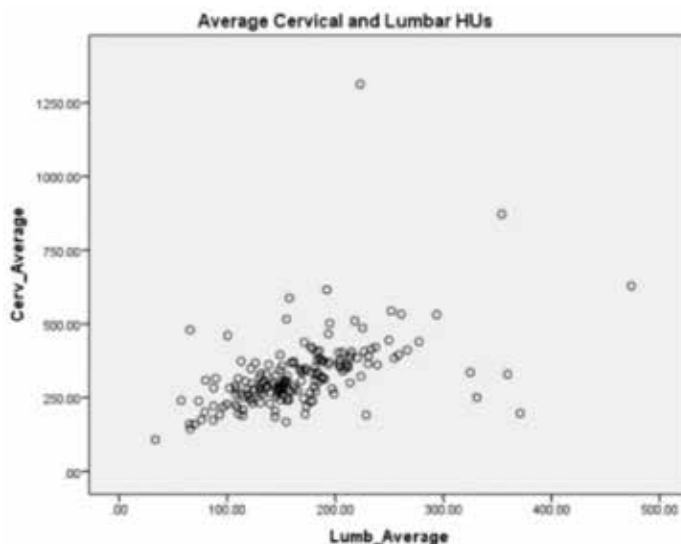
Average Cervical and Lumbar HUs

40. LOWER HOUNSFIELD UNITS AT THE UPPER INSTRUMENTED VERTEBRAE ARE SIGNIFICANTLY ASSOCIATED WITH PROXIMAL JUNCTIONAL KYPHOSIS AND FAILURE

Anthony L. Mikula, MD; Jeremy L. Fogelson, MD; Nikita Lakomkin, MD; Zachariah W. Pinter, MD; Matthew K. Doan, BS; Mohamad Bydon, MD; Ahmad Nassr, MD; Arjun Sebastian, MD; Kingsley Abode-Iyamah, MD; Benjamin D. Elder, MD, PhD

Summary
Hounsfield units (HU) can estimate bone mineral density in a targeted manner at the intended operative levels. A retrospective chart review identified 150 patients who underwent fusion from the pelvis to a upper instrumented vertebrae (UIV) of T10 to L2. Lower HU at the UIV/UIV+1 was the only independent predictor of proximal junctional kyphosis and failure.

Hypothesis
Patients with lower HU at the upper instrumented vertebrae (UIV) and vertebral body superior to the UIV (UIV+1) are at greater risk for PJK and PJF.

Design
Retrospective Chart Review

Introduction
Low bone mineral density (BMD) on dual energy x-ray absorptiometry (DXA) is likely a risk factor for proximal junctional kyphosis (PJK) and proximal junctional failure (PJF). However, prior instrumentation and degenerative changes can preclude a lumbar BMD measurement. Hounsfield units (HU) represent an alternative method to estimate BMD via targeted measurements at the intended operative levels.

Methods
A retrospective chart review identified patients at least 50 years of age who underwent instrumented lumbar fusion with

pelvic fixation, a UIV from T10 to L2, and a pre-operative CT encompassing the UIV. HU were measured at the UIV, UIV+1, and the L3-L4 vertebral bodies.

Results
One hundred and fifty patients (80 women and 70 men) were included with an average age of 66 years and average follow up of 32 months. Multivariable logistic regression analysis with an AUC of 0.89 demonstrated HU at the UIV/UIV+1 as the only independent predictor of PJK/PJF with an odds ratio of 0.94 (p-value=0.031) for a change in a single HU. Patients with HU at UIV/UIV+1 of <110 (n=35), 110-160 (n=73), and >160 (n=42) had a rate of PJK/PJF of 63%, 27%, and 12%, respectively (p-value <0.001).

Conclusion
Patients with lower Hounsfield units at the UIV and UIV+1 were significantly associated with PJK and PJF, with an optimal cutoff of 120 HU that maximizes sensitivity and specificity.

Take Home Message
Lower HU at the UIV/UIV+1 was an independent predictor of PJK and PJF, irrespective of age, gender, BMI, UIV, interbody fusion, spinopelvic parameters, femoral neck BMD, and HU at L3/L4.
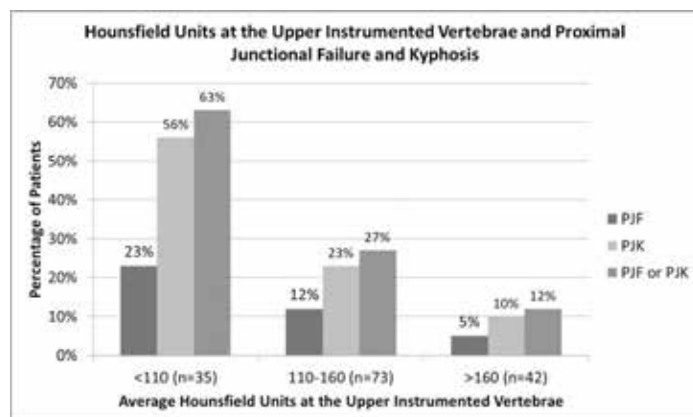
Subjects were grouped according to average Hounsfield units (HU) at the upper instrumented vertebrae (UIV) and level superior to the UIV (UIV+1). Rates of proximal junctional failure (PJF) and proximal junctional kyphosis (PJK) were reported within each group. Analysis of variance (ANOVA) comparing the three groups showed statistically significant differences with p-values <0.001.

41. IS THE PELVIC INCIDENCE A DETERMINANT FACTOR FOR KYPHOSIS CURVE PATTERNS OF ANKYLOSING SPONDYLITIS PATIENTS?

Xiaolin Zhong, MD; Bangping Qian, MD; Yong Qiu, MD

Summary
This is the first study attempting to investigate the influence of PI on the kyphosis curve patterns of AS patients. PI plays a key role in determining kyphosis curve patterns and in rationalizing surgical planning for AS patients with thoracolumbar kyphosis.

Hypothesis
Different kyphosis curve patterns may have some intrinsic interaction with different PI in AS patients.

Design
A retrospective study.

Introduction
The purpose of this study is to investigate the influence of PI on the kyphosis curve patterns in AS patients with thoracolumbar kyphosis. Another purpose is to establish a classification system of AS patients with thoracolumbar kyphosis according to the value of PI.

Methods
One hundred and seven AS patients with thoracolumbar kyphosis underwent single-level lumbar pedicle subtraction osteotomy (PSO) and finished a 2-year follow-up. Standing lateral radiographs were taken to evaluate the location of the kyphotic apex, thoracic kyphosis (TK), lumbar lordosis (LL), C7 sagittal vertical axis (SVA), spino-sacral angle (SSA), global kyphosis (GK), pelvic incidence (PI), sacral slope (SS), and pelvic tilt (PT). Visual Analogue Scale (VAS) score for back pain, Oswestry Disability Index (ODI) questionnaire and Bath Ankylosing Spondylitis Functional Index (BASFI) were administered to evaluate the quality of life (QOL).

Results
All patients were divided into three groups according to the value of PI, 31 in the low PI group (PI≤40°), 63 in moderate PI group (40°<PI≤60°) and 13 in the high PI group (PI>60°). Before surgery, the mean SVA, TK, PI-LL in each group were 148.8mm, 44.8° and 37.8° to 159.2mm, 43.9° and 44.1° to 147.8mm, 53.0° and 51.4°, respectively. At the final follow-up, the average of SVA, TK, and PI-LL in the low PI group were 30.4mm, 43.5° and -1.4° compared to 42.4mm, 42.6° and 4.0° in the moderate PI group and 64.0mm, 55.5° and-19.3° in the high PI group (P<0.05). . The correction of SVA, GK and LL were 89.2mm, 42.4°, 31.3° in the high PI group compared to 118.4mm, 47.8°, 42.4° and 121.3mm, 47.2°, 39.7° in the low and moderate PI group. There was a weak correlation between PI and the correction of LL (r=-0.235, P<0.05).

Conclusion
PI can be used to classify the patterns of kyphosis in AS patients and complementary corrections may be required in dealing with AS patients with high PI.

Take Home Message
PI plays a key role in determining kyphosis curve patterns and in rationalizing surgical planning for AS patients with thoracolumbar kyphosis.

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42. CERVICAL SAGITTAL ALIGNMENT IN LENKE 1 ADOLESCENT IDIOPATHIC SCOLIOSIS AND ITS ALTERATION WITH SURGERY: A RETROSPECTIVE, MULTI-CENTRIC STUDY

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Summary

In this multicentric study, the baseline cervical spine sagittal alignment and its alteration with surgery in 82 patients with Lenke 1 adolescent idiopathic scoliosis (AIS) was analyzed. A high incidence of cervical kyphosis was found in AIS patients- unlike thoracic kyphosis, the cervical sagittal alignment was not significantly altered with surgery.

Hypothesis

We explored the following questions: i) What are the baseline cervical sagittal characteristics in Lenke 1 AIS patients? ii) To what degree are these cervical sagittal characteristics altered after surgery? and, iii) Does the change in cervical sagittal parameters correlate with the degree of correction obtained in the coronal or sagittal plane?

Design

Retrospective, Cohort

Introduction

Despite the increasing recognition of the importance of CSA in patients with AIS, there is scarcity in literature regarding the baseline CSA in AIS patients, the degree of its correlation with other sagittal and coronal parameters, its impact on the global SVA and its alteration with surgery.

Methods

Preoperative and 1-year postoperative radiographs of 82 Lenke 1 AIS patients recruited from 5 hospitals were analysed. Selected radiographic parameters capturing regional and global sagittal alignment were measured. Comparison was made between groups based on baseline thoracic kyphosis (TK: TK < 20°, TK ≥ 20°). Preoperative and postoperative values were compared- the change in each radiographic parameter was correlated with the degree of sagittal and coronal correction.

Results

At baseline, TK was 29.8° ± 16°, cervical lordosis (CL) was -1° ± 14°, lumbar lordosis (LL) was-57.1° ± 21°, C2-C7 sagittal vertical axis (SVA) was 16 ± 14 mm and C7-S1 SVA was-15 ± 28 mm; 44% of patients had cervical kyphosis. Patients with thoracic hypokyphosis had a significantly lower LL and more kyphotic cervical spine compared to those with thoracic normohyperkyphosis. The effect of surgery on TK depended on preoperative thoracic sagittal alignment – TK increased in patients with thoracic hypokyphosis but decreased in patients with thoracic normohyperkyphosis. Neither CL nor C2-C7 SVA changed significantly with surgery; 46% of patients still had cervical kyphosis postoperatively.

Conclusion

There is a high incidence of cervical kyphosis at baseline in AIS patients – more so in those with preoperative thoracic hypokyphosis. Unlike TK, CL is not significantly altered with surgery – and correlates weakly with sagittal correction of the structural curve.

Take Home Message

The cervical sagittal alignment is altered in patients with AIS- with a tendency towards greater cervical kyphosis. Surgery does not alter the cervical sagittal alignment significantly.

43. INDEPENDENT RISK FACTORS FOR POSTOPERATIVE CERVICAL KYPHOSIS IN LENKE TYPE 1 AIS PATIENTS

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Summary

In adolescent idiopathic scoliosis (AIS) patients who underwent correctional surgeries, while correction of deformity on coronal plane has been thoroughly discussed, postoperative sagittal malalignment especially cervical kyphosis and the mechanism behind it remains controversial. This study identified preoperative CL ≥2.35° kyphosis and postoperative TK <22.6° as independent risk factors for final cervical kyphosis (CK) in Lenke type 1 AIS patients by retrospective radiographic review in a population of 62 Lenke 1 patients.

Hypothesis

We assumed that several sagittal parameters before, immediately after correctional surgery and during the follow-up period could play central roles in determining final cervical alignment, so that could be identified by logistic regression.

Design

This is an observational study. Patients were grouped by final cervical lordosis or kyphosis. Comparison of sagittal parameters between outcome groups and logistic regression analysis were conducted to prove our hypothesis.

Introduction

Numerous literatures reported sagittal malalignment of cervical spine in Lenke 1 AIS patients before and after correctional surgery as well as its correlation with health-related life quality in recent years. Risk factors for final cervical malalignment has not yet been thoroughly discussed so far.

Methods

A total of 62 Lenke 1 AIS patients who underwent posterior correctional surgery using all pedicle screws with at least 2-year follow-up were enrolled. Pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), lumbar lordosis (LL), thoracic kyphosis (TK), proximal thoracic kyphosis (PRTK), cervical lordosis (CL), T1-slope (TS), McGregor slope, and cobb angle of main scoliosis were measured on full spine radiographs preoperatively, postoperatively and at last follow-up. Chi-square test, paired and unpaired t-test, Pearson's correlation analysis, multivariate logistic regression and ROC curve were used for statistical

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analysis. P<0.05 was considered statistically significant.

Results
Preoperative PT, LL, TK, CL, TS, postoperative PI, SS, TK, CL, TS, and △PI, △TK from preoperatively to last follow-up as well as lower instrumented vertebra level showed significant difference between outcome groups. Larger preoperative CL and smaller postoperative TK were identified as independent risk factors for ultimate CK by stepwise multivariate logistic regression. ROC curve showed that preoperative CL ≥2.350° kyphosis (sensitivity=0.818, specificity=0.919) and with postoperative TK <22.60° (sensitivity=0.833, specificity=0.632) could predict final cervical kyphosis.

Conclusion
Larger preoperative CL and smaller postoperative TK were independent risk factors for final cervical kyphosis in Lenke 1 patients.

Take Home Message
CL≥2.350° kyphosis preoperatively and TK <22.6° postoperatively could lead to high risk of developing final cervical kyphosis. This conclusion could be used to predict radiographic outcomes and guide surgical treatment.

44. T1 TILT AND CLAVICLE ANGLE ARE THE BEST PREDICTORS OF POSTOPERATIVE SHOULDER AND NECK BALANCE IN AIS PATIENTS

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Summary
T1 tilt and CA play a role in predicting shoulder balance status. The restoration of these angles to near 'normal' levels can aid in yielding normal radiographic shoulder height (RSH) postoperatively. Our results indicate that T1 tilt and CA are radiographic markers that show significant association with abnormal shoulder balance before and after surgery.

Hypothesis
Decreasing T1 tilt and clavicle angle level the shoulders postoperatively

Design
Retrospective review

Introduction
Shoulder imbalance post PSF is a major concern. Most studies analyze multiple radiographic parameters associated with postop uneven shoulders. However, there is paucity in literature analyzing predictors for balanced shoulders. This study evaluates XRs of AIS patients who underwent PSF, and control patients (no spinal curvature) to identify radiographic predictors of shoulder balance

Methods
RSH used as proxy for shoulder height. RSH <2cm = 'normal'. T1 tilt and CA in the same orientation as RSH defined as concordant. Part I: Control patients XRs evaluated with T1, clavicle angle (CA) and RSH recorded to determine 'normal' T1 and CA values. Kruskal-Wallis tests performed. Part II: Preop, postop, and final follow up XRs of AIS patients who underwent PSF measured. Spearman's correlation- to evaluate correlation between radiographic parameters and RSH. Fisher's exact test - to evaluate distribution of abnormal postop RSH. Part III: XRs from multiple surgeons evaluated to predict RSH. Fisher's exact test- to evaluate distribution of abnormal postop RSH

Results
Part I: 211 control patients evaluated. 191 had normal RSH and 20 abnormal. T1 tilt (2.0 vs 4.1) and CA (1.1 vs 4.95) significantly different between the 2 groups (p<.05) Part II: 186 patients, preop and postop CA correlated very strongly with RSH (r = 0.856/0.921). T1 tilt correlated moderately with RSH (r = 0.399), but better when concordant (r = 0.51). RSH did not change significantly from immediate postop to final follow up (p=0.423). Restoring CA below 3° yielded normal RSH postop (p<0.0001). Restoring Concordant T1 tilt below 3° yielded normal RSH in nearly all cases (p<0.006) Part III: 59 patients across 4 surgeons, restoring CA below 3° yielded normal RSH at postop in all cases. Restoring concordant T1 tilt below 3° yielded normal RSH at postop in nearly all cases

Conclusion
Restoring the CA < 3° yields normal RSH postoperatively. When T1 is concordant, restoring it to < 3° can yield normal RSH. Proximal thoracic fusion did not correlate with post op RSH

Take Home Message
Our results indicate that T1 tilt and CA are radiographic markers that show significant association with abnormal shoulder balance before and after surgery.

45. PREDICTORS OF OPTIMAL OUTCOMES OF SELECTIVE THORACIC FUSION AT 5 YEARS

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Summary
Previously established guidelines for when to perform a STF for AIS were evaluated to determine which were likely to result in an optimal outcome at 5 years. Of the parameters tested (preop lumbar Cobb, lumbar bend, apical translation ratio, thoracic:thoracolumbar Cobb ratio), performing a STF with a preoperative lumbar curve <45º was the most likely variable to result in an optimal outcome 5 years postoperatively.

Hypothesis
The predictors of optimal outcome of selective thoracic fusion (STF) for adolescent idiopathic scoliosis (AIS) at 5 years will

mirror those seen in a previous 2 year publication

Design
Longitudinal

Introduction
Prior work by Schulz et al. (2014) identified optimal outcomes at 2 years following STF and found that a preop lumbar curve less than 45º and lumbar bend less than 25º were the best predictors for a successful STF. It is unclear whether these published predictors of an optimal outcome at 2 years represent what is required to achieve an optimal outcome with further time and potential growth.

Methods
Patients with primary thoracic AIS (Lenke 1-4C curves) who underwent a STF and had minimum 5 years of follow-up were included. Optimal postop outcomes for a STF as defined by Schulz et al. (2014) included a deformity-flexibility quotient (DFQ) less than 4, lumbar curve less than 26º, lumbar correction greater than 37%, C7-CSVL less than 2cm, lumbar prominence less than 5º, and trunk shift less than 1.5cm. These outcomes were used to determine whether adhering to "guidelines" for STF increased the likelihood of obtaining an optimal outcome at 5 years. The "guidelines" tested included a preop lumbar curve less than 45º, a lumbar bend less than 25º, apical vertebral translation ratio greater than 1.2, and a thoracic/thoracolumbar Cobb ratio greater than 1.2.

Results
127 patients met inclusion. A preoperative lumbar curve less than 45º was associated with an increased likelihood of achieving 3 of the optimal outcomes: DFQ<4, lumbar curve <26º, and lumbar prominence <5º (p<0.05. Table). AVT > 1.2 resulted in 2 optimal outcomes while following the 25º bend rule and a Cobb ratio > 1.2 only increased the chance of achieving 1 optimal outcome.

Conclusion
The previous study by Schulz et al. suggested that performing a STF in patients with a preoperative lumbar Cobb less than 45º or a preoperative lumbar bend less than 25º increased the chances of success at 2 years. This study found that at 5 years, performing a STF when there is a preoperative lumbar Cobb less than 45 remained the best guideline for increasing the likelihood of an optimal outcome.

Take Home Message
Of the established guidelines for when to perform a STF, having a lumbar curve <45º preoperatively was most likely to result in optimal outcomes at 5 years.

	45 degree rule		25 degree bend		AVT > 1.2		Cobb ratio >1.2	
	< 45	> 45	<25	> 25	> 1.2	< 1.2	> 1.2	<1.2
DFQ < 4	52%	33%	50%	50%	31%	49%	53%	30%
Lumbar Cobb < 26	65%	39%	50%	61%	51%	57%	62%	46%
L correction > 37%	56%	67%	100%	60%	67%	55%	67%	48%
C7-CSVL < 2 cm	63%	76%	68%	65%	67%	68%	64%	74%
L prominence < 5	58%	39%	56%	35%	46%	55%	56%	44%
Trunk shift < 1.5 cm	52%	44%	52%	39%	39%	55%	44%	56%

Highlighting represent statistical differences. Values represent the % of cases in which an ideal outcome was achieved.

46. ZERO PATIENT-CONTROLLED ANALGESIA (PCA) IS AN ACHIEVABLE TARGET FOR POSTOPERATIVE RAPID RECOVERY MANAGEMENT OF AIS PATIENTS

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Summary
In 2018, we instituted a rapid recovery pathway (RRP) for scoliosis patients undergoing Posterior Spinal Fusion (PSF) utilizing intrathecal micro dose (ITM). Retrospective review shows use of micro-dose ITM with oral analgesics has adequate recovery, significantly better postop pain control and superior periop outcomes to PCA in AIS population following PSF.

Hypothesis
Use of intrathecal single micro-dose ITM can replace PCA in RRP protocol after scoliosis surgery

Design
Retrospective review

Introduction
Narcotics often given as PCA during postop recovery and take-home medication. The study aims to report one institution's use of single bolus micro-dose intrathecal morphine (ITM) during PSF for AIS vs. patients whose pain was controlled with PCA.

Methods
In ITM protocol, patients receive 1.5 mcg/kg ITM diluted in 1 cc saline preop by anesthesiologists or intraop by the surgeon. Postop, patients received IV ketorolac at 0.5mg/kg Q6h, PO Tylenol (15 mg/kg q6h), PO Oxycodone (0.1 mg/kg q4), IV Hydromorphone (15 mcg/kg) for breakthrough pain. At discharge PCA patients received 14-day prescription for 5mg Oxycodone q6 vs 7-day prescriptions in the ITM group. PCA patients included in Group1 and ITM in Group2. Periop data and patient requests for home prescription refills analyzed using Kruskal-Wallis and Chi-squared tests

Results
296 AIS patients (PCA: 198; ITM:98) from 2011-2019. Periop major Cobb angles (p = 0.195) levels fused (p = 0.481) BMI (p = 0.978) similar between the two. Group1 averaged 2 days of PCA. 23.7% of patients in group1 had a length of stay (LOS) > 4 days, which was significantly higher than the 12.6% of patients in group2 (p < 0.001). Group2 patients began ambulating significantly earlier with 89.6% patients out of bed by POD2 vs

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81.6% in group1 (p < 0.001). Group2 patients had significantly lower maximum pain scores with activity compared to group2 (p < 0.001). Foley catheters removed earlier in group2 (p = 0.002) and 70.5% of patients had first fluid intake on POD0 in group2, significantly higher than 34.4% in group1 (p < 0.001). Time to first stool (p = 0.935), postoperative emesis (p = 0.614) similar. No cases of pruritus, respiratory depression, required supplemental oxygenation.

Conclusion
The first study to show use of micro-dose ITM with oral analgesics has adequate recovery, significantly better postop pain control and superior periop outcomes to PCA in AIS population following PSF.

Take Home Message
Use of single bolus micro-dose intrathecal morphine has adequate recovery, significantly better postop pain control, and superior outcomes to PCA in AIS population following PSF.

48. MYELOPATHIC PATIENTS WITH SEVERE PEDIATRIC SPINAL DEFORMITY CAN IMPROVE NEUROLOGIC FUNCTION CLOSE TO NON-MYELOPATHIC PATIENTS BY 1-YEAR AFTER SURGERY

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Summary
Severe pediatric spinal deformity patients with myelopathy can expect significant improvement in neurologic function close to neurologic function of non-myelopathic patients by 1-year postoperative. Mean lower extremity motor scores (LEMS) in myelopathic patients increased significantly compared to baseline at every postoperative visit up to 2 yrs. While non-myelopathic patients had significantly higher postoperative outcomes in SRS mental health, function, and total score, both groups had significantly superior outcomes in every SRS domain compared to baseline.

Hypothesis
In severe pediatric spinal deformity, we sought to compare short- & long-term neurologic outcomes in myelopathic vs. non-myelopathic pts

Design
Prospective multicenter cohort

Introduction
In severe pediatric spinal deformity, ambulatory myelopathic pts. are a high-risk population for intraop & postop neurologic complications. Given the decreased neurologic function before surgery, periop & long-term neurologic outcomes in a large series of these pts. are unknown

Methods
311 pts. with severe pediatric deformity were enrolled in a prospective, multicenter, observational study. Pts were split into two groups: myelopathic & non-myelopathic. Preop, periop, & postop variables & neurologic outcomes were compared

Results
Of the 311 pts, 29 (9.3%) were myelopathic preop while 282/311 (90.7%) were non-myelopathic. Both groups were similar in age (p=0.18), gender (p=0.09), & Risser Stage (p=0.06), while more pts in the non-myelopathic group had previous surgery (50 vs.12;p=0.03). There were no significant differences in length of surgery (7.4±2.4vs.6.4±3.6;p=0.14), levels fused (12.7±11.9vs.12.3±12.0;p=0.41), or EBL (1209±1041vs.1307±940;p=0.60), however the myelopathic pts had a significantly longer postop length of stay (13.0±10.0 vs. 8.6±5.0; p<0.01). Mean LEMS in myelopathic pts. increased significantly compared to baseline (40.7±9.9) at every postop visit (First Erect: 46.0±7.1,p=0.02; 1yr: 48.2±3.7,p<0.01; 2yr: 47.2±7.7,p<0.01), while the non-myelopathic group didn't experience any significant postop changes. Both groups had significant increases in every SRS domain compared to preop, while the non-myelopathic pts had significantly higher outcomes in mental health (p<0.01), function (p=0.02), & total score (p=0.01) compared to the myelopathic group

Conclusion
Severe pediatric spinal deformity pts. with myelopathy can expect significant improvement in neurologic motor (LEMS) function postop, close to neurologic function of non-myelopathic pts by 1-yr f/u, while both groups had significantly superior outcomes in every SRS domain 2 yrs postop compared to preop scores

Take Home Message
Myelopathic patients with severe pediatric-deformity can expect significant improvement in neurologic motor function postoperatively, close to that of patients without myelopathy. Both groups had superior postoperative outcomes compared to baseline.

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Variables (mean±SD or n (%))	Myelopathy (n=29)			No myelopathy (n=282)			p-value
Age (yrs)	15.3±2.8			14.6±2.7			0.18
Male	8 (2.6)			123 (39.8)			0.09
Risser	3.7±1.8			3.0±1.9			0.06
Syndromic	9(2.9)			64 (20.7)			0.32
Prior surgery	12 (3.9)			50 (16.1)			0.03
Preop Halo Gravity Traction							
Used	16 (5.2)			110 (35.5)			0.09
Time (days)	61.6±48.4			64.1±42.4			0.87
SRS-22 (preop)							
Total	3.06±0.58			3.51±0.64			<0.01
Pain	3.47±0.79			3.86±0.86			0.02
Self-image	2.32±0.70			2.71±0.83			0.02
Function	3.07±0.83			3.70±0.81			<0.01
Mental health	3.44±0.77			3.84±0.71			<0.01
Satisfaction	2.86±1.25			3.23±1.32			0.18
SRS-22 (postop)							
Total	3.96±0.62			4.26±0.51			0.01
Pain	3.97±0.93			4.27±0.82			0.12
Self-image	3.86±0.71			4.12±0.65			0.08
Function	3.97±0.73			4.31±0.63			0.02
Mental health	3.84±0.68			4.26±0.63			<0.01
Satisfaction	4.45±0.67			4.49±0.70			0.83
Radiographic							
Major curve	79.3±39.3			87.5±42.3			0.32
Secondary curve	51.3±30.6			57.9±26.3			0.22
Trunkshift	1.8±1.8			2.9±2.5			0.06
PI	24.5±22.3			39.8±13.6			0.14
PT	-4.5±18			6.4±12.4			<0.01
SS	35.1±24.0			35.0±15.8			0.96
Preop Motor score							
Upper extremities	49.4±1.3			48.3±8.5			0.48
Lower extremities	40.7±9.9			48.2±8.2			<0.01
Levels of fusion	12.7±11.9			12.3±12.0			0.41
Staged	6 (1.9)			64 (22.7)			0.37
Length of surgery (hrs)	7.4±2.4			6.4±3.6			0.14
Estimated blood loss (cc)	1209±1041			1307±940			0.60
Length of stay (days)	13.0±10.0			8.6±5.0			<0.01
IONM Changes (n used)							
SSEP (302)	9 (3.0)			50 (16.7)			.02
TcMEP (259)	14 (5.4)			97 (37.5)			.02
DNEP (55)	2 (4.0)			7 (14.0)			.18
Neurologic Outcomes (LEMS)	FE	1yr postop	2yr postop	FE	1yr postop	2yr postop	
LEMS	46.0±7.1	48.2±3.7	47.2±5.7	49.0±3.7	49.3±3.6	49.2±3.3	
Decline from baseline	2 (6.9)	0 (0)	2 (6.9)	19 (6.8)	7 (2.5)	6 (2.1)	
Improved from baseline	16 (55.2)	13 (44.8)	16 (55.2)	13 (4.6)	12 (4.3)	2 (0.7)	

Table 1. Demographic, radiographic, surgical, and PRO data

49. ROD FRACTURE IN TRADITIONALLY GROWING ROD TECHNIQUE IN EARLY ONSET SCOLIOSIS: WHEN DOES IT OCCUR?

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Summary

High rates of complications are documented in traditionally growing rod (TGR) technique. We assessed variables associated to rod fracture in TGR in EOS-patients. We reported 45 EOS-patients (<10yrs), mean age at surgery 6yr+3mo. Mean follow-up 4yrs+8mo. Eleven patients registered 18 broken rods, 14 titanium/4 CrCo. Pediatric rod breakages, 67%, adult rods, 33%. One-rod construction, 100% rod breakage. Syndromic patients reported (55% rod breakage). Rod fracture variables associated: titanium and pediatric rods, syndrome disorders, TGR single rod-construction and the usage of domino/connector.

Hypothesis

These TGR technique is effective in controlling early spinal deformity, and presumably to some extent restore spinal growth. However, they show a high rate of complications: infection, rod breakage, anchors pull out and progressive spinal stiffness, reducing long-term efficacy. We believe that several variables are closely associated to implant related complication rates.

Design

Retrospective, longitudinal and observational study (cohort) was conducted.

Introduction

Surgical treatment of early-onset scoliosis (EOS) has greatly developed in recent years. However, some authors are concerned about documented high rates of complications as high as 58%. The aim of the study was to assess variables associated to rod fracture in traditionally growing rod (TGR) technique in early onset scoliosis.

Methods

January 2010 to January 2018, we assessed 45 EOS (<10yrs), 21 females and 24 males, mean age at surgery 6yr+3mo. All patients underwent posterior growing rod treatment implantation and consecutives distraction surgeries with TGR technique. Mean follow-up 4yrs+8mo.

Results

Mean age at index surgery was 6yr+3mo. Mean scoliosis/kyphosis pre-operative AV was 77°/52°. Eleven patients registered 18 broken rods, 14 titanium broken rods (78%), and 4 CrCo rods (22%). Pediatric instrumentation (4.5mm diameter rods) reported rod breakages in 67%, and adult (5.5 diameter rods) 33%, Dual-rod construction, rod brakeage incidence, 13%, and in one-rod construction, all 6 cases (100%). Syndromic patients reported 10 broken rods events (55%). TGR using domino/connector documented rod brakeage 35%. The group that did not use domino/connector 16%. The most frequent location, where the rod failure took place, was in lumbar region (14 cases, 78%). Mean post-operative time when rod breakage was 33 months.

Conclusion

EOS can be effectively treated using dual TGR technique. Variables associated with rod fracture, titanium rods, pediatric rod/instrumentation, syndrome underlying disorders, TGR with one single rod-construction and the usage of domino/connector.

Take Home Message

TGR technique is effective in controlling spinal deformity in EOS. Variables associated with rod fracture: titanium rods, pediatric rod/instrumentation, syndrome disorders, one/single TGR construction and the usage of domino/connector.

50. MORTALITY IN PATIENTS WITH NEUROMUSCULAR EARLY ONSET SCOLIOSIS UNDERGOING SPINAL DEFORMITY SURGERY

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Summary

This is the first study reporting on mortality and associated risk factors in patients undergoing surgery for neuromuscular (NM) early onset scoliosis (EOS) using a large international registry with mid-term follow-up. The mortality risk was high and increased steadily from the 1-year post-operative (post-op) to the 10-year post-op period. Several factors were associated with an increased mortality rate, including cerebral palsy (CP) diagnosis, major curve ≥100° at index surgery, and unplanned return to the operating room (UPROR).

Hypothesis

Mortality is high in NM EOS patients undergoing spinal surgery and there are identifiable factors associated with an increased mortality rate.

Design

Multicenter retrospective cohort study.

Introduction

Current treatment paradigms for NM EOS patients are aimed at maximizing function and improving mortality. However, severe deformities and extensive surgery often complicate management. The purpose of this study was to report mortality in patients with NM EOS after spinal surgery and investigate its associations with risk factors.

Methods

Patients with NM EOS who underwent index surgery from 1994-2020 were identified in an international registry. NM diagnoses included CP, spinal muscular atrophy (SMA), myelodysplasia, muscular dystrophy (MD), and myopathy. Analyzed risk factors included age, diagnosis, major curve at index surgery, UPROR, and comorbidities. Mortality risk was calculated in confirmed cases [death/ (death + alive)] as well as in best [death/ (death + alive + loss to FU)] and worst [(death + loss to FU)/ (death + alive + loss to FU)] scenarios. To account for unequal follow-up, proportional hazard modeling was utilized to investigate associations between risk factors and mortality rate.

Results

702 patients [age at surgery: 7.3±2.5 yrs, major curve: 70.1±28.0° (range: 2-140), follow-up: 5.1±3.7 yrs (range: 0.1-19.7)] were identified. Diagnoses included 244 (34.8%) CP, 168 (23.9%) SMA, 152 (21.7%) myelodysplasia, 97 (13.8%) MD and 41 (5.8%) myopathy. UPROR occurred in 308 (72%) of 427 patients who had data available, and the average number of UPROR was 2.3±2.0 (range: 1-19) per patient. Mortality risk was 15%, 17%, 26% and 40% at 1, 2, 5 and 10 years, respectively. Multiple proportional hazard models demonstrated that patients with CP (hazard ratio [HR]: 2.5, p=0.046), major curve ≥100° at index surgery (HR: 2.1, p=0.132), and UPROR (HR: 2.5, p=0.145) had increased rates of mortality (Figure). There was no evidence of association between age at index surgery and mortality.

Conclusion

High mortality risk was observed in NM EOS patients after spine surgery. CP, major curve ≥100° at index surgery, and UPROR increased the rate of mortality.

Take Home Message

Mortality in NM EOS patients is high and there are specific patient factors associated with an increased rate. Special attention is needed to potentially prevent death in these patients.

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51. THE INCIDENCE OF REOPERATION FOR RECURRENT PROXIMAL JUNCTIONAL KYPHOSIS AT FIVE YEAR FOLLOW UP

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

Summary
Proximal junctional kyphosis (PJK) after adult spinal deformity surgery continues to pose a vexing challenge, particularly when it entails multiple revision surgeries. We found that over a five-year follow up period from an initial revision procedure for PJK, 8% of patients developed PJK at a more cephalad level necessitating a second revision. After a second revision surgery incorporating wide laminectomy at the kyphotic level and extension of fusion, there were no additional revision surgeries required for PJK.

Hypothesis
A subset of patients who require revision surgery for PJK will require more than one revision surgery for this problem.

Design
Retrospective review of a prospectively collected single center database.

Introduction
Despite improvements in surgical techniques, PJK continues to pose a challenge. To date, there is a paucity of data demonstrating the rate of subsequent revision surgeries required for PJK, over long-term follow up.

Methods
A single center database of 367 adult spinal deformity patients (Age: 58 ± 16 y; mFI: 0.6 ± 0.7; Levels fused at index surgery: 10.1 ± 4.8) was analyzed for rate of revision surgery for PJK at five-year follow up. We sought to define the rate of recurrent revision surgeries to address PJK.

Results
At an average follow-up of 68.1 months from the initial procedure, 25/367 (6.8%) of patients required a revision procedure to address PJK. 24/25 patients (96%) underwent extension of fusion (6.0 ± 2.4 levels added to the previous instrumentation) and 1 patient (4%) underwent vertebroplasty alone at the upper instrumented vertebra (UIV) and UIV+1. Of the 25 patients who required revision for PJK, 17/25 (68%) had an associated neurologic injury, of which 14/17 (82%) had complete resolution at final follow up. Proximal junctional angle improved from 21.4° ± 16.1° to 17.3° ± 12.8° post-PJK revision and mean sagittal vertical axis improved from 94.2 mm ± 63.9 mm to 91.2 mm ± 66.3 mm. Following initial revision surgery 2/25 (8%) developed PJK at a more cephalad level with associated neurologic deficit related to cord compression and required a second revision. At final follow-up after the second revision, no further revision procedures were required for PJK.

Conclusion
In summary, the rate of revision surgery for PJK was 25% with an associated neurologic complication rate of 68% in this group.

Over 5 year follow up, 8% of these patients developed recurrent PJK at a more cephalad level requiring a second revision procedure.

Take Home Message
8% of patients will develop recurrent proximal junctional kyphosis requiring multiple revision surgeries.

52. TRENDS IN 2 YEAR OUTCOMES OF A PROSPECTIVE SINGLE-SURGEON ADULT CERVICAL DEFORMITY SERIES: OPTIMAL REALIGNMENT CORRELATES WITH SUPERIOR OUTCOMES

Lara Passfall, BS; Nicholas A. Kummer, BS; Oscar Krol, BA; Sara Naessig, BS; *Peter G. Passias, MD*

Summary
Adult cervical deformity (CD) is a debilitating disorder of the spine characterized by radiographic malalignment of the cervical vertebral segments in the sagittal and/or coronal planes. CD significantly compromises patient's health-related quality of life. While advances in spinal realignment have shown promising short-term clinical results, the durability of CD-corrective surgery remains a clinical challenge. This study demonstrates that correction of cervical deformity results in sustained clinical and radiographic improvement. Most patients improve with favorable outcomes, though complications still occur.

Hypothesis
Correction of cervical deformity results in clinical and radiographic improvement.

Design
Retrospective

Introduction
Despite high complication rates, surgical correction of cervical deformity has promising short-term clinical and radiographic outcomes.

Methods
Operative CD patients >18yrs were included. CD was defined as meeting at least one of the following radiographic parameters: C2-C7 lordosis <-15°, T1S-CL >35°, segmental cervical kyphosis >15° across any 3 vertebra between C2-T1, C2-C7 SVA >4cm, McGregor's slope >20°, or CBVA > 25°. Demographics, surgical descriptors, radiographic parameters, and HRQL scores at baseline and 2 years postoperatively as well as complications were assessed.

Results
101 CD patients included (60yrs, 59%F, BMI 29kg/m2, CCI: 0.58), and underwent surgical correction (levels fused 6.1±4.5, EBL: 1050 mL, operative time: 684 min). By surgical approach, 15.8% anterior-only, 57.4% posterior-only, and 24.8% combined. Of 47 patients (46.5%) who underwent osteotomy, 33 had facet osteotomy, 19 SPO, 5 PSO, and 4 VCR. 30 patients required postoperative SICU care. From BL to 2Y postop, 9 patients improved in Ames cSVA modifier, 2 in TS-CL, 6 in Horiz, 1 in

SVA, and 13 in mJOA. Overall, 24 patients (23.8%) improved in ≥1 Ames modifier. By 2Y, 14 patients met MCID for EQ5D, 22 met MCID for NDI, and 11 met MCID for mJOA. At 2Y postop, 14.3% of patients had PT age-adjusted match, 19.0% had PILL age-adjusted match, and 12,5% had SVA age-adjusted match. By 2Y, 27 patients (26.7%) required reoperation. 35 patients (34.7%) experienced a complication, 9 of which were classified as major. 2 patients developed dysphagia, 13 had a neuro comp, 5 cardiopulmonary comp, and 3 had surgical infection. There were 3 mortalities. 15 patients (11.9%) had a radiographic complication, 12 of which were DJK.

Conclusion

Correction of cervical deformity results in clinical and radiographic improvement. Most patients improve with favorable outcomes, though complications most notably distal junctional kyphosis still occur and need to be minimized.

Take Home Message

Correction of cervical deformity results in clinical and radiographic improvement. Most patients improve with favorable outcomes, though complications most notably distal junctional kyphosis still occur and need to be minimized.

53. SERIAL CASTING IS AN EFFECTIVE NON-OPERATIVE METHOD FOR TREATING EARLY ONSET SCOLIOSIS

Stephen Wanner, MD; Lindsay R. Schultz, CCRP; Nichole S. Leitsinger, BS; _Peter F. Sturm, MD_

Summary

This retrospective study reviewed the treatment and outcomes for EOS patients undergoing Serial Mehta Castings. Casting provides a non-operative treatment to assist in correcting, improving and/or delaying surgical treatment. The team analyzed patient parameters to determine if this is the most effective approach in providing initial treatment for this patient population.

Hypothesis

Mehta casting provides a non-operative treatment that can correct significant spinal curvatures or improve/prevent worsening until effective surgical treatment can be performed.

Design

Retrospective, single site

Introduction

Early onset scoliosis is a challenging disease, if left untreated can lead to progressive thoracic cage deformity and restrictive lung disease. Mehta casting can delay surgical treatment until lengthening constructs are appropriate interventions.

Methods

EOS patients who underwent general anesthesia for Mehta casts from 2011-2018 were reviewed. Parameters included EOS type, sex, age, degree of curve, # of casts, & treatment status.

Results

117 patients were analyzed, 93 patients met inclusion criteria, 17 were lost to follow up. Idiopathic 24 females/30 males;

initial casting mean age 18 ± 12 mths; initial curve 40.2 ± 13.5; last follow up 21 patients curves < 10 remaining patient curves 31.2 ± 21.6; cast total 6.5 ± 4.3. Current status of idiopathic: 28 observation, 18 brace, 6 casting, 1 lengthening construct, 1 definitive fusion. Syndromic 7 females/4 males; initial mean age 33 ± 15.1 months; initial cast major curve 58.9 ± 21.6; curve at follow up 53.7 ± 20.8; cast total 4.8 ± 3. Syndromic patients 4 brace, 3 casting, and 4 GR construct (2 TGR and 2 MCGR). NM group 3 females/14 males; initial cast mean age 28.7 ± 13.9 mths; initial curve 52.6 ± 10.8; curve at last follow up 31.6 ± 16.4; cast total 6.4 ± 2.5. Current NM status: 1 observation, 9 brace, 8 lengthening constructs. Congenital group 5 female/6 males; initial cast mean age 24 ±7.8 months; initial cast curve 66.1 ± 17.5; curve at last follow up 56.3 ±21.9; cast total 7.8 ± 7.5. Congenital: 3 brace, 6 lengthening constructs (3 TGR 3 MCGR), 2 definitive fusions.

Conclusion

Serial casting can provide effective initial treatment, intermediate treatment until patients are able to undergo implantation of lengthening devices, or definitive treatment in patients with EOS.

Take Home Message

Serial casting is an effective non-operative initial treatment in patients with EOS.

54. CHANGE IN SAGITTAL ALIGNMENT AFTER DECOMPRESSION ALONE IN PATIENTS WITH LUMBAR SPINAL STENOSIS: A PROSPECTIVE COHORT STUDY

Jamal B. Bouknaitir, MD; Leah Y. Carreon, MD; Mikkel Østerheden Andersen, MD; Stig Brorson, MD, PhD

Summary

This Single center longitudinal cohort study included patients mean age 71.80, operated with decompression alone for degenerative lumbar spinal stenosis, comparing pre-operative and 6-month post-operative full-length 36" standing lateral and posterior-anterior x-rays. Showed significant improvement in sagittal balance. Sagittal vertical axis (SVA) changing from 52.3mm pre-operatively to 33.9mm post-operatively (p=0.0001) and significant increase in lumbar lordosis from 41.5° pre-operatively to 44.0°post-operatively (p=0.055). Statistically significant correlations were seen between SVA and all the PROMs.

Hypothesis

Decompression alone for degenerative lumbar spinal stenosis leads to a less stooped posture improving sagittal balance

Design

Prospective longitudinal cohort study

Introduction

Patients with lumbar spinal stenosis present with low back pain, numbness and pain in the legs and gait difficulties due to neurogenic claudication. Patients often walk in a stooped posture to increase the spinal canal diameter by stretching out

the ligamentum flavum. This stooped posture leads to a positive sagittal balance. After decompressive surgery, patients may walk in a less stooped manner, improving their sagittal balance, which may lead to less back pain and improved patient reported outcomes.

Methods
This study compares pre-operative and 6-month post-operative full-length 36" standing lateral and posterior-anterior x-rays and one year Oswestry Disability Index (ODI), Visual analogue scale (VAS)- leg and back pain, in patients undergoing decompression alone without fusion for central or combined central and lateral stenosis, in patients 60 years and older from March 2016 until September 2017. The following radiographic parameters were measured Coronal Cobb Angle (COBB), Pelvic Incidence (PI), Sagittal Vertical Axis (SVA), Lumbar Lordosis (LL), Pelvic Tilt (PT), Pelvic Incidence-Lumbar Lordosis ratio (PI-LL) and Sacral Slope (SS).

Results
Forty-five patients (24 males) with a mean age of 71.80 years were included. Sagittal balance showed a statistical significant improvement with the SVA changing from 52.3mm pre-operatively to 33.9mm post-operatively (p=0.0001). There was a statistically significant increase in lumbar lordosis from 41.5° pre-operatively to 44.0°post-operatively (p=0.055) and a statistically significant decrease in the Pelvic Incidence – Lumbar Lordosis from 8.4°pre-operatively to 5.8° post-operatively (p=0.002). All PROM scores showed a significant improvement after spinal decompression surgery. Statistically significant correlations were seen between SVA and all the PROMs at both pre-operative and post-operative.

Conclusion
Sagittal balance and PROMs improve in patients undergoing decompression alone for lumbar spinal stenosis.

Take Home Message
Surgeons can expect restoration of sagittal balance without the need for intraoperative correction maneuvers, instrumentation and fusion, in patients operated for degenerative lumbar spinal stenosis

55. PREDICTING READMISSION AFTER A LUMBAR SPINAL FUSION: A NOVEL NEURAL NETWORK MACHINE LEARNING APPROACH

Eren Kuris, MD; Ashwin Veeramani; Andrew Zhang, MD; Kevin Disilvestro, MD; Alan H. Daniels, MD; Christopher McDonald, MD; Eric Cohen, MD

Summary
Machine learning algorithms are clinical tools that can help identify patients susceptible to readmission after lumbar fusion.

Hypothesis
Machine learning can be utilized to predict readmission after lumbar arthrodesis.

Design
This study was an analysis of the National Surgical Quality Improvement Program database.

Introduction
Readmission after spine surgery is a costly, but relatively common occurrence. Previous research has identified several risk factors for readmission however, the conclusions remain equivocal. Machine learning algorithms offer a unique perspective in the analysis of risk factors for readmission and can help predict the likelihood of this occurrence. In this investigation, two supervised machine learning algorithms, logistic regression and neural network, are examined to determine whether they can predict readmission after lumbar fusion.

Methods
The American College of Surgeon's database, the National Surgical Quality Improvement Program (NSQIP), was queried between 2009 and 2018. Patients who had undergone anterior, lateral, and/or posterior lumbar fusion were included in the study. The Python Sci-Kit Learn package was utilized to run the logistic regression and neural network algorithms. A multivariate regression was performed to determine risk factors for readmission.

Results
The logistic regression technique was able to accurately predict readmission 81.6% of the time for Anterior/Lateral Lumbar Interbody Fusion (ALIF), 83.4% for posterior spinal fusion with interbody fusion (PLIF), and 82.5% for posterior spinal fusion alone (PSF). The neural network algorithm accurately predicted readmission for 82.2% of ALIF, 84.4% of PLIF, and 84.0% of PSF.

Conclusion
The accurate metrics presented here indicate the capability for supervised machine learning algorithms to predict readmission after lumbar arthrodesis. Further, the results of this study serve as a catalyst for further research into the utility of machine learning in spine surgery.

Take Home Message
Machine learning algorithms are clinical tools that can help identify patients susceptible to readmission after lumbar fusion.

56. NEUROLOGIC COMPLICATIONS FOLLOWING ADULT SPINAL DEFORMITY AND IMPACT ON HEALTH-RELATED QUALITY OF LIFE MEASURES

Eric Klineberg, MD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Gregory M. Mundis, MD; Han Jo Kim, MD; Munish C. Gupta, MD; Michael P. Kelly, MD; Christopher P. Ames, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Douglas C. Burton, MD; Frank J. Schwab, MD; Shay Bess, MD; Virginie Lafage, PhD; International Spine Study Group

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Summary

Neurologic complications following adult spinal deformity (ASD) are common and play a role in the outcomes for our patients. Radiculopathy significantly impacts HRQL at 1 year, as does any continued decrease in the patient's lower extremity motor score (LEMS). Normal motor score, improved motor score, or motor score that returns to normal at 1 year all have similar HRQL improvement, regardless of other complications.

Hypothesis

Significant neurologic injuries that occur following surgery will be impactful at 1yr

Design

Retrospective cohort study

Introduction

Neurologic complications are common following ASD. Understanding their impact on Health-related quality of life (HRQL) measures is critical.

Methods

ASD pts (>18yrs, scoliosis≥20°, SVA≥5cm, PT≥25° and/or TK>60°). Inclusion criteria was HRQL at baseline (BL) and 1 year and lower extremity motor score (LEMS) at BL, 6wk and 1 yr. ODI, SRS22r and SF36 were determined at BL and 1yr. LEMS was calculated from 0-50, with 50 designated as normal motor function. Patients were divided into 4 groups: pLEMS (perfect, no deficit), dLEMS (new postop deficit that returned to normal at 1 yr), iLEMS (deficit improved from abnormal baseline), and wLEMS (new postop deficit persistent at one year.)

Results

733 patients were eligible, with 95(12.96%) reporting neurologic complications (NC). Impact of any NC vs. no complication at 1yr was significant for ODI (Δ5.1), PCS (Δ3.6) and SRSpain (Δ0.2) at 1yr (p<0.001 all). For NC vs. any other complication, there was still a decrease in ODI (Δ3.9) and PCS (Δ2.4) at 1 yr (p<0.01). NC subtype: radiculopathy caused worse outcomes for (Δ4.3) and SRS pain (Δ0.3)(p<0.05), sensory deficit caused worse SRSmental(Δ0.5) (p<0.05), but no HRQL change was detected for motor deficit at 1 year. pLEMS(456/733) had improvement in all HRQL, and these improvements were not different with or w/o NC, or non-NC. Compared to pLEMS w/o complication, dLEMS (62/733) and iLEMS (147/733) were statically similar, however wLEMS (68/733) had worse ODI (Δ7.1), SRStotal (Δ0.3), activity (Δ0.3), mental (Δ0.3), pain (Δ0.3) (p<0.05 all).

Conclusion

Neurologic complications that occur following ASD have a significant effect on HRQL's. The magnitude of effect is driven by radiculopathy and by lower extremity motor score. LEMS scores that remain normal, return back to normal or improve have similar outcomes, while patients that have continued weakness remain statistically worse at 1 year.

Take Home Message

Neurologic complications affect our patient's outcomes 1 year

following ASD surgery. The outcomes are most impacted by radiculopathy and lower extremity weakness that does not improve following surgery.

57. COMPLICATIONS FOLLOWING ADULT SPINAL DEFORMITY IMPACT LENGTH OF STAY AND ARE DRIVEN BY INTERVENTION SEVERITY AND CAN BE PREDICTED USING A WEIGHTED SCORE

Eric Klineberg, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Gregory M. Mundis, MD; Han Jo Kim, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Douglas C. Burton, MD; Frank J. Schwab, MD; Shay Bess, MD; International Spine Study Group

Summary

Complications occur commonly following adult spinal deformity surgery. Length of stay is influenced by the type of surgical intervention, and by post-operative complication. While all complication types increase the LOS, it is most lengthened by renal and pneumonia complications and by the intervention severity type. When the intervention severity type is weighted and combined into a score, it can also accurately predict the incremental increase in LOS.

Hypothesis

Complications following ASD will impact LOS and can be predicted using a weighted intervention score

Design

Retrospective cohort study

Introduction

Complication occur commonly following adult spinal deformity (ASD) and can influence the LOS.

Methods

ASD pts (>18yrs, scoliosis≥20°, SVA≥5cm, PT≥25° and/or TK>60°). Complications were classified based on complication type, and intervention severity (grade 0, no intervention, Grade 1 minimal intervention (medication change, etc..), Grade 2 moderate (cardioversion, chest tube, etc..), grade 3 major intervention (return to OR).

Results

1418 patients included, 901 had at least one complication event, with 568 with a complication before discharge. 306 had an event that required a reoperation and 275 were readmitted for their event. When determining LOS, a baseline was established that was influenced by the type of surgery and place into the groups based on osteotomy (O) and interbody use (I); Group 1 (n408): 0% O, 75% I, LOS=7.9, Group 2 (n374): 100% O, 0% I, LOS=11.9, Group 3 (n595) 100% O and I, LOS=11.2. Having a complication event prior to discharge led to an increase of 1-4 days for each group ($p<0.01$). This was true for every complication, regardless of type, but was worse for renal and pneumonia. The increase in LOS was most driven by the intervention required. No intervention had a LOS of 6.9, Grade 1 +1.2d, Grade 2, +1.8d, Grade 3 +2.5 d. Using the sum of a weighted intervention score (SUM=1*#grade1 + 2*#grade2 + 3*#grade3) we can even more accurately predict the incremental increase in LOS (figure1). This occurs until a weighted score of 7 which accurately predicts and increase in 7.5 days.

Conclusion

Length of stay following ASD is predicted by the type of surgical intervention, and post-operative complication profile. Additional days are most predicted by the type of complication and by intervention severity. A weighted intervention score can predict the additional LOS and is useful to help understand the impact of complications.

Take Home Message

Complications following ASD surgery increase the length of stay which can be predicted using a weighted intervention score.
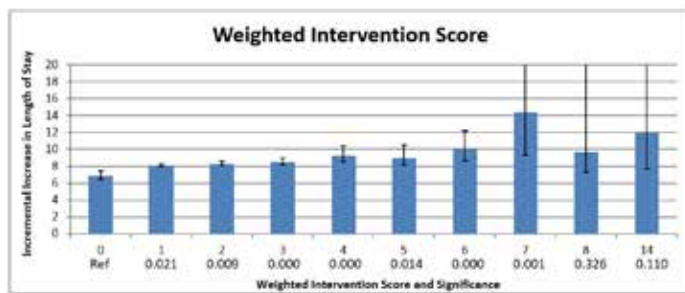
58. VERTEBRAL COLUMN RESECTION SURGICAL PLANNING PRE- AND POST-3D MODELLING

Sumeet Garg, MD; Eun Kim, BA; Jennifer Wagner, BS; Todd Hankinson, MD; Mark A. Erickson, MD

Summary

This study evaluated the impact of 3D printed spine models on pre-surgical planning for vertebral column resection surgery. Spine models aided in creating a patient-specific surgical plan.

Hypothesis

3D printed spine models will be an effective tool for pre-surgical planning for vertebral column resection surgery (VCR).

Design

Descriptive Case Series

Introduction

This study evaluated the impact of 3D printed spine models on pre-surgical planning for VCR surgery. The study compared pre-operative surgical planning with and without the use of 3D printed models.

Methods

7 patients between the ages of 1-17 years at time of planned VCR surgery were enrolled. Using image segmentation software (ScanIP-Simpleware) CT images were converted to stereolithogsraphy files used by 3D printers to produce physical models with acrylonitrile butadiene styrene using a Fortus 200mc fused deposition modeler or adhesive-bound gypsum powder using a Projet 660 colorjet machine. A surgical plan questionnaire was sent to the three participating surgeons with the physical models. Requested information included levels of surgery, location and type of planned spinal implants, deformity correction strategies, and staging vs. single day surgery. The questionnaire was completed after reviewing imaging but prior to seeing the 3D model, after the 3D model was received for review, and after surgery by the treating surgeon only to describe the actual operative procedure done. Surgeries were performed by Team A (pediatric orthopedic surgeon and APP) or Team B (pediatric orthopedic surgeon, pediatric neurosurgeon, and APP).

Results

6 cases were performed by Team A and 1 by Team B. Surgical plan was changed often after reviewing the 3D model. Table 1 shows, in 6/7 cases, the operating surgeon changed their surgical plan after reviewing the model. Method of posterior correction and fixation plan changed in 5 cases, and whether an osteotomy was done changed in 1 case. 3D models also led to differences in labeling of the hemivertebra between surgeons.

Conclusion

3D printed models were effective tools for surgical planning of complex pediatric spinal deformities. Models allowed surgeons to study complex anatomy of each patient and aided in creating a patient-specific surgical plan that often deviated from what was planned based only on imaging review.

Take Home Message

3D printed spine models are a valuable tool for surgical planning in VCR surgery.

Table 1: Surgical plan changes between pre-3D model, post-3D model, and post-surgery surveys

Cases	Method of Posterior Correction	Fixation	Osteotomy
1	X		
2	X	X	
3		X	
4	X	X	
5			
6	X	X	X
7	X	X	

Surgical plan changes between pre-3D model, post-3D model, and post-surgery surveys

59. EVALUATION OF HEALTH-RELATED QUALITY OF LIFE IMPROVEMENT IN PATIENTS UNDERGOING SPINE VS. ADULT RECONSTRUCTIVE SURGERY AFTER 1 YEAR FOLLOW-UP

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Summary
Patient Reported Outcome Information System (PROMIS) provide a tailored ability to compare different procedures. This study compares PROMIS results for patients undergoing common single-level spinal surgery, total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures with minimum 1 Year Follow-Up (FU). Spine surgery patients showed lower initial PROMIS scores and showed greater PROMIS improvement compared to THA and TKA (RECON) after 1 year.

Hypothesis
Spine surgery patients may have greater improvement in PROMIS scores than adult reconstruction patients have, despite having lower baseline PROMIS scores.

Design
Retrospective review of single-level spine surgery, THA, and TKA patients.

Introduction
Comparing outcomes between distinct procedures and diseases was limited by different standards. Recent advent of computer adaptive PROMIS provides the ability to compare and reevaluate differing disease states and procedures to each other.

Methods
Patients>18 years old who underwent spine surgery [Laminectomy only (Lami), Microlumbar Discectomy (MLD), Transforaminal Lumbar Interbody Fusion (TLIF)] or RECON surgery with Baseline (BL) and 1 Year (1Y) PROMIS scores of Physical Function (PF), Pain Interference (P-IF), and Pain Intensity (PI) were grouped based on surgery type. Paired t-tests calculated differences in BL, 1Y, and change in PROMIS scores for spine vs. RECON procedures. Significance set at p<0.05.

Results
90 spine patients (Age=55.65±17.02; 51.11% Female) and 157 RECON patients (Age=65.9±8.5; 61.15% Female) were compared. Spine patients undergoing Lami, MLD, or TLIF had more disability and pain at baseline than RECON patients, according to all 3 PROMIS categories (Table 1). 1Y PROMIS scores were significantly improved compared to at least one RECON in PF [MLD, TLIF], P-IF [Lami, MLD, TLIF], and PI [Lami, TLIF]. When assessing all lumbar surgery patients with RECON, Spine patients had greater improvements in all PROMIS domains (Table 1).

Conclusion
Patients undergoing single level spinal surgery had worse baseline disability and pain compared to those undergoing RECON surgery. PROMIS improvement is at least as good, and often greater in the spine patients compared to RECON.

Take Home Message
Although patients undergoing spine surgery had lower initial PROMIS scores than RECON patients, spine patients showed at least as good or better improvement at a 1Y post-operative time point.

Table 1. Baseline, 1Y and Change Mean in PROMIS metrics in Laminectomy alone, MLD, TLIF, THA, and TKA patients with Comparison of Improvement between Spine and Recon Patients

60. COMPARISON OF COMPLICATIONS AND 90 DAY READMISSIONS BETWEEN OPEN AND MINIMALLY INVASIVE SURGERY FOR ADULT SPINE DEFORMITY

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Summary
In a propensity score match analysis of open and MIS treatment for ASD, open surgery is associated with larger constructs, more EBL, LOS, ICU admissions, and complications than MIS. There was a trend toward higher overall readmission rates in open with no difference in 90-day readmissions. Open had greater increase in PJK and TK and lower maximum coronal cobb at 1 year. At 1 year MIS had lower SRS-22 appearance and mental subscores.

Hypothesis
Open treatment for adult spinal deformity (ASD) may have higher complication rates and readmissions when compared to minimally invasive spinal surgery (MIS).

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Design
Retrospective review of prospective multicenter database.

Introduction
Surgical management of ASD improves HRQoL. However, these procedures carry 40-86% risk of perioperative complications, resulting in readmissions and increased burden to patients and health systems. This study compares complication and readmission rates between open and MIS treatments for ASD.

Methods
Assessment of patients who underwent either open or MIS treatment for ASD with inclusion criteria: age>18years, major coronal Cobb≥20°, SVA≥5cm, PT≥25° and/or TK>60°, with 1 year follow up. The open and MIS groups were propensity score matched based on age, BMI, preoperative sagittal and coronal alignment parameters, date of surgery, and previous surgery. The matched cohorts were analyzed for differences in surgical techniques, HRQoL, complications, readmission, revisions, alignment correction, and length of stay.

Results
260 patients were matched, 130 in each. Operative time was similar (p=0.220). Open had greater EBL (p<0.001), number of levels fused (p<0.001), PCOs (p<0.001), LOS (p=0.001), and ICU admissions (p<0.001). MIS had more interbody fusions (p<0.001) and ACRs (p<0.001). Open had higher major (p=0.028), neurological (p=0.029) and overall (p=0.012) complications. There was a trend toward greater overall readmissions in the open group (19.23% vs. 12.31%, p=0.126) but no difference in 90-day-readmissions. There was no difference in revision rates. Both had significant improvements in ODI and SRS-22, with greater appearance (p=0.006) and mental health (p<0.001) in open. Open had greater postop TK (p=0.013) and change in PJA (p<0.001).

Conclusion
For the same preoperative deformity, there were similar 90-day readmissions between open and MIS surgery. However, open surgery is associated with longer constructs, more EBL, LOS, ICU admissions, and complications, achieving similar spinal alignment and overall HRQoL.

Take Home Message
Open surgery carries more invasiveness, greater complications, and LOS than MIS for ASD. Overall, 1-year ODI and SRS-22 are similar, with no difference in 90-day readmissions.

	Open	MIS	p value
Age	66.7+/-9.4	68.2+/-10.6	0.338
BMI	29.4+/-6.1	28.6+/-6.3	0.368
Preop Alignment parameters			
PI-LL	15.1+/-17.0	14.3+/-17.5	0.703
SVA	57.91+/-62.04	56.86+/-59.91	0.887
PT	23.64+/-9.00	23.36+/-10.16	0.816
T1PA	21.9+/-10.6	21.7+/-11.3	0.891
TK	39.42+/-18.84	40.58+/-15.76	0.581
Max coronal cobb	29.64+/-16.40	28.82+/-14.30	0.976
Coronal C7PL	28.65+/-27.59	28.53+/-27.48	0.883
Postop Alignment parameters			
PI-LL	3.8+/-13.52	5.7+/-13.63	0.281
SVA	27.79+/-48.89	35.53+/-47.63	0.217
PT	22.10+/-10.71	21.76+/-9.31	0.456
T1PA	17.89+/-9.67	17.97+/-9.64	0.949
TK	52.14+/-16.23	47.02+/-15.23	**0.013**
TK Change	13.10+/-14.27	6.94+/-10.69	**<0.001**
Max coronal cobb	14.64+/-11.20	19.00+/-13.00	**0.003**
Coronal C7PL	24.33+/-18.71	26.47+/-19.28	0.352
PJA Change	8.83+/-7.67	4.48+/-7.79	**<0.001**
HRQoL Metrics			
Preop ODI	44.67+/-16.04	46.55+/-13.55	0.309
Preop SRS-22	2.74+/-0.62	2.85+/-0.61	0.121
Postop ODI	25.73+/-18.56	26.17+/-16.61	0.841
Postop SRS-22	3.7+/-0.68	3.58+/-0.69	0.121
Postop SRS-22 appearance	1.2+/-1.05	0.8+/-1.07	**0.006**
Postop SRS-22 mental	0.56+/-0.83	0.11+/-0.95	**<0.001**
Surgical Factors			
Previous surgery	22.60%	21.90%	0.885
Date of surgery (days)	Mar 12, 2017 +/- 548	Dec 19, 2016 +/- 518	0.198
Operative time (min)	438.49+/-183.36	416.68+/-230.56	0.220
EBL (ml)	1426.20+/-1151.02	410.27+/-479.19	**<0.001**
Number posterior levels	10.70+/-3.76	5.55+/-3.38	**<0.001**
Interbody use	66.15%	95.38%	**<0.001**
Number of interbody levels	2.56+/-1.48	3.39+/-1.50	**<0.001**
PCO	77.69%	27.69%	**<0.001**
ACR	13.08%	33.85%	**<0.001**
Outcome Metrics			
Hospital LOS (days)	7.95+/-5.17	6.21+/-4.17	**0.001**
ICU admission	64.62%	23.85%	**<0.001**
Overall Complications	65.38%	50%	**0.012**
Major Complications	29.23%	17.69%	**0.028**
Neurological Complications	4.62%	0%	**0.029**
Implant Failure	11.54%	9.23%	0.542
Discharge to Home	56.8%	58.3%	
Discharge to Rehab	30.6%	17.5%	**0.017**
Discharge to SNF	11.7%	24.2%	
Overall Readmissions	19.23%	12.31%	0.126
90 Day Readmissions	6.13%	5.38%	0.790
Revision	18.46%	11.54%	0.118

61. DEVELOPMENT OF RISK STRATIFICATION PREDICTIVE MODELS FOR CERVICAL DEFORMITY SURGERY

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Summary
In order to minimize suboptimal postoperative outcomes for adult cervical deformity corrective surgery, it is important to develop a tool that allows for proper preoperative risk stratification. We developed risk stratification models to determine with accuracy theses occurrences. Our results demonstrate baseline radiographic, demographic, surgical

factors can be utilized to predict the occurrence of major complication and revisions.

Hypothesis
Preoperative risk stratification will limit potential for suboptimal outcomes.

Design
Retrospective

Introduction
This study aimed to develop predictive models for identification of risk-factors associated with the adverse outcomes.

Methods
CD patients≥18 years old with complete baseline (BL) and at least 1-year HRQoL and radiographic data were included. Patients were stratified into two groups based on their outcome from surgery: Revision [Rev] and Major Complication [MC]. Descriptive analysis identified demographics, radiographic parameters, and surgical details. Univariate analysis of preoperative and surgical factors was conducted to determine associations with either of the two outcomes. Stepwise logistic regressions identified surgical, radiographic, and HRQL factors that were associated with Rev or MC. Decision tree analysis established cut-offs for predictive variables.

Results
105 CD patients were included (61.6yrs, 67%F, BMI: 28.4kg/m2). Postoperatively, 20 patients experienced a MC and 17 patients underwent a subsequent Rev. Instrumentation location (LIV: 1.1[1.0-1.3] and UIV: 1.5[1.1-2.1]) was significantly associated with undergoing a Rev after index surgery (all p<0.05). The development of a postoperative MC was significantly associated with BL radiographic pelvic parameters (all <0.05). Predictive modeling incorporating preoperative and surgical factors identified development of a Rev to include: UIV>C3, LIV>T3, C2-T3 SVA<46.7°, C2-C7 SVA>57.6°, CTPA>7.8°, and C2S<60.4 (AUC:0.80). For developing a MC, a model consisting of preoperative and surgical factors included BL EQ5D-VAS<30, TS-CL>59.2°, C2-C7 SVA > 69.1°, C2-T3 SVA < 18.6, Apex C2-C7 SVA >4.25, surgical invasiveness and posterior osteotomies (AUC:0.83).

Conclusion
After corrective cervical deformity surgery, 16.2% of patients had a revision and 19.0% experienced a major complication. Revision after surgical intervention for cervical deformity was predicted with an accuracy of 80% using a UIV, LIV, C2-T3 SVA, C2-C7 SVA, CTPA, and C2S. The occurrence of major complications was also predicted with high reliability utilizing baseline HRQoL data, radiographic alignment, and surgical factors.

Take Home Message
The development of a predictive model incorporating preoperative and surgical factors can allow for a thorough risk stratification of postoperative outcomes.

62. THE MINIMALLY INVASIVE INTERBODY SELECTION ALGORITHM FOR SPINAL DEFORMITY

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Summary
The use of the MIISA provides consistent guidance for surgeons who plan to perform MIS deformity surgery.

Hypothesis
Interbody graft approach in MIS surgery is dependent on level and degree of segmental lordosis (SL) desired.

Design
A retrospective dataset of circumferential minimally invasive surgery (cMIS) for adult spinal deformity over a 5-year period was analyzed by level in the lumbar spine to evaluate preferences and SL outcomes.

Introduction
Minimally invasive surgery (MIS) for spinal deformity use interbody techniques for correction, indirect decompression, and arthrodesis. We created the minimally invasive interbody selection algorithm (MIISA) to provide a framework for rational decision making in MIS deformity surgery.

Methods
Data was used to inform a Delphi session of MIS deformity surgeons from which the algorithm was created. The algorithm lead to one of four interbody approaches: anterior lumbar interbody fusion (ALIF), anterior column release (ACR), lateral lumbar interbody fusion (LLIF), and transforaminal interbody fusion (TLIF). Preoperative and 2-year postoperative radiographic parameters and clinical outcomes were compared.

Results
LLIF was preferred for L1-L2 (91.2%), L2-L3 (85.2%), and L3-L4 (80.7%). ACR was most commonly performed at L3-L4 (8.4%) and L2-L3 (6.2%). At L4-L5, LLIF (69.5%), TLIF (15.7), and ALIF (9.8%) were most commonly utilized. TLIF and ALIF were the most selected approaches at L5-S1 (61.4% and 38.6%, respectively). SL increased with ALIF, especially at L4-5 (9.2 degrees) and L5-S1 (5.3 degrees). Substantial increase in lordosis was achieved with ACR at L2-L3 (10.9 degrees) and L3-L4 (10.4 degrees). Lateral interbody arthrodesis without the use of an ACR did not generally result in significant lordosis restoration. There were statistically significant improvements in PI-LL mismatch, coronal Cobb angle, and ODI at 2-year follow-up.

Conclusion
For L1-L4, the surgeons preferred lateral approaches to TLIF and reserved ACR for patients who needed the greatest increase in SL. For L4-L5, the surgeons' order of preference was LLIF, TLIF,

and ALIF, however TLIF failed to demonstrate any significant lordosis restoration. At L5-S1 the surgeon team typically preferred an ALIF when SL was desired and preferred a TLIF if preoperative SL was adequate.

Take Home Message
The use of the MIISA provides consistent guidance for surgeons who plan to perform MIS deformity surgery.
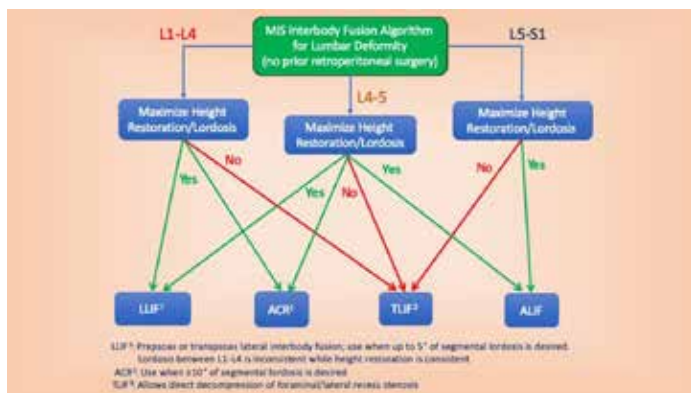
63. SPINOPELVIC ALIGNMENT CHANGES BETWEEN SEATED AND STANDING POSITIONS IN PRE AND POST TOTAL HIP REPLACEMENT PATIENTS

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Summary
Patients undergoing Total Hip Arthroplasty (THA) demonstrated a reduction in standing (ST)_SVA due to an increase in pelvic tilt (PT). This occurred without a significant change in spinal alignment. ST_SVA reduction was more pronounced in patients with thoracolumbar (TL) spinal deformity (SVA>50, TPA>20, PI-LL>10). On the converse, PT was reduced in sitting (SE) post-THA compared to pre-THA, and the compensatory change in PT was also reduced between ST and SE.

Hypothesis
Patients with Osteoarthritis (OA) of the hip undergoing THA will have an increase in ST_PT and reduction in ST_SVA as a result of restoring hip extension. In addition, PT change from ST to SE will also be reduced due to restoration of hip flexion ROM.

Design
Retrospective review at a single institution

Introduction
Changing from ST to SE requires rotation of the femur from an almost vertical plane to the horizontal. OA of the hip significantly limits hip extension, resulting in less ability to recruit PT in ST, and requiring increase PT in SE to compensate for loss of hip flexion. To date, the effect of THA in altering spinopelvic SE and ST mechanics has not been reported.

Methods
Patients ≥18yo undergoing THA for hip OA with full spine SE and ST radiographs pre and post THA. Spinopelvic alignment was analyzed pre-THA and post-THA in both ST and SE positions in a relaxed posture with the fingers on the clavicles. Paired t-test analysis were performed to compare Pre-and Post-THA groups. Statistical significance set at $p<0.05$. The effect of TL deformity on these changes was also analyzed.

Results
192 patients were assessed. 179 patients had TL deformity; TPA>20 (N=46), PI-LL>10 (N=55), and SVA>50 (N=78). In ST position, patients have a significant reduction in SVA post THA vs. pre THA (p=0.001) as a result of an increase in PT (16° vs. 14°, p=0.028), without significant changes in spinal alignment. This change in ST_SVA was larger in patients with TL deformity. When moving from ST to SE, the ΔPT was reduced post THA (16° vs. 21°, p=0.001) in addition to a smaller SE_PT vs. pre-THA (p=0.006).

Conclusion
Patients undergoing THA reduce global deformity as measured by SVA in ST, due to the ability to increase PT, without changes in spinal alignment. SE_PT was also reduced as a result of restoration of hip flexion.

Take Home Message
THA results in a change in spinopelvic alignment compared to pre-THA in both standing and sitting, as a result of restoration of hip ROM.

Figure 1: Representative full body sitting (SE) and standing (ST) radiographs for patient pre-THA (BL) and post-THA (FU)

64. HOW MUCH RESIDUAL DEFORMITY IS ACCEPTABLE ACCORDING TO SRS-22R AND SATISFACTION SCORES AFTER POSTERIOR SPINAL FUSION FOR LENKE TYPE 1 AND 2 CURVES IN ADOLESCENT IDIOPATHIC SCOLIOSIS PATIENTS?

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ABOUT SRS

Miyaoka, MD; Jun Takahashi, MD, PhD

Summary
We aimed to clarify the extent to which a residual postoperative deformity is acceptable according to Scoliosis Research Society (SRS)-22r and satisfaction scores following Lenke type 1 and 2 adolescent idiopathic scoliosis (AIS) surgery. Residual postoperative thoracolumbar/lumbar Cobb angle was associated with SRS-22r self-image and satisfaction with treatment. The thoracolumbar/lumbar Cobb angle cutoff value for treatment satisfaction was 12.5 degrees.

Hypothesis
Any deformity is related to the patient's quality of life and satisfaction and has an acceptable threshold.

Design
A retrospective study

Introduction
In recent years, it has become possible to predict postoperative correction in adolescent idiopathic scoliosis (AIS) surgery based on the technique and the extent of fixation. However, the recommended degree of correction has not yet been clarified. This study aimed to clarify the extent to which a residual postoperative deformity is acceptable according to Scoliosis Research Society (SRS)-22r and satisfaction scores following AIS surgery.

Methods
92 patients who underwent posterior spinal fusion for Lenke type 1 or 2 AIS were enrolled. The Patient Acceptable Symptom State (PASS) for each SRS-22r domain was calculated using receiver operating characteristic (ROC) curves to obtain predictive values of treatment satisfaction at 2 years postoperatively. Multivariate logistic regression analysis was performed with the parameters of deformity and demographic data as explanatory variables and the PASS of each SRS-22r domain and treatment satisfaction as objective variables. Cutoff values were calculated using ROC testing.

Results
The PASS values for SRS-22r domains were 3.69 (area under the curve [AUC]: 0.86) for self-image, 4.25 (AUC: 0.82) for mental health, and 4.22 (AUC: 0.82) for subtotal. Residual main thoracic Cobb angle was not significantly associated with SRS-22r and treatment satisfaction. Thoracolumbar/lumbar (TL/L) Cobb angle was significantly associated with treatment satisfaction, with a cutoff value of 12.5 degrees (AUC: 0.75). The parameters of deformity that associated significantly with obtaining PASS for self-image were TL/L Cobb angle and main thoracic curve apical vertebral translation, although respective AUCs were < 0.7.

Conclusion
In Lenke type 1 and 2 AIS patients, residual postoperative TL/L Cobb angle was associated with SRS-22r self-image and satisfaction with treatment. The TL/L Cobb angle cutoff value for treatment satisfaction was 12.5 degrees.

Take Home Message
In Lenke type 1 and 2 AIS patients, residual postoperative TL/L Cobb angle was associated with SRS-22r self-image and satisfaction with treatment.

65. ENHANCED RECOVERY AFTER SURGERY (ERAS) IN ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) – A META-ANALYSIS AND SYSTEMATIC REVIEW

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Summary
Corrective surgery for AIS is a major surgical procedure and may be associated with significant postoperative pain, prolonged hospital stays and lengthy rehabilitation. ERAS is a multidisciplinary approach aimed at improving outcomes of surgery by a specific evidence-based protocol. The rationale of this rapid recovery regimen is to maintain homeostasis so as to reduce the postoperative stress response and pain.

Hypothesis
ERAS protocols will reduce the length of stay following posterior correction of AIS without any significant increase in complication and readmission rate.

Design
Systematic review and meta-analysis

Introduction
Enhanced recovery after surgery (ERAS) is a multimodal and multidisciplinary approach for improving perioperative outcomes of patients using specific evidence-based protocols in the care of the surgical patient. The implementation of an ERAS based protocol is aimed to expedite the recovery and return of function, minimize the morbidity and in turn reduce the length of stay (LOS) associated with the posterior corrective surgery in patients with AIS. This would also improve the over-all peri-operative experience of patients and reduce health care costs.

Methods
A systematic review of the English language literature was undertaken using search criteria (postoperative recovery AND adolescent idiopathic scoliosis) using the PRISMA guidelines (Jan 1999-Sept 2019). Isolated case reports and with <5 patients were excluded. LOS, complication and readmission rates were used as outcome measures. Statistical analysis was done using random effects model.

Results
Of 24 articles,11 studies meet the inclusion criteria were analyzed. Overall, 1068 patients were identified who underwent an ERAS-type protocol following posterior correction of scoliosis and were compared to 986 patients following traditional protocols. There was a significant reduction in the length of stay in patients undergoing ERAS when compared to a traditional protocol (p<0.00001). There was no significant difference in the

complication (p = 0.19) or readmission rates (p = 0.30). Each protocol employed a multidisciplinary approach focusing on optimal pain management, nursing care and physiotherapy.

Conclusion

This systematic review demonstrates advantages with ERAS protocols by significantly reducing the length of stay without increasing the complications or readmission rates as compared to conventional protocols. However, current literature on ERAS in AIS is restricted largely to retrospective studies with non-randomized data, and initial cohort studies lacking formal control groups.

Take Home Message

ERAS in AIS resulted in reduction in length of stay without significant increase in complication and readmission rates. Standardization of protocols will further improve the positive impact on overall health care.

Analysis of complication rates:

Analysis of Length of stay:
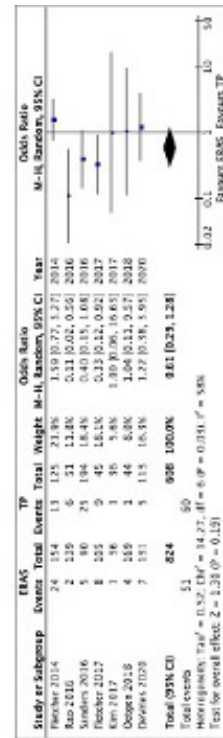
Analysis of readmission rates:

66. SEGMENTAL SPINAL GROWTH MODULATION AFTER VERTEBRAL BODY TETHERING: HOPE OR HYPE?

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Summary
Radiographs of 34 patients with idiopathic scoliosis and 2-year follow-up after anterior vertebral body tethering were analyzed to determine the growth rates of the concave and convex sides of individual vertebrae. Tethered thoracic vertebrae demonstrated greater concave-sided growth than convex-sided. However, untethered thoracic vertebrae demonstrated greater convex-sided growth than concave-sided. Lumbar vertebrae growth was not different for concave vs. convex sides, whether tethered or not.

Hypothesis
The vertebrae of idiopathic scoliosis (IS) patients treated with vertebral body tethering (VBT) will grow at a higher rate on the concave side compared to the convex side of the instrumented curve.

Design
Retrospective case series

Introduction
The effects of VBT on longitudinal growth of the spine for the treatment IS are not well reported. Does differential growth occur along the convex and concave sides of the instrumented vertebral bodies?

Methods
Patients treated with VBT and 2-year follow-up were included; and heights of each thoracic and lumbar vertebrae on concave and convex sides were measured on first erect and 2-year postoperative imaging (see image). Growth velocities for concave and convex sides of each individual vertebrae were calculated. Vertebrae were categorized as adjacent (those at the most cephalad or caudad aspects of the tether construct), instrumented (those in the tether construct), or uninstrumented. Five patients with double curves underwent VBT of both; and, in these patients, the dual instrumented vertebrae were excluded.

Results
34 patients were included, yielding 573 vertebrae for measurements (68 adjacent, 189 instrumented, 316 uninstrumented). The average age and Risser score at time of surgery was 12.5 ± 1.7 and 1.3 ± 1.5, respectively. For instrumented and adjacent vertebrae, concave sided growth was significantly greater than convex sided growth in thoracic vertebrae (TV), but no difference was found in lumbar vertebrae (LV) (see image). For uninstrumented vertebrae, convex sided growth was significantly greater than concave sided growth in TV, but no difference was found in LV (see table).

Conclusion
In this study of IS patients treated with VBT, concave-sided vertebral body growth was significantly greater than convex-sided growth in tethered vertebrae, in agreement with expectations based on the Hueter-Volkmann principle and forces directed by the tether. Interestingly, convex sided vertebral growth in uninstrumented TV was significantly greater than concave sided growth. However, no differential growth was detected in lumbar segments.

Take Home Message
Differential vertebral growth in instrumented and uninstrumented segments was seen with thoracic VBT and can form the basis for predictive modeling and future VBT strategies in skeletally immature scoliosis patients.

Radiograph showing measurements used, radiographs demonstrating differential growth, and tabulated results.

67. WHICH THORACIC CURVES ARE AT THE GREATER RISK FOR DISTAL ADDING ON: COMPARISON BETWEEN TYPICAL AND ATYPICAL LENKE 1A CURVES

Rui Yin, PhD; Xiaodong Qin, PhD; Yong Qiu, MD; Zhen Liu, MD; Benlong Shi, PhD; Hongda Bao, MD; Xu Sun, MD; Zezhang Zhu, MD

Summary
Adolescent idiopathic scoliosis (AIS) patient with atypical Lenke 1A curve (apex at T10/11-T11/12) was more likely to develop distal adding-on (AO) following posterior spinal fusion. We highly recommended selecting last substantially touching vertebra (LSTV) as lowest instrumented vertebra (LIV) in atypical Lenke 1A curves.

Hypothesis
AIS patient with atypical Lenke 1A curve was predisposed to postoperative AO and "LSTV rule" should be followed.

Design
Retrospective study

Introduction
The difference between typical (apex at T7/8-T10) and atypical (apex at T10/11-T11/12) Lenke 1A curve has been reported. However, there was no further investigation on the surgical strategy and clinical outcomes for atypical Lenke 1A curve. Therefore, the purposes of the study were to identify the characteristics and the incidence of AO in atypical Lenke 1A patients, and to investigate whether atypical and typical Lenke 1A curve should follow the same LIV selection strategy.

Methods
A total of 251 Lenke 1A patients who underwent posterior spinal fusion were analyzed. The minimum follow-up were 2 years. Curves were classified into 2 groups according to the apex. At last, 42 atypical Lenke 1A patients were identified and divided into atypical group (G1). Meanwhile, 42 age, gender, and Cobb angle matched typical Lenke 1A patients were enrolled into the typical group (G2). The radiographic characteristics were evaluated, and the incidence of AO were compared between the 2 groups.

Results
The incidence of atypical Lenke 1A curves was 16.7%. Patients in G1 were found to have more left thoracic curves (P=0.029), better flexibility of thoracic (P=0.011) and lumbar curve (P=0.014), and more preoperative coronal imbalance (CIB) (P=0.001). At the final follow-up, G1 developed more AO (38.1% vs. 19.0%). Especially for patients with LIV proximal to LSTV, the incidence of AO was significantly higher in G1 (82.4% vs. 42.9%, P=0.022).

Conclusion
Atypical Lenke 1A curve had its own radiographic characteristics. It was more likely to develop AO when LIV was proximal to LSTV, which indicated different fusion level should be considered in these two subtypes of Lenke 1A. We recommended LSTV as LIV in atypical Lenke 1A cases, while one level proximal to LSTV (LSTV-1) might be available in typical Lenke 1A curve.

Take Home Message
The incidence of atypical Lenke 1A curves was 16.7%. "LSTV rule" was recommended in patients with atypical Lenke 1A curve. For typical Lenke 1A curve, fusion to LSTV-1 might be an alternative.

70. PREDICTING THE MAJOR CORONAL CURVE ANGLE ON INITIAL STANDING X-RAYS BASED ON INTRAOPERATIVE CORRECTION DURING ANTERIOR SCOLIOSIS CORRECTION AND VERTEBRAL BODY TETHERING: COMPARISON OF SINGLE VS. DOUBLE CORD/SCREW CONSTRUCTS

Laury A. Cuddihy, MD; Maciej Swiercz, MD; Christopher L. Antonacci, BS; M. Darryl Antonacci, MD; Randal R. Betz, MD

Summary
Typically, in anterior scoliosis correction (ASC) and vertebral body tethering (VBT), there is a significant loss of correction from intraoperative images to initial standing x rays with single screw/cord (SC) constructs. In this study there was less loss of correction with a double screw/cord (DC) construct. This may be because the SC construct is not rigid in controlling rotation when the patient stands, whereas the DC construct is more rotationally stable.

Hypothesis
Following anterior scoliosis correction (ASC) and vertebral body tethering (VBT), there is less loss of correction with a double screw/cord (DC) construct than with a single screw/cord (SC) construct.

Design
Retrospective radiological review

Introduction
Evidence is increasing for the use of growth modulation via an anterior cord/screw construct to correct AIS. Predicting how much residual curve to leave at the time of surgery to allow for growth correction is a challenge. This study analyzes the correction obtained intraoperatively versus initial residual curve on early postoperative x-rays.

Methods
Major coronal curve angles of instrumented thoracic (TH) and/or lumbar (L) curves of patients undergoing non-fusion ASC or VBT were measured on intra-op and first erect post-op radiographs.

Results
96 patients with SC constructs (85 instrumented TH curves and 11 L curves) and 68 patients with DC constructs (58 TH curves and 40 L curves) were evaluated. The overall average change (loss of correction) from intra-op to first standing x-ray was 8.5° (SD 4.7) for SC and 3.8° (SD 3.5) for DC. For a subset of 20 TH and 20 L curves, Perdriolle rotation measurements change were compared (Table 1).

Conclusion
Because the SC construct is not rigid in controlling rotation, we found an average correction loss of 8.5° (SD 4.7) from intra-op to initial standing x-rays. With an SC construct, surgeons should expect this significant loss when calculating a desired correction to allow for growth modulation. We found significantly less loss of correction (avg. 3.8°, SD 3.5) with the DC construct, possibly because the DC construct is more rotationally stable as shown with Perdriolle measurements.

Take Home Message
Typically, in anterior scoliosis correction and VBT, the single cord construct does not control rotation; we found avg. correction loss of 8.5° (SD 4.7) from intra-op to initial standing x-rays.

	Single Cord (SC)	Double Cord (DC)	P value
Angle change of major coronal curve			
Number of patients	96	68	
Thoracic curves	85	58	
Avg. change	8.7° (1-25°)	4.3° (0-11°)	<0.000002
Lumbar curves	11	40	
Avg. change	8.2° (2-26°)	3.0° (0-17°)	0.001
Avg. change in rotation			
Thoracic curves	5.3° (SD 7.4)	2.6° (SD 5.8)	0.592
Lumbar curves	8.5° (SD 7.0)	5.0° (SD 5.8)	0.238

Table 1. Loss of Correction from Intra-op to First Erect

71. WHICH FRAILTY SCALES FOR PATIENTS WITH ADULT SPINAL DEFORMITY ARE FEASIBLE AND ADEQUATE? A SYSTEMATIC REVIEW

Kazuya Kitamura, MD, PhD; _Miranda Van Hooff, PhD_; Wilco Jacobs, PhD; Kota Watanabe, MD, PhD; Marinus De Kleuver, MD, PhD

Summary

Systematic search was performed to evaluate the feasibility and measurement properties of frailty scales for patients with spinal disorders, including adult spinal deformity (ASD). Of the 1006 references found, 52 studies were included and 17 scales were identified. Only 7 studies reported measurement properties of 5 scales and no adequate scales were identified. The ASD Frailty Index comprises the most comprehensive domains for ASD patients, but its feasibility and measurement properties remain inconclusive.

Hypothesis

Feasible and adequate frailty scales, in terms of measurement properties, are necessary to evaluate patients with adult spinal deformity

Design

Systematic review

Introduction

Frailty assessment is important considering the invasiveness of adult spinal deformity (ASD) surgery. We aimed to evaluate the feasibility and measurement properties of frailty scales for patients with spinal disorders including ASD.

Methods

A systematic search was performed between 2010 and 2020, including terms relating to spinal disorders, frailty scales, and methodological quality. Clinical studies with frailty scales involving spinal disorders and studies that evaluate measurement properties of frailty scales were included. The Risk of Bias was determined with QAREL score.

Results

Of the 1006 references found, 52 studies (15 ASD, 5 cervical deformity, 11 trauma, 11 degenerative, and 10 other spinal disorders) were included. Seventeen scales were identified, among which 11-point modified Frailty Index (mFI-11, n=24) and ASD Frailty Index (ASD-FI, n=7) that were most frequently used in 39 studies the scales were used to evaluate frailty in relation to clinical outcomes and in 13 studies to indicate prevalence of frailty. Seven studies reported measurement properties of 5 scales (mFI-11, Nottingham Hip Fracture Score, Metastatic Spinal Tumor Frailty Index, ASD-FI, and mFI-5). In the 15 ASD studies, 3 scales were used: ASD-FI (n=7); mFI-11 (n=6); and mFI-5 (n=2). While mFI-11 and mFI-5 consist of 2 domains (comorbidity and physical) covered by 11 and 5 items respectively, ASD-FI consists of 5 domains (comorbidity, physical, psychological, social, and others) covered by 40 items. Construct validity was evaluated for ASD-FI and mFI-5, but these studies were not free of bias because most of the QAREL items were scored unclear.

Conclusion

No adequate scale was identified. ASD-FI comprises the most comprehensive domains for ASD patients, but its feasibility and measurement properties remain inconclusive. We recommend evaluating simple scales in ASD populations that have been evaluated in other medical fields, such as FRAIL, Clinical Frailty Scale, and Edmonton Frail Scale.

Take Home Message

No adequate frailty scale was identified, specifically for patients with spinal disorders. For ASD, the ASD Frailty Index is the most comprehensive but its feasibility and measurement properties remain inconclusive.

73. THE EFFECT OF CONSTRUCT DESIGN ON RATES OF REVISION FOR PSEUDARTHROSIS AND ROD FRACTURE AT THE LUMBOSACRAL JUNCTION

Michael Dinizo, MD; Karnmanee Srisanguan, BS; Thomas J. Errico, MD; _Tina Raman, MD_

Summary

A hallmark of the strategy in ASD surgery is to promote a solid union at the lumbosacral junction. At minimum 5 year follow up, there was no difference found in rates of rod fracture, or revision surgery for rod fracture or pseudarthrosis, or maintenance of deformity correction when comparing constructs utilizing 2 rods only (2R), 2 rods with interbody fusion (2RIBF), 3 rods only (3R), and 3 rods with interbody fusion (3RIBF).

Hypothesis

Multiple rods spanning the lumbosacral junction with or without IBF do not outperform 2 rods with or without IBF with respect to rates of pseudarthrosis and rod fracture.

Design

Retrospective review of prospectively collected single center database.

Introduction

Different construct configurations at the lumbosacral junction are possible, including the use of multiple rods and IBF. There is a paucity of data evaluating the relationship with pseudarthrosis and rod fracture rates at long term follow up.

Methods

367 ASD patients (Age: 58 ± 16 y; mFI: .6 ± .7; Levels: 10.1 ± 4.8) were separated into groups based on construct configuration at L4-S1: 2R (108), 2RIBF (107), 3R (85), and 3RIBF (67). Outcomes evaluated were the rates of revision surgery for pseudarthrosis and rod fracture at average follow-up of 68.1 months.

Results

Of interbody devices used, 76.6% were titanium, 16.7% PEEK, and 6.7% femoral allograft. Rods utilized were 5.5 mm cobalt chrome (86.4%), 5.5 mm titanium (12.4%), and 6.0 mm titanium (1.2%). All patients had iliac (97.5%) or S2AI (2.5%) fixation. There was a greater number of PSOs in 3R and 3RIBF groups (2R, 2RIBF, 3R, 3RIBF) (11%, 14.3%, 37.8%, 46.2%, p<0.0001). At 5 year follow up there was no difference in the rates of rod fracture at the lumbosacral junction (13.5%, 18.5%, 14.1%, 15.9%, p=0.75), revision for rod fracture (7.2%, 10.2%, 8.2%, 11.1%, p=0.80), or revision for pseudarthrosis (7.2%, 16.7%, 9.4%, 12.7%, p=0.15). There was no difference in the proximal junctional angle at final follow-up (12.6%, 13.1%, 13.8%, 12.0%, p=0.73), or rate of revision for PJK (8.1%, 6.5%, 8.2%, 3.2%, p=0.59). There were no differences seen in correction of SVA (-21,-38,-20,-23, p=0.27), coronal alignment (-3.7,-6.7,-7.0,-7.4, p=0.77), or lumbar lordosis (5.1, 8.8, 9.4, 11.9, p=0.42).

Conclusion

At a single center with relatively homogeneous surgical technique, at 5 year follow up there was no effect of IBF or multiple rods on the rates of revision surgery for rod fracture or pseudarthrosis at the lumbosacral junction. There was no difference seen in radiographic parameters relevant for sagittal alignment correction.

Take Home Message

Three rods with or without IBF perform equivalently to two rods with respect to 5-year revision rates for pseudarthrosis and rod fracture at the lumbosacral junction.

74. EVOLUTION OF CERVICAL DEFORMITY SURGERY, OUTCOMES AND RADIOGRAPHIC ACHIEVEMENTS AMONG A MULTICENTER PROSPECTIVE STUDY; ARE WE IMPROVING AND CHANGING OUR APPROACH?

Oscar Krol, BA; _Peter G. Passias, MD_; Lara Passfall, BS; Nicholas A. Kummer, BS; Shaleen Vira, MD; Patrick Cronin, MD; Navraj Sagoo, BS

Summary

With adult cervical deformity becoming increasingly prevalent in our aging population, corrective surgery is expected to continue to be a frequently utilized treatment option. Within the last decade, significant advancement has been made in surgical technique in order to improve patient outcomes and reduce adverse events. The purpose of our study is to retrospectively evaluate whether surgical and patient outcomes have improved or changed over an eight-year period between 2012 and 2020.

Hypothesis

To investigate if outcomes or surgical approach have changed over the years

Design

Retrospective

Introduction

The purpose of our study is to evaluate whether surgical and patient outcomes have improved or changed over an eight-year period between 2012 and 2020.

Methods

ACD patients ≥18 yrs old undergoing corrective surgery were included. Descriptive analysis included demographics, radiographic, and surgical details. Patients were grouped into Group I (2012-2016) and Group II (2017-2020) by surgery dates. Differences in surgical, radiographic, and clinical outcomes between groups was assessed. DJK was defined by an angle <-10. Multivariate analysis was used to control for age, levels fused, and BL deformity.

Results

210 cervical deformity pts met inclusion criteria (57yrs, 53%F, BMI: 29kg/m2, CCI: 0.73±6). Group I consisted of 83 p, and Group II consisted of 129. Complication rates of Groups I and II are shown in Table 1. Group I had a higher EBL (770ml vs. 382ml) and operative time (516 min vs. 301 min, both p<0.05). Group II had a higher BL disability (NDI) (62 vs. 53) and higher CCI (1.1 vs. .5, both p<0.05). At BL, Group I had a higher PT (19 vs. 14) and lower T4-T12 (-39 vs. 23, both p<0.05). At 1Y, Group II had a lower SVA C2-C7 (4.3 vs. 27), higher C2-T3 (1.5 vs.-5.8), higher T10-L2 (7 vs.-12.6), higher T4-T12 (34 vs.-32), higher T2-T12 (35 vs.-47), lower SS (21.5 vs. 37), lower S1P1 (40 vs. 55), lower L1S1 (-32 vs. 42), and lower T12-S1 (-35 vs. 46, all p<0.05). Group I had more pts that were overcorrected at 1Y in PT age-adjusted Schwab, (p<0.05). MVA showed Group II was less likely to develop DJK .102[.011-.936], and experience radiographic complications .07[.007-.714], with less cases of symptomatic DJK (0% vs. 11.1%, all p<0.05). Controlling for BL disability, Group II had a shorter Neck Pain Duration (3.7 vs. 7, both p<0.05).

Conclusion

Despite performance of cervical realignment on more morbid patients with more complex deformities, patient reported functional outcomes have not diminished, and the occurrence of several notable adverse events, including distal junctional kyphosis has declined.

Take Home Message

Surgery on patients with greater deformity and morbidity has yielded similar outcomes, with a reduction in distal junctional kyphosis suggesting broader understanding of risks and goals.

Table 1. Complication rates and radiographic differences at 1Y between Group 1 and Group 2.

Complication	Group 1 (2012-2016)	Group 2 (2017-2020)	p-value
Any	14%	18%	.344
Reoperation	23%	21%	.802
Intraoperative	0%	.08%	.430
Radiographic	20%	5%	.001
Cardiac	0%	2%	.262
Weakness	2%	0%	.074
Neuro	3.7%	5.4%	.570
Dysphagia	2%	5%	.424
Mortality	2%	1%	.316
Respiratory	2.5%	.08%	.316

76. PROOF OF CONCEPT: ARTIFICIAL INTELLIGENCE BASED ESTIMATION OF SKELETAL MATURITY FROM BIPLANAR SLOT SCAN SCOLIOSIS IMAGING

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Summary

We demonstrate a proof of concept that an automated algorithm can reliably classify ossification about the shoulder and hip using established staging systems.

Hypothesis

An artificial intelligence based algorithm can accurately extract multiple skeletal maturity classifications from standard biplanar slot scan scoliosis radiographs.

Design

Retrospective cohort analysis.

Introduction

Skeletal maturity assessment plays an important role in the management of scoliosis. The most common method to estimate skeletal growth remaining using scoliosis radiographs is the Risser score, which has limited accuracy. Patterns in the closure of the proximal humeral physis along with the modified Oxford bone score (mOBS) have recently been described to estimate skeletal maturity.

Methods

After obtaining IRB approval, we retrospectively collected 1197 anteroposterior pediatric scoliosis radiographs performed from 2019- 2020. Radiographs were manually annotated and used to train a Faster rCNN Inception V2 model from the TensorFlow Object Detection API to detect the humeral head, ilium, and hip joint. We then applied EfficientNet neural networks to classify clinical stages of the humeral head and mOBS regions (Figure 1).

Results

Our detection model achieved an average F1-score of 0.99, indicating excellent accuracy. For the image classification models, average percent accuracy was 89% and average intraclass correlation coefficient was 0.84.

Conclusion

Reliable assessment of skeletal maturity remains a challenge with methods that rely on a single body region. Obtaining multiple radiographs increases radiation exposure and cost. By simultaneously quantifying ossification of many visible growth centers often captured on scoliosis radiographs, orthopedic surgeons can maximally leverage information gained from standard imaging and avoid the cost and radiation exposure associated with additional radiographs.

Take Home Message

This lays the groundwork for future models to estimate skeletal maturity, combining data from multiple staging systems when complete staging is impossible due to partial shielding, collimation, or suboptimal positioning.
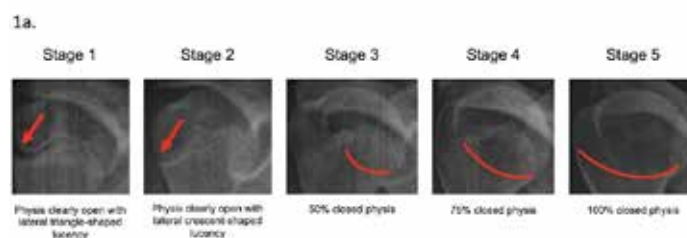
Figure 1: 1a. Humeral Head Staging System. 1b: mOBS Staging System

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77. RAPID RECOVERY PATHWAY (RRP) UTILIZING INTRATHECAL MORPHINE DECREASES OVERALL HOSPITAL COSTS AND IMPROVES QUALITY OF CARE IN ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS)

Vishal Sarwahi, MD, MBBS; Sayyida Hasan, BS; Aaron M. Atlas, BS; Jesse M Galina, BS; Yungtai Lo, PhD; Terry D. Amaral, MD; Benita Liao, MD; Michelle Kars, MD

Summary
Posterior spinal fusion (PSF) for adolescent idiopathic scoliosis (AIS) is a complex procedure for which can be costly. Among the total costs, inpatient and intensive unit care contributed 22%. Retrospective review found RRP protocol following PSF has lower total hospital costs, lower home opioid requirements post surgery than traditional PCA, and periop costs were significantly lower.

Hypothesis
Utilization of a standardized RRP using multimodal analgesia without PCA improves patient quality of care, decreases opioid use, and costs less than traditional PCA methods

Design
Retrospective review

Introduction
Many institutions have implemented rapid recovery pathways (RRP) to improve patient care following scoliosis surgery. Most RRPs encourage early ambulation, feeding, and stooling in combination with patient controlled analgesia (PCA). This study aims to determine the effects of a multi-modal RRP, utilizing intrathecal morphine (ITM) in combination with oral pain medication, on hospital costs and patient management.

Methods
Patients after Feb 2018 were placed in the RRP group and received ITM as part of their multimodal analgesia. Fusion level-matched control patients, treated before Feb2018, received hydromorphone PCA as mainstay of their postop pain management. At discharge PCA patients received 14-day prescriptions for oxycodone compared to 7-day prescriptions in the ITM group. Periop data, requests for opioid refill, and overall costs compared using McNemar's and Wilcoxon Signed-Rank tests.

Results
363 patients included (PCA: 255, RRP/ITM: 108). BMI (p = 0.786) and median preop Cobb angle (p = 0.343) similar between both groups. RRP patients had significantly shorter length of stay (p <0.001). 65.2% of RRP patients ambulated by POD1 compared to 43.4% of PCA patients (p < 0.001). The fraction of patients who requested opioid refills similar between both groups (p = 0.082). Cost of intraoperative anesthesia significantly higher for RRP patients (p<0.001). Periop hospital stay cost (p<0.001) significantly lower for the RRP patients. Due to different prescription durations, cost of home opioid medications was $98.9 for PCA patients vs. $56.3 for RRP, based on standard Medicaid costs.

Conclusion
The RRP protocol following PSF had lower total hospital costs and lower home opioid requirements after surgery than the traditional PCA protocol.

Take Home Message
RRP protocol following PSF has lower total hospital costs, lower home opioid requirements post surgery than traditional PCA, and periop costs were significantly lower.

78. POSTOPERATIVE DEPRESSION IN LUMBAR DEGENERATIVE PATIENTS ASSOCIATED WITH WORSE SATISFACTION FOLLOWING SURGERY

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Summary
In our retrospective review of 183 adult lumbar degenerative patients with one-year follow-up, we found that following surgery, patients with postoperative depression have significantly higher odds of dissatisfaction. This is irrespective of preoperative depression status. Our results highlight the importance of postoperative screening for mental health in patients with postoperative dissatisfaction.

Hypothesis
Lumbar degenerative patients with postoperative depression would report worse satisfaction postoperatively.

Design
Retrospective review

Introduction
Poor preoperative mental health has been shown to negatively affect postoperative satisfaction among spine surgery patients, but there is limited evidence on the impact of postoperative mental health on satisfaction. We sought to assess the association between preoperative and postoperative mental health status with postoperative satisfaction in lumbar degenerative spine surgery patients.

Methods
We included adult patients undergoing spine surgery for lumbar degenerative conditions at a single institution. Mental health was assessed preoperatively and 12-months postoperatively using PROMIS Depression and Anxiety scores. Satisfaction was assessed 12-months postoperatively using NASS Patient Satisfaction Index (PSI). We evaluated associations between mental health and satisfaction with univariate and multivariable logistic regression to adjust for confounders. Preoperative depression/anxiety level was corrected for postoperative depression/anxiety level, and vice versa. Statistical significance was assessed at $\alpha=0.05$.

Results
Of 183 patients (47% male; avg. age 62 years), depression

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was present in 27% preoperatively and 29% postoperatively, and anxiety in 50% preoperatively and 31% postoperatively. 19% reported postoperative dissatisfaction using NASS PSI. Univariate analysis identified race, family income, relationship status, current smoking status, change in pain interference, and change in physical function as potential confounders. In adjusted analysis, odds of dissatisfaction were increased in those with mild postoperative depression (adjusted odds ratio [aOR]=6.1; 95% confidence interval [CI]=1.2, 32; p=0.03) and moderate or severe postoperative depression (aOR=7.5; 95% CI=1.3, 52; p=0.03). Preoperative and postoperative anxiety and preoperative depression were not associated with postoperative satisfaction.

Conclusion
Following lumbar degenerative surgery, patients with postoperative depression, irrespective of anxiety or preoperative depression, have significantly higher odds of dissatisfaction.

Take Home Message
Our results emphasize the importance of postoperative screening and treatment of depression in surgical lumbar degenerative patients with postoperative dissatisfaction.

79. AMBULATORY NEUROMUSCULAR SCOLIOSIS PATIENTS HAVE SIMILAR RATES OF INFECTION, PERIOPERATIVE COMPLICATIONS, AND REVISION TO ADOLESCENT IDIOPATHIC SCOLIOSIS PATIENTS

Vishal Sarwahi, MD, MBBS; Jesse M Galina, BS; Aaron M. Atlas, BS; Sayyida Hasan, BS; Yungtai Lo, PhD; Terry D. Amaral, MD; Marina Moguilevtch, MD; Beverly Thornhill, MD

Summary
NMS patients usually have severe curves with more comorbidities and procedural complexity. They require extensive fusion levels, have increased blood loss, and suffer increased periop complications. However, NMS patients have a variable spectrum of severity. Our study finds that ambulatory NMS patients can achieve periop outcomes similar to AIS patients with regards to surgical complication rate, infections, revisions, and blood loss.

Hypothesis
Following posterior spinal fusion (PSF), ambulatory NMS cases compare similarly in their safety profile to AIS patients.

Design
Ambispective review

Introduction
As a collective group, NMS has worse prognosis and surgical outcomes than the AIS group. However, not all operative patients with diagnoses of Cerebral Palsy, Duchenne Muscular Dystrophy, or other NMS pathology suffer similar poor outcomes associated with the class. Our aim is to examine more mildly affected NMS patients to determine if their surgical outcomes are comparable to AIS with regards to patient safety

Methods
Radiograph and retrospective chart review of NMS and AIS patients undergoing PSF with pedicle screws from 2005-2018 was analyzed. Group1 included NMS patients who could ambulate without assistance (GMFCS I-III). Group 2 was AIS patients. Demographics, intra-op parameters, and radiographic measurements were collected at pre- and post-op. Wilcoxon rank sums tests and chi-square tests performed

Results
Group1 (n = 48) and Group2 (n = 158) were similar in age, sex, preoperative kyphosis, pre- and postoperative Cobb angle, and Cobb correction. Additionally, EBL (p=0.143), postoperative transfusions (p=0.5), and perioperative complications within 30 days (p=0.5) were similar between groups. Infections (p = 0.592), DVT (p = 0.232), revisions (p = 1.0), and mortality (p = 1.0) were statistically similar. Group 2 NMS patients had increased fusion levels (p<0.001), fixation points (p=0.002), pelvic fixation (p=0.002), anesthesia and surgery time (p<0.001), ICU and hospital stay (p<0.001), intraop transfusions, pulmonary complications (p=0.012). Also, fewer NMS patients extubated in the OR (p<0.001).

Conclusion
NMS inherently confers high risk of blood loss, longer surgeries and fusions, complications, ICU and hospitals stays. Our data confirms longer fusion levels, surgical time, and hospital stay, with lower extubation rates. Infection rate, revisions, radiographic outcomes, and overall complications were similar to AIS population. This suggests that NMS patients who are ambulating can expect surgical outcomes comparable to AIS patients.

Take Home Message
Ambulating NMS patients can expect comparable surgical outcomes to AIS patients following PSF with further room for improvement in surgical duration and anesthesia protocols.

80. VALIDATION OF A NEW CLASSIFICATION SYSTEM FOR SURGICAL PLANNING OF VERTEBRAL BODY TETHERING (VBT)

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Summary
A new classification for planning and comparing surgical treatment of patients with idiopathic scoliosis by Vertebral Body Tethering is proposed. 11 experienced international spine surgeons were able to classify x-rays of 27 patients with five different curve types. Statistical analysis showed an excellent intra- and inter-rater reproducibility.

Hypothesis
This new classification system has a high reliability

Design
Validation Study

Introduction
VBT promises to be an alternative to fusion for some patients with scoliosis but the ideal candidate yet remains to be identified. Some surgeons see skeletal maturity as most important parameter for patient selection but curve location and flexibility also influence the decision making process. We have developed a new classification to facilitate decision making for VBT and comparison of outcomes. Our classification is based on five fundamental curve types (lumbar, double, long thoracic, short thoracic, any type with presence of high thoracic curve). This study aims to analyze the intra- and interrater variability.

Methods
11 experienced spine surgeons from 9 different countries were invited to evaluate the classification. 9 of them were not involved in the classification development. A series of 4 x-rays (a. p., lateral, right and left bending) was prepared for 27 patients. Two sets of x-rays were sent to each participant, both containing the identical x-rays from those 27 patients, but in different order. Each participant was given instructions on how to employ the classification and was asked to apply it to the two sets on two subsequent days. The inter- and intra-observer reliability was assessed evaluating the kappa coefficient (k). The strength of the kappa coefficients was 0.01 < | k | < 0.20 slight; 0.21 < | k | < 0.40 fair; 0.41 < | k | 0.60 moderate; 0.61 < | k | 0.80 substantial; 0.81 < | k | 1.00 almost perfect. P-values < 0.5 were considered statistically significant.

Results
The inter-observer reliability was k = 1.00 for the developers, k = 0.81 (0.73 to 0.91; P < 0.0001) for the non-developers and k = 0.84 (0.76 to 0.91; P < 0.0001) overall. The intra-observer reliability was k = 1.00 for the developers, k = 0.84 (0.54 to 1.00; P < 0.0001) for non-developers and k = 0.88 (0.68 to 1.00; P < 0.0001) overall.

Conclusion
The provided classification for planning VBT showed an excellent reliability that compares favorably with classifications that aid planning for spinal fusion.

Take Home Message
This new classification for planning Vertebral Body Tethering has an excellent reproducibility.

81. PREDICTING MECHANICAL FAILURE FOLLOWING CERVICAL DEFORMITY SURGERY: A COMPOSITE SCORE INTEGRATING AGE-ADJUSTED CERVICAL ALIGNMENT TARGETS

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Summary
Inspired by recent publications in the thoracolumbar field, this study aims to investigate a composite score to evaluate for a relationship between alignment proportionality and risk of failure. This score was composed of 3 parameters (T1 Slope, SVA, TS-CL) and their offset with age-adjusted values. Results demonstrated a strong association between this Cervical score at 3 months and failure at 1Y; a score of ≥3 had an Odd Ratio of 38 of having a failure within the following year.

Hypothesis
Combining radiographic parameters into a singular score can enable accurate prediction of mechanical failure following cervical deformity surgery

Design
Retrospective review of a multicenter database of CD patients with minimum 1-year follow-up

Introduction
Cervical deformity (CD) surgery is a complex procedure where mechanical failures, such as distal junctional kyphosis (DJK), are not rare. Inspired by recent publications in the thoracolumbar field, this study aims to investigate a composite score to evaluate for a relationship between alignment proportionality and risk of DJK.

Methods
Cervical score was constructed using offset from age-adjusted normative values of SVA, T1 Slope (TS), and TS minus cervical lordosis (CL). Individual points were assigned based on offset with alignment targets and added to the Cervical Score (Figure). Rates of mechanical failure (DJK revision or severe DJK [DJK> 20° & ΔDJK> 10°]), were reported overall and based on Cervical Score. Logistical regressions assessed associations between early radiographic alignment and 1Y failure rate.

Results
84 patients were included (61.1yo±10.3, 64.3%F). Failure rate was 21.4% (N=18), including 10.7% revision. Overall, there was a significant change in cervical and thoracolumbar sagittal alignment (all p<0.01). By multivariate logistical regression, 3 months T1S (OR: 0.935), TS-CL (OR:0.882) and SVA (OR:1.015) were all independent predictors of 1Y failure (all p <0.05). Cervical Score ranged from-6 to 6, with 37.8% of the patients between-1 and 1, and 50.0% with 2 or higher. DJK patients had a significantly higher Cervical Score (4.1±1.3 vs. 0.6±2.2, p=0.000). Patients with a score ≥ 3 were significantly more likely to develop a failure (71.4%) with an OR of 38.55 (95%CI [7.73; 192.26]) and a Nagelkerke r2 of 0.524 (p<0.001)

Conclusion
This study developed a composite alignment score predictive of mechanical failures in the setting of CD surgery. A score ≥3 at 3 months post-op was associated with a large increase in

failure rate. This Cervical Score can be used to analyze sagittal alignment and help define realignment objectives to reduce mechanical failure.

Take Home Message
This cervical score derived from literature and age-adjusted data and incorporating global and regional alignment was strongly associated with failure following CD surgery.
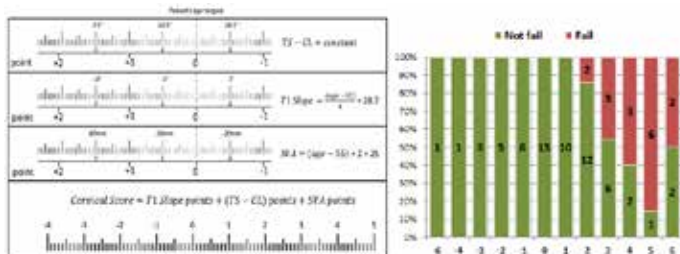
82. THE MODIFICATION OF APPROPRIATENESS CRITERIA FOR A CERVICAL DEFORMITY CORRECTIVE SURGERY

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Summary
The Scoliosis Research Society established Appropriateness criteria for surgery for degenerative lumbar scoliosis (DLS) in order to improve and unify clinical decision making. This study sought to modify the DLS criteria for a cervical deformity (CD) cohort. Patients classified as 'Not Meeting Criteria' in the newly developed CD Appropriateness, based upon a combination of symptoms, myelopathy severity, global imbalance, risk factors, and spine curvature, demonstrated higher rates of postoperative DJK and revisions by 2-years.

Hypothesis
The DLS Appropriateness criteria can be effectively modified to a surgical CD cohort.

Design
Retrospective

Introduction
Though utilized and validated in various cohorts, an Appropriateness criteria has yet to be developed in a CD population.

Methods
CD patients>18yrs were included. Each patient was scored based upon the SRS-appropriateness criteria, comprised of clinical or radiographic characteristics and was modified for a cervical deformity cohort: (1)Severity of Symptoms[NDI], (2)Severity of Myelopathy[mJOA.], (3)Progression of Deformity, (4)Global Sagittal Malalignment[Schwab modifiers], (5)Severity of Risk Factors, (6)Degree of the T1S-CL curvature. For the category 'progression', radiographs were only available at one preoperative time point, and we were unable to include this

in the total score. Based upon certain combinations of criteria, patients were stratified into Appropriate and Not Appropriate.

Results
100 patients included (61yrs, 62%F, 29.5kg/m2). Assessment of the categories of Appropriateness of CD surgery(Table 1):(1) Symptoms: 6% None to Mild, 94% Moderate to Severe; (2) Myelopathy: 16% None to Mild, 45% Moderate, 39% Severe; (3) All were grouped No Progression in the present study; (4)19% demonstrated Global Malalignment(+/++Schwab), 81% did not; (5)Risk Factors: 27% had None to Mild, 63% Moderate, 10% Severe; (6)Curvature TS-CL demonstrated 88.6% of patients Severe(>20°).Patients were stratified into Not Appropriate and Appropriate categories based upon the DLS study(Table 1). In the present cohort, 94% were deemed Appropriate for surgery, 6% Not Appropriate. Less Appropriate patients demonstrated higher rates of postop dysphagia complications (17% vs. 2%), met MCID for NDI less (0% vs. 30.9%), and had more occurrences of DJK (16.7% vs. 6.4%) by 2-years, p<0.05.

Conclusion
In light of the heterogeneity and uncertainty surrounding CD, this study developed modified-CD appropriateness criteria, using established methodology, for surgeons to consider in the preoperative decision-making that correlate well with major post-op occurrences.

Take Home Message
Application of the appropriateness criteria for CD may optimize patient selection and reduce the incidence of unwarranted surgery, although future validation is necessary.

DLS Appropriateness criteria used to stratify a population of cervical deformity patients.

83. HOW LOW CAN YOU GO? IMPLANT DENSITY IN POSTERIOR SPINAL FUSION CONVERTED FROM GROWING CONSTRUCT FOR EARLY ONSET SCOLIOSIS

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Summary
While length gain and curve correction were similar at all implant densities, more revisions occurred in ultra-low implant densities (<1.3 anchors/vertebrae) in growing rod conversions.

Hypothesis
Early onset scoliosis (EOS) patients treated with low implant density (ID) constructs will have similar outcomes as patients treated with high ID constructs.

Design
Retrospective, Multicenter

Introduction
Our purpose was to determine if EOS patients treated with low ID constructs have similar outcomes to patients treated with high ID constructs when undergoing conversion to fusion.

Methods
EOS patients with minimum 2-years follow-up treated with growth-friendly constructs converted to fusion between 2000-2017 were reviewed from a multicenter database. ID was defined as the number of anchors per level fused. Patients were divided into high (≥1.6), low (1.3-1.6) and ultra-low (<1.3) ID.

Results
152 patients were included: 39(25.6%) in the high ID group, 33(21.7%) in the low ID group, and 80 in the ultra-low ID group (52.6%). Radiographic follow-up after fusion was similar for all groups(p=0.90) The high ID group (946.8±606.0 mL) had significantly higher EBL than the low ID (733.9+434.5 mL) and ultra-low ID group (617.4+517.2mL) (p=0.01). There no was significant difference in operative time between the groups(p=0.61). Initial improvements in major curve from pre- to post-fusion were: high ID group=21.6o, low ID=18.0o and ultra-low =12.6o(p=0.01). During post-fusion follow-up, there was slightly greater loss of correction in the high ID group(-7.1o) vs. the low ID(-2.6o) and ultra-low ID(-2.8o) groups(p=0.19). Consequently, there was no significant difference in major curve correction from pre-fusion to final follow up between the groups (high ID:14.5º, low ID:15.5º and ultra-low ID: 9.7o, p=0.14). At final follow-up, there was no significant difference in T1-S1 length gain between the groups (p=0.68)). Revision rate was higher in the ultra-low group (13.8%) compared to the high ID (5.1%) and low ID (0%) groups(p=0.04).

Conclusion
In the largest series of growth-friendly construct conversion to fusions reported to date, similar curve correction and spinal length gain were seen for all implant density constructs, but with implant density <1.3, a higher revision rate was observed.

Take Home Message
Patients with ID < 1.3 had similar curve correction and length gain as higher ID constructs, but underwent significantly more revisions.

85. SACRAL OSTEOTOMY FOR HIGH GRADE SPONDYLOLISTHESIS IN ADOLESCENTS

Karen A. Weissmann, MD; Francoise Descazeaux, MD

Summary
There is no consensus regarding surgical treatment of high-grade spondylolisthesis in adolescents. We analyzed 5 patients that underwent posterior only correction with L4-iliac fusion and sacral osteotomy. Statistically significant differences were found in pelvic tilt (p=0.016), T1 Pelvic angle (p=0.042) and Slippage percentage (p=0.023). Fusion was achieved in a 100% of the cases. Posterior only surgery with L4-iliac crest fusion and sacral osteotomy allow good restoration of sagittal balance and clinical results in adolescents with high grade spondylolisthesis

Hypothesis
Sacral osteotomy allows good clinical and radiological results in high grade spondylolisthesis

Design
Case series

Introduction
No consensus exists in surgical treatment of high-grade spondylolisthesis in adolescents. Posterior only approaches allow sagittal restoration, report high rates of pseudoarthrosis and complications

Methods
We analyzed 5 cases of high grade spondylolisthesis that underwent posterior only correction of L4-iliac fusion and sacral osteotomy. Clinical and radiological parameters were recorded. 2 years follow up. Analysis included student t-tests

Results
5 patients, mean age 13 years, 4 female, 60% comorbidities, 3 cases pf Ehler Danlos syndrome at pre-operative evaluation 4 patients had L5 unilateral palsy. 3 cases were Labelle type 6 and 2 cases type 7. Mean operative time was 294 min±53, bleeding 1290cc±589 transfusion rate was a mean of 1.6 U±1.51/patient. Length of stay was an average of 2.2±0.83 days in an Intensive care unit and 3.4±1.14 days in a pediatric unit. Drain was used in all cases with a mean of 2.8±0.44 days and a debit of 508cc±296. Preoperative lumbar visual analog scale (LVAS) was 7.2±4, radicular (RVAS) was 7.2±4 and Oswestry disability index (ODI) was 62.8±36, at follow up LVAS was 2.0±2, RVAS 2.6±1, ODI 20.8±12 (p=0.027, p=0.023, p=0.021). There were no differences between pre and postoperative measurements in Coronal cobb, coronal balance, cervical lordosis, T1 slope, thoracic kyphosis, lumbar lordosis, Pelvic incidence, sacral slope, T1Spi, T9Spi, sagittal vertebral alignment, sacral kyphosis and Lumbosacral angle. Statistically significant differences were found in pelvic tilt(p=0.016), T1 Pelvic angle(p=0.042) and Slippage percentage(p=0.023). Fusion was achieved in all cases. There was 1 screw pullout in L5 that was corrected in surgery and 2 postoperative L5 root palsy, one transitory, one permanent. At 1 year follow up, a secondary foraminal stenosis

that was decompressed was seen in 1 patient. No infections

Conclusion
Posterior only surgery with L4-iliac crest fusion and sacral osteotomy allows good restoration of sagittal balance and clinical results in adolescents with high grade spondylolisthesis. Fusion rates of 100%

Take Home Message
Posterior only surgery with L4-iliac crest fusion and sacral osteotomy allow good restoration of sagittal balance and clinical results in adolescents with high grade spondylolisthesis. Fusion rates are 100%.

86. INTRA-OPERATIVE RADIATION EXPOSURE IN PEDIATRIC SCOLIOSIS SURGERY

Nicole Fares, BA; Sarah Toner, BS; William R. Barfield, PhD; Robert F. Murphy, MD; Sara Van Nortwick, MD

Summary
Pediatric orthopedic surgeons repeatedly perform spinal fusions throughout their careers and repeated radiation exposure may increase the risk of certain cancers. Pediatric patients have developing radiosensitive tissues including breast tissue directly in the fluoroscopy field. Determining a baseline effective intra-operative radiation dose is important in understanding patient and surgeon radiation risks and how to minimize them. Our study evaluated fluoroscopy times during 148 pediatric spinal fusion procedures and found significant variability in pediatric patient and spine surgeon intra-operative radiation exposure.

Hypothesis
Patients with more levels fused will experience a higher fluoroscopy time, as will patients with a greater BMI as compared to patients with a lower BMI and a similar number of levels fused. Patients with a higher preoperative curve are also expected to have a higher amount of intraoperative fluoroscopy.

Design
A retrospective review of spinal fusions performed from 2017-2019 at a single institution by three fellowship trained pediatric orthopedic surgeons was performed.

Introduction
Pedicle screw placement during pediatric spinal fusions is often aided by fluoroscopy. The purpose of this study was to evaluate the variability in the amount of intra-operative radiation pediatric patients receive during fluoroscopically assisted spinal fusions.

Methods
Diagnosis (idiopathic (AIS) v. neuromuscular (NM)), age, preoperative curve, number of levels fused, and BMI data was collected in addition to total intra-operative fluoroscopy time. One-way ANOVA tests, Bonferroni post-hoc tests, independent t tests, and Pearson correlations were utilized.

Results
148 pediatric spinal fusion patients had a mean fluoroscopy time of 142.7 ± 66.9 seconds.; AIS patients (n=117) had a mean fluoroscopy time of 129.3 ± 58.0 sec.; NM patients (n=31) had a mean fluoroscopy time of 193.1 ± 74.7 sec.; AIS patients had a mean BMI of 22.02 ± 8.12 kg/m2, and a pre-op curve of 61.2 ± 13.3 degrees. In patients with AIS, fluoroscopy time correlated to the patient's preoperative curve (r=.182, p=.050) and varied significantly between patients with 0-11 levels fused versus patients with 12-16 levels fused. When controlling for levels fused, AIS patients with higher BMIs had significantly greater fluoroscopy times (p=.001). In NM patients, fluoroscopy time correlated to BMI (r=-.459, p=.009) and preoperative curve (r=.475, p=.007), but not the number of levels fused. The whole patient absorbed radiation dose ranged from 2.12-3.26 mG.

Conclusion
There is significant variability in pediatric patient and spine surgeon intra-operative radiation exposure. Minimizing intra-operative radiation while maintaining safety is important to minimize the stochastic effects to pediatric patients and the surgical team.

Take Home Message
Spinal fusion is a medically necessary procedure that exposes the pediatric patient and surgeon to intra-operative radiation when fluoroscopy is utilized.

89. OPTIMIZING SAFETY IN ROBOTIC LUMBAR INSTRUMENTED FUSIONS: A RISK FACTOR ANALYSIS OF ROBOTIC FAILURES

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Summary
Robot-guided lumbar instrumented fusion (RGLF) has the potential to improve safety and accuracy of pedicle screw placement. However, there are pitfalls in adopting this new technology. Optimizing workflow by avoiding interbody placement prior to pedicle screws placement (interbody-first workflow, IFW) and using caution in patients with poor bone quality (L1 Houndsfield Units under 148) may improve outcomes.

Hypothesis
Robot-related complications can be avoided by placing pedicle screws first.

Design
Single-center retrospective study

Introduction
As in adopting any new OR technology, there may be early complications when introducing RGLF. This study assess the pitfalls experienced by a single institution.

Methods
RGLFs over 1.5 years were included. Univariate analysis

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with t-tests, Mann-Whitney U tests, or chi-squared analysis assessed demographics, L1 and UIV Houndsfield units, levels fused, L5-S1 inclusion, IFW, hyperlordotic cage, and robot registration method as risk factors for intraoperative robot mechanical failures, pedicle screw malpositioning, and robot registration failure. Multivariate logistic regression of risk factors approaching or achieving significance was conducted. A receiver operating characteristic (ROC) curve was created to determine a threshold for independent risk factors.

Results
273 RGLFs were included. Female gender, smoking, L5-S1 inclusion, and IFW were independent risk factors for registration failure. Gender and L5-S1 inclusion were independent risk factors and IFW approached significance for mechanical failure. In univariate analysis, IFW was a significant risk factor for pedicle screw malpositioning. There were no independent risk factors. (Fig 1) Subanalysis of 89 robot-guided anterior-posterior lumbar fusion (RG APLF), L1 Houndsfield units were the only independent risk factors for registration and mechanical failures.Age, L1 and UIV Houndsfield units, and levels fused were significant risk factors for pedicle screw malpositions on univariate analysis. ROC analysis revealed a cutoff of L1 Houndsfield units of 148.5 for mechanical failures (area under the curve = 0.889).

Conclusion
In all RGLFs, interbody-first workflow was a risk factor for robot-related complications. In RG APLF, low L1 Houndsfield units, indicative of poor bone quality, was a risk factor for robot-related complications.

Take Home Message
Robot-related complications may be avoided by placing pedicle screws prior to interbody and by using caution in patients with poor bone quality.

Figure 1: Univariate and Multivariate Analysis of Risk Factors for Robot Registration Failure, Intraoperative Robot Mechanical Failure, or Pedicle Screw Malposition in Robot-Guided Anterior-Posterior Lumbar Instrumented Fusions of a Single Institution

90. WHAT FACTORS INFLUENCE LEVEL SELECTION AT THE UPPER INSTRUMENTED VERTEBRA (UIV) IN PATIENTS WITH ADULT IDIOPATHIC SCOLIOSIS (ADIS): A MULTI-CENTER SURVEY STUDY OF DEFORMITY SURGEONS

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Summary
This study found a high degree of variability in UIV selection when surgeons utilized xrays, CT and MRI to assess the spinal deformity. Surgeons reported the sagittal plane is the most important factor in choosing a UIV, however, more clear and reproducible guidelines are needed to standardize UIV selection to better optimize patient care.

Hypothesis
We hypothesize that low intra and inter-rater reliability will exist between surgeons with UIV selection in AdIS.

Design
Survey

Introduction
A consensus on appropriate UIV selection does not exist and still remains largely a matter of opinion.

Methods
20 consecutive patients with a diagnosis of AdIS (mean age 46.6, 80% Female) were included in the survey, which was sent to 11 deformity-focused spine surgeons at various institutions. The survey was administered in 3 rounds: 1) radiographs alone, 2) radiographs + CT scan and 3) radiographs, CT, + MRI scan. After each round respondents were asked to choose their UIV selection. Additionally, respondents were asked to identify the presence of degenerative disc disease and what factors drove them to select a UIV. The interobserver and intraobserver reliability to measure the repeatability and reproducibility, respectively, was calculated using Fleiss' kappa coefficient.

Results
Overall intra-rater reliability for respondents between surveys was extremely poor (k=0.16, p<0.001). Total inter-rater reliability was also found to be quite poor (k=0.12, p< 0.001) with the greatest discrepancy arising after reviewers were selecting the UIV based off of XR +CT (k=0.11; p<0.001). The highest rate of UIV agreement was found when assessing XR, +CT, +MRI (k=0.15). Overall, rates of degenerative disc disease were 59% (107/181), with higher rates in the cervical spine (43%, 78/181) compared to the thoracic spine (33%, 60/181) (p=0.03). Respondents listed the sagittal plane to be the greatest factor in determining UIV selection (59%, 106/181; p<0.001) followed by shoulder height and MRI (40%, 72/181 (p<0.001).

Conclusion
We found extremely poor reliability of UIV selection in AdIS

which reflects a high degree of variability even after successive introduction of CT and MRI studies. Likewise, a very poor total interrater reliability suggests a lack of consensus criteria and need of more clear guidelines when choosing the UIV, with surgeons reporting the sagittal plane as the most important factor in UIV selection.

Take Home Message
This study found extremely poor intra/interrater reliability of UIV selection, supporting the utility of advanced imaging and need for the development of clear guidelines for UIV selection in AdIS patients.

91. COST-UTILITY ANALYSIS OF A COMBINED APPROACH FOR SURGICAL CORRECTION OF ADULT SPINAL DEFORMITY

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Summary
With the increasing emphasis on value-based outcomes in healthcare, there has been an increased focus on the cost of surgical intervention in patients with adult spinal deformity (ASD). Our results demonstrated that a combined approach trended towards being more cost-effective with a lower cost per QALY at two years postoperatively and at life expectancy. Combined approach had lower rates of operative complications and rates of revisions

Hypothesis
Increased incidence of revision and complications with posterior-only approach increases cost

Design
Retrospective

Introduction
A thorough accounting of cost of surgical approach has been understudied in the literature

Methods
ASD patients with no previous history of fusions, complete radiographic, and HRQL data at baseline and 2Y were included. Patients were propensity score matched for age, CCI, levels fused, frailty, SVA, PI-LL and osteotomies. Utility data was calculated using ODI converted to SF-6D using published conversion methods. Costs was calculated using the PearlDiver database incorporating complications, comorbidities (CC), major complications, and comorbidities (MCC). After accounting for CC, MCC, length of stay (LOS), revisions, and death, cost per QALY at 2Y and life expectancy were calculated for surgical approach.

Results
208 PSM ASD patients were included (62.2yrs, 84% F, 26.9 kg/m2). Patients undergoing a combined approach had a longer LOS (6.55 vs.8.15), greater op time (517min vs. 371min), and experienced significantly greater blood loss (all p<0.05). Posterior-only approach patients had significantly higher rates of operative complications and revisions within 2Y of index surgery (both p<0.05). Overall, posterior vs. combined patients did not significantly differ at BL ODI (44.3 vs. 41.5, p>0.05). Despite initial higher costs of a combined approach, the average cost of ASD surgery at 2Y follow up for posterior-only approach was greater compared to a combined approach ($72,749 vs. $65,073). Furthermore, the cost per QALY was higher for posterior-only patients at 2Y compared to patients undergoing a combined approach ($363,910 vs. $333,981). If utility gained is sustained to life expectancy, the cost per QALY was $54,027 for posterior-only and $49,584 for combined.

Conclusion
In a matched cohort of ASD patients, a combined approach trended towards a lower average cost of surgery at 2Y, lower cost per QALY, significantly lower rates of operative complications and revisions.

Take Home Message
Although improvement after surgical intervention was similar between the two approaches, cost per QALY of posterior-only approach was greater primarily driven by increased operative complications and rates of revisions.

92. THE EFFECTS OF CONNEXIN INHIBITORS ON THE BEHAVIORAL, CELLULAR AND MOLECULAR OUTCOMES IN A PORCINE SPINAL CORD INJURY MODEL

Khaled Alok, MD; Charbel Moussalem, MD; Wassim Baassiri, MD; Mohamad El Houshiemy, MD; Safwan Alomari, MD; Ibrahim A. Omeis, MD

Summary
Connexin-43 (Cx43) has been linked recently to a feed-forward mechanism that leads to ATP-induced neuroinflammation. Furthermore, several ex vivo and rodent studies have demonstrated better histological and functional outcomes of spinal cord injury (SCI) upon the application connexin inhibitors. We aimed to test two emerging promising agent in a standardized large animal SCI model, a necessary step before testing this treatment in a clinical trial.

Hypothesis
Acute treatment with intrathecal connexin inhibitors, either the gap junction blocker Carbenoxolone, or Gap26, a Cx43 mimetic peptide, can improve the outcome of spinal cord injury in a pig model

Design
Three groups of pigs underwent a standardized compression/contusion spinal cord injury. Group A was kept as a control, Groups B and C were treated with Carbenoxolone and Gap26,

respectively. Please refer to the attached figure and the methodology section for details.

Introduction
Several ex vivo and rodent studies have demonstrated a promising neuroprotective effects of connexin inhibitors. We aimed to see if connexin inhibitors are effective in a larger animal SCI model.

Methods
SCI was induced using a compression/contusion weight drop model in three groups of pigs with 2 animals per group. Group A: sham, Group B: Nonselective gap junctions blocker (Carbenoxolone) treated, Group C: Connexin-43 memetic peptide (Gap26) treated. The medication was delivered intrathecally at the time of injury. Serial blood samples were collected from the animals to measure the serum levels of prostaglandin E2 (PGE2). The locomotor development of the animals was assessed over 11 weeks. After which the animals were euthanized and their spinal cords were harvested for histological and immunofluorescence assessment.

Results
In terms of locomotion recovery, Groups B and C regained the stepping ability in their hind limbs, whereas the control group did not. Histological staining of the control group (A) sections revealed signs of severe neuronal damage beyond the epicenter. Whereas the damage was limited in Gap 26-treated group (C). Groups B and C exhibited a decreased level of astrocytes activation. Finally, PGE2 serum levels remained low in the two treated groups.

Conclusion
We translated the positive neuroprotective effect of a connexin-43 memetic peptide and gap junction blockers in a porcine SCI model. This study provides further evidence supporting the potential role of these agents in improving SCI outcome.

Take Home Message
Given the promising results of Cx43 memetic peptides in pre-clinical studies we hope that it gains enough supporting evidence to be considered for a future spinal cord injury clinical trial.
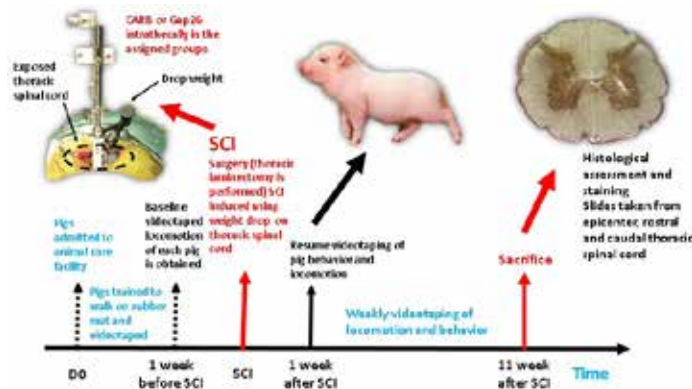
The outline of the experiment. Note that following euthenesia, the spinal cords were harvested for morphological/ histological/ IF studying.

93. WHAT ARE THE POST-OPERATIVE CONSEQUENCES OF INTRAOPERATIVE NEUROMONITORING CHANGES DURING CERVICAL SPINE SURGERY

Shalin Shah, DO; Won Park, BS; Addisu Mesfin, MD

Summary
To date there is no consensus on the utility of intraoperative neurophysiological monitoring (IONM) for cervical spine surgery. The objective is to identify risk factors and outcomes for patients undergoing cervical spine surgery and sustained IONM changes. A retrospective study of 561 patients from 2012 to 2016 demonstrated an overall rate of neuromonitoring changes of 3.7% (21/561). However, only one patient (0.18%) demonstrated new postoperative neurologic changes, demonstrating no correlation between IONM changes and postoperative neurologic outcomes.

Hypothesis
Positive IONM changes during cervical spine surgery correlate with prevention of worsening neurological outcomes post-op

Design
Retrospective

Introduction
To date there have been several studies with no consensus on the utility of intraoperative neurophysiological monitoring (IONM) for cervical spine surgery. Considering the purpose of these surgeries is to relieve compression on neural elements, any worsening of neurologic symptoms following surgery is considered an unexpected complication. IONM is widely utilized in spinal surgery to detect in real time and hopefully to prevent intraoperative neurologic complications. The objective is to identify risk factors and outcomes for patients undergoing cervical spine surgery and sustained IONM changes.

Methods
A retrospective study of patients undergoing cervical spine surgery at level 1 trauma center from 2012 to 2016 was performed. Demographic and surgical variables were collected as well as the presence of IONM changes and post-operative neurological changes.

Results
561 patients undergoing cervical spine surgery were identified. There were 249 females and 312 males with an average age of 54.4 years. 90 black/African American, 454 white, 6 Hispanic, 4 Asian, 1 Native American. The overall rate of IONM changes was 7.13% (40/561). The rate was 4.40% (16/361) in patients undergoing an anterior approach versus 11.3% (19/168) in patients who had posterior approaches versus 15.6% (5/32) in patients who had circumferential fusions (P = 0.0021). The overall rate of neuromonitoring changes that did not improve by

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the conclusion of the surgery was 3.7% (21/561). However only one patient experienced (0.18%) new significant postoperative neurologic changes.

Conclusion
Of the 40 patients with IONM changes, only one patient had changes in their neurologic status postoperatively. Our study demonstrates positive IONM changes during cervical spine surgery did not correlate with worsening neurological outcomes post-op.

Take Home Message
Positive IONM changes during cervical spine surgery did not correlate with worsening neurological outcomes postoperatively.

94. SCOLIOSIS FLEXIBILITY CORRELATES WITH POST-OPERATIVE OUTCOMES FOLLOWING GROWTH FRIENDLY SURGERY

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Summary
As lower pre-operative flexibility was associated with less post-operative scoliosis correction and pre-operative flexibility <30% was associated with a higher risk of post-operative complications, curve flexibility should be considered when deciding upon the timing of growth friendly surgery.

Hypothesis
For EOS patients who have received growth friendly surgery (GFS), lower pre-op flexibility will result in decreased scoliosis correction and a higher risk of post-op complications.

Design
Retrospective review of prospectively collected study group data.

Introduction
There has been insufficient study of the relationship between pre-op flexibility and post-op outcomes for EOS patients who receive GFS.

Methods
EOS patients with pre-op flexibility x-rays (traction or bend) were identified. Pre-op % flexibility and immediate post-op % correction were calculated for each patient. Complications were recorded. Pearson correlations were determined for % flexibility vs. % correction for all patients and were compared between etiologies and between device types (MCGR, TGR, rib-base distraction).

Results
107 patients (14 congenital, 43 NM, 31 syndromic, 19 idiopathic) with mean age 7.1 years at index surgery were identified. Pre-op scoliosis was 77°. Mean flexibility of 36% did not differ between etiologies. Immediate post-op scoliosis was 46°* with

mean correction of 38%. Percent correction did not differ by etiology (Table 1), but did differ between device types (MCGR 45%, TGR 40%, rib-base distraction 14%*). Pearson correlation for preoperative % flexibility vs. % correction was fair (r=0.37*). This correlation was observed for idiopathic (r=0.53*) and NM (r=0.46*), but not for congenital or syndromic. At a mean of 4.8 years follow up, 66 patients (62 %) experienced at least one complication. Risk ratio for developing a complication was 1.58 (1.18-2.11) for patients with pre-op flexibility <30%*. *denotes p<0.05.

Conclusion
As lower pre-operative flexibility was associated with less post-operative scoliosis correction and pre-operative flexibility <30% was associated with a higher risk of post-operative complications, curve flexibility should be considered when deciding upon the timing of growth friendly surgery.

Take Home Message
EOS patients with greater pre-operative flexibility are more likely to have greater scoliosis correction and less likely to have complications following growth friendly surgery.

	n	Mean Flexibility	Mean Correction	Correlation	p Value
All	107	36%	38%	0.37	<0.001
Etiology					
Idiopathic	19	34%	37%	0.53	<0.05
Congenital	14	30%	37%	0.13	0.67
Neuromuscular	43	38%	39%	0.46	<0.01
Syndromic	31	37%	38%	0.24	0.20
Device Type					
MCGR	39	40%	45%	0.6	<0.0001
TGR	54	35%	40%	0.12	0.38
Rib-Base Distraction	14	29%	14%	0.019	0.95

Table 1: Pre-op flexibility and post-op scoliosis correction for EOS patients following growth friendly surgery. Patients are categorized by etiology and by implant device type.

95. PROVIDER CONFIDENCE IN THE TELEMEDICINE SPINE EVALUATION: RESULTS FROM A GLOBAL STUDY

Francis C. Lovecchio, MD; Grant Riew, BS; Dino Samartzis, PhD; Philip K. Louie, MD; Michael H. McCarthy, MD; Melvin C. Makhni, MD; Sravisht Iyer, MD

Summary
An anonymous global survey performed in May 2020 consisting of 485 spine surgeons from 75 countries found that surgeons are confident in the ability of telemedicine to communicate with patients or take a history, but are skeptical of its ability to make diagnoses traditionally based on physical exam. Videoconferencing technology and increased experience with telemedicine was associated with provider confidence in making diagnoses.

Hypothesis
Spine surgeons lack confidence in telemedicine to make accurate diagnoses.

Design
Anonymous cross-sectional survey of 485 spine surgeons from

75 countries.

Introduction
Understanding what factors determine provider's confidence in telemedicine is essential to decrease barriers to adoption.

Methods
Members of AO Spine International were sent an anonymous survey in May 2020. The survey was designed through a Delphi approach, with four rounds of review by multi-disciplinary authors. Final version consisted of 42 questions on participant's experience with, perception of, and comparison of telemedicine to in-person visits. Responses were compared by provider age, experience, telemedicine platform, trust in telemedicine, and specialty.

Results
Most participants were between 35-44 (35.7%) or 45-54 years old (33.0%), 94.5% male, practicing in Africa (19.9%), Asia Pacific (19.7%), Europe (24.3%), North America (9.4%), and South America (26.6%). Videoconferencing platforms were utilized by 57.5%, while 34.6% used telephone calls only. At the time of the survey, 55.6% had performed fewer than 25 visits, 22.2% having performed 50 telehealth visits (22.2%). Generally, providers felt that physical exam-based tasks (e.g., provocative testing, assessing neurologic deficits, assessing myelopathy, etc.) were inferior to in-person exams, while communication-based aspects (e.g., history taking, imaging review, etc.) were equivalent. Participants who performed greater than 50 visits were more likely to believe telemedicine was at least equivalent to in-person visits in making accurate diagnoses (OR 2.37, 95% C.I. 1.03-5.43). Video (versus phone only) visits were associated with increased confidence in the ability of telemedicine to formulate and communicate a treatment plan (OR 3.88, 95% C.I. 1.71-8.84).

Conclusion
Spine surgeons believe communication with patients may be performed through telemedicine, but are concerned about its capacity to accurately make physical exam-based diagnoses. Future research should concentrate on standardizing the remote examination and developing appropriate use criteria.

Take Home Message
Surgeons remain skeptical of the ability of telemedicine to make physical-exam based diagnoses. Standardized remote examination techniques and appropriate use criteria will be needed to increase surgeon confidence in telemedicine.

Compared to in-person visits, telemedicine is equivalent or better to...
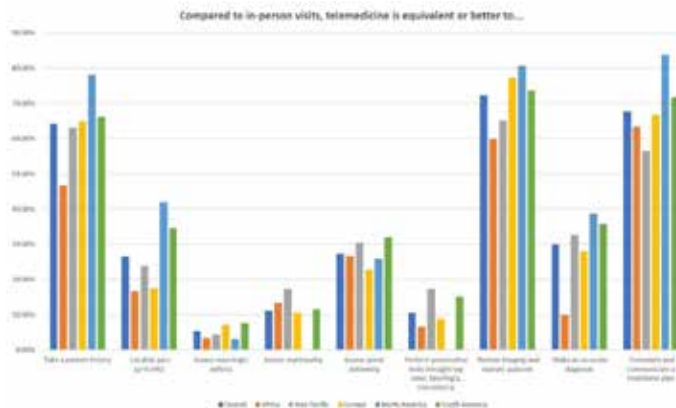
96. DETERMINING LOWEST INSTRUMENTAL VERTEBRAE (LIV) ON PRONE X-RAY CAN SAVE FUSION LEVELS WITH GOOD CORRECTION AND BALANCE IN AIS PATIENTS COMPARED TO TRADITIONAL METHODS

Vishal Sarwahi, MD, MBBS; Jesse M Galina, BS; Sayyida Hasan, BS; Aaron M. Atlas, BS; Yungtai Lo, PhD; Terry D. Amaral, MD; Stephen F. Wendolowski, BS

Summary
The study aims to determine if using the 'touched' vertebra (TV) affects the fusion levels in PSF for AIS. A retrospective cohort study of 260 patients finds that in AIS, using TVP to determine LIV allows for shorter fusion. LIV tilt and disc wedging is also within 'acceptable' levels determined on controls. TV on prone XRs (TVP) is an effective and better way to determine the lowest instrumented vertebra.

Hypothesis
Using TVP to determine LIV saves fusion levels with good correction and coronal balance.

Design
Ambispective cohort study

Introduction
Minimizing fusion levels in PSF for AIS is important. Previous studies have shown good results utilizing TV as the LIV. TV is 'touched' vertebra determined by central sacral vertical line on standing AP XRs (TVS). We found TV moves proximally on supine/prone XRs. Thus, utilizing TVP in LIV decision making may allow even shorter fusion.

Methods
Group1: patients where TVP used to determine LIV. Group2: patients where TVS used to determine LIV. Group3: non-operative AIS (Risser 4/5, Cobb <30) to determine 'acceptable' end vertebra tilt and disc wedging. Patients with only thoracic fusion excluded. Cobb angle, coronal balance (CB), LIV tilt angle and translation, and disc wedging collected at preop and postop. Median values and interquartile collected for the subsets.

Results
The control group (n=132) with a median (IQR) Cobb of 20°

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(16-26), age of 16 (14.8-17), coronal balance 1.4 (0.5-2.2), disc wedging of 4° (2-5), and LIV tilt of 10° (7-13). In Group1 (n=102), median preoperative Cobb =53.8° and coronal balance =1.8. Final Cobb =12.4° and coronal balance =0.9. Compared to controls, Group1 patients had significantly less coronal imbalance (p =0.023), lower disc wedging (p>0.001) and LIV tilt (p<0.001). In Group2 (n=26), preop Cobb =53.5° and coronal balance =2. Final Cobb =20° and coronal balance =0.7. Group2 patients could have saved an avg 2.24 levels, if fused to TVP. Preop Cobb angle, coronal balance, LIV tilt, disc angle, and LIV translation similar between Group1 and Group2. While final coronal balance was not significantly different between Group1 and Group2, final Cobb angle (p<0.001), disc angle (p<0.001), and LIV translation (p=0.002) all significantly smaller for Group1. Group2 fused significantly fewer levels (p = 0.005), and had significantly more patients with final disc angle > 5° (p < 0.001).

Conclusion

In AIS, using TVP to determine LIV allows for shorter fusion, without comprising LIV tilt or disc wedging, emphasizing its efficacy.

Take Home Message

TV on prone xray is an effective and better way to determine the lowest instrumented vertebra. At 2-year follow up, this study did not find coronal decompensation.

97. MINI-OPEN APPROACH TO LATERAL TRANSPSOATIC INTERBODY FUSION: AN UPDATE AT 6,000 LEVELS

Gary A. Fantini, MD; Alexander P. Hughes, MD; Federico P. Girardi, MD; Andrew A. Sama, MD; Darren Lebl, MD; Charles Goodwin, MD; Frank P. Cammisa Jr, MD

Summary

Mini-open approach to LTIF obviates the need for complex and unreliable neuro-monitoring systems. Direct visualization of the retroperitoneum and palpation of the disc space places control in the hands of the surgeon. Complete paralysis facilitates dissection and reduces operative time. Injury to the neural elements, viscera and vascular structures is thus minimized.

Hypothesis

Mini-open technique of LTIF, permitting direct visualization of retroperitoneal and neural structures, will result in a lower incidence of neural, visceral and vascular injuries.

Design

Retrospective chart review via computerized registry.

Introduction

Lateral transpsoatic interbody fusion (LTIF) typically employs a series of tube shaped dilators to traverse the psoas muscle and expose the target disc. These systems rely upon hand held depolarizing technology to avoid damage to the exiting nerve roots and lumbar plexus. Despite this methodology, injury to the neural elements, viscera and vascular structures continue to occur.

Methods

From 2007 through 2020, a patient registry accrued > 2,750 patients undergoing LTIF. At an average of 2.2 levels/patient, > 6,000 levels were done using a mini-open muscle splitting approach, permitting visualization of the retroperitoneal space and digital palpation of the target disc. A transpsoatic dissection plane ventral to the exiting nerve roots and lumbar plexus was established via direct visualization and palpation. Retraction was maintained by table mounted Altus®, DePuy®, or Nuvasive® self-retaining systems, or by hand held renal vein retractors. Coronal deformities were approached through the concavity of the curve. In cases involving the L4-5 disc space, coronal angulation of the L4-5 disc was the principal factor determining choice of operative side.

Results

There have been no instances of peritoneal violation or permanent motor deficit. Incidence of minor sensory deficit at one year was < 5%. Segmental vessel injury was easily handled, as were various venous anomalies. A single aortic injury was repaired following conversion to midline laparotomy.

Conclusion

Vision and palpation are familiar skills to the operating surgeon. Mini-open approach to LTIF of the lumbar spine permits the use of these skills, facilitating safe localization of the target disc, thus avoiding injury to the viscera and minimizing damage to the neural elements and vascular structures.

Take Home Message

Mini-open technique of LTIF obviates the need for complex and unreliable neuro-monitoring systems, thus simplifying the procedure and enhancing patient outcomes.

98. COMPARING LONG-TERM OUTCOMES BETWEEN MINIMALLY INVASIVE TRANSFORAMINAL LUMBAR INTERBODY FUSION (TLIF) AND EXTREME LATERAL INTERBODY FUSION (XLIF) IN THE TREATMENT OF LUMBAR SPINAL DISORDERS

Daniel Coban, MD; Stuart Changoor, MD; Conor J. Dunn, MD; Michael Pompliano, MD; Kumar Sinha, MD; Ki S. Hwang, MD; Michael J. Faloon, MD; Arash Emami, MD

Summary

Minimally invasive transformational lumbar interbody fusion (MI-TLIF) and extreme lateral interbody fusion (XLIF) have both been progressively utilized by spinal surgeons, offering advantages of reduced tissue trauma, blood loss, medication use and cost. In this study, we sought to assess and compare the overall revision rates and functional clinical outcomes with long-term follow-up in both MI-TLIF and XLIF. Our two-year results suggest XLIF and MI-TLIF are both reasonable alternatives for the treatment of lumbar spinal disease.

Hypothesis

XLIF and MI-TLIF will have comparable outcomes in the

treatment of lumbar spinal disease

Design
Retrospective Cohort Study

Introduction
Minimally invasive lumbar fusion has developed into a popular surgical option for patients with degenerative lumbar pathology. These techniques offer similar clinical outcomes to the open approach, often reporting less complications in the long-term. However, there is a natural paucity in the literature directly comparing different minimally invasive approaches, as these are often compared singularly with their open counterparts.

Methods
A retrospective review was performed to identify all patients between 2013-2018 who underwent XLIF of MI-TLIF with a minimum follow-up of 2 years. Demographic data was recorded and compared between both cohorts. Revision rates and average time to revision in each group was compared. Functional outcomes were assessed with ODI and VAS-back measurements at follow-up visits. Standard binomial and categorical comparative analysis were performed.

Results
A total of 340 consecutive patients were included, 115 in the XLIF cohort and 225 in the MI-TLIF cohort. The overall revision rates were 7.8% for the XLIF group and 8.0% for the MI-TLIF group, respectively (p= 0.929). Average time to revision was 376.3 ± 284.3 days and 404.1 ± 240.7 days for the MI-TLIF and XLIF groups, respectively (p= 0.366). The most common reason for revision in each cohort was pseudarthrosis in the MI-TLIF group (60.0%) and adjacent segment disease in the XLIF group (44.4%). There were 134 males and 91 females in the MI-TLIF cohort compared to 46 males and 69 females in the XLIF cohort (p= 0.001). Both cohorts experienced significant improvements in their functional outcome scores compared to their pre-operative values; however, VAS-back scores decreased by a mean of 5.6 in the XLIF group and a mean of 2.9 in the MI-TLIF group, a significant difference (p= <0.001).

Conclusion
After long-term follow-up, XLIF demonstrated superior improvements in VAS-back scores, without increased revision rates.

Take Home Message
Our two-year results suggest XLIF and MI-TLIF are reasonable alternatives for the treatment of lumbar spinal disease. After long-term follow-up, XLIF demonstrated superior improvements in VAS-back scores, without increased revisions

99. PATIENTS UNDERGOING MINIMALLY INVASIVE SURGERY HAVE SUPERIOR PAIN CONTROL TO TRADITIONAL POSTERIOR SPINAL FUSION

Vishal Sarwahi, MD, MBBS; Jesse M Galina, BS; Aaron M. Atlas, BS; Yungtai Lo, PhD; Terry D. Amaral, MD; Sayyida Hasan, BS

Summary
The purpose of this study was to evaluate the MIS technique on postoperative recovery, particularly postoperative pain, when compared to the traditional PSF method in one tertiary medical institution. A retrospective review of 86 patients found that MIS patients had significantly lower morphine consumption compared to PSF patients, overall better pain scores, and operative care.

Hypothesis
MIS technique will have lower pain scores to patients undergoing traditional procedures.

Design
Retrospective Review

Introduction
Narcotics have long been given to patients for pain control after spinal surgery. However, recently, narcotic use has been shown to be drastically rising across all patient populations, often leading to addiction. Minimally invasive surgery (MIS) has been shown to demonstrate significant benefits compared to posterior spinal fusion (PSF). The objective of this study is to compare on institution's use of narcotics in patients undergoing MIS and its comparison to patients undergoing PSF.

Methods
AIS patients undergoing spinal surgery from 2011 – 2019 were reviewed retrospectively. Radiographic and operative data were collected for MIS and PSF patients. In addition, narcotic consumption, pain score, time to first ambulation and length of stay were recorded and compared. Patients were matched based on fusion levels, to avoid any confounding variables. Data is presented as Median (IQR).

Results
86 patients were reviewed (MIS: 36; PCA: 50). Preoperative major cobb angles were similar between the two groups (p = 0.25). MIS patients had significantly lower morphine consumption compared to PSF patients (p<0.001). In addition, MIS patients had lower maximum pain scores at activity (p = 0.039) and shorter time to catheter removal (p = 0.023). Patients were matched based on levels fused, amongst patients with <12 levels fused, MIS patients had significantly lower total morphine consumption (p = 0.007), significantly shorter time to catheter removal (p = 0.023), but similar pain scores at activity (p = 0.874). In patients with ≥ 12 levels fused, MIS patients had significantly lower total morphine consumption (p < 0.001) and lower maximum pain scores at activity (p = 0.007) but similar time to catheter removal (p = 0.428).

Conclusion
This is the first study to objectively analyze pain measures between MIS and PSF patients. Patients seem to benefit from MIS outside the realm of operative care exclusively, but rather they consume less morphine, and have overall better pain scores.

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MIS approach was found to reduce overall morphine consumption, overall better pain scores, and operative care.

100. MACHINE LEARNING MODEL FOR PREDICTION OF EARLY RECURRENT DISC HERNIATION AFTER ENDOSCOPIC LUMBAR DISCECTOMY

Junseok Bae, MD

Summary

The authors developed machine learning model to predict recurrence after endoscopic lumbar discectomy. After training, validation and adjustment, final model performed 98.7% accuracy and 92.3% F1 score with AUC value of 0.993. It is possible to predict early recurrence with various hyperparameters of patients, which is helpful for preoperative consultation and postoperative care to prevent early recurrence after surgery.

Hypothesis

It is possible to predict early recurrence after endoscopic lumbar discectomy with machine learning model.

Design

Retrospective review

Introduction

Various demographic, radiological, and surgical factors are related to early recurrence (<3mo after surgery) after endoscopic lumbar discectomy (ELD). Individualized prediction of risk is important in preoperative surgical decision making and postoperative care. The aim of this study is to train and validate machine learning (ML) models to predict of early recurrence after ELD.

Methods

One thousand consecutive patients who underwent ELD at a single spine center between 2014 and 2018 were retrospectively reviewed. Based on the EMR data and radiological data, 63 items including demographic, radiological factors and surgical factors were evaluated. A model was developed through pre-processing using data mining-based feature engineering. Using the Cross-Validation method and the Grid Search method, a tree-based algorithm, SVM, and Ensemble algorithm (random forest and gradient boosting model) were applied to select the most appropriately trained model and build a prediction system.

Results

There were 54 symptomatic early reherniations diagnosed at mean 2.1±1.6 months after surgery. After training and optimization of hyperparameters, the random forest model was selected as the best model with 90% accuracy and 95% F1 score. The performance was improved by adjusting the model's threshold. Finally, a model was developed with 98.7% accuracy, 85.7% precision (positive predictive value), 100% recall, and 92.3% F1 score. The AUC value was 0.993.

Conclusion

The present study demonstrated that generating ML based predictive model of recurrent disc herniation after ELD is feasible. Although it is limited in single center and surgeon's experience should be considered, the result is useful in preoperative patient counselling and postoperative care to improve outcomes.

Take Home Message

The ability to predict the likelihood of recurrence with developled machine learning model could be useful in consultation and shared decision-making, and postoperative management.
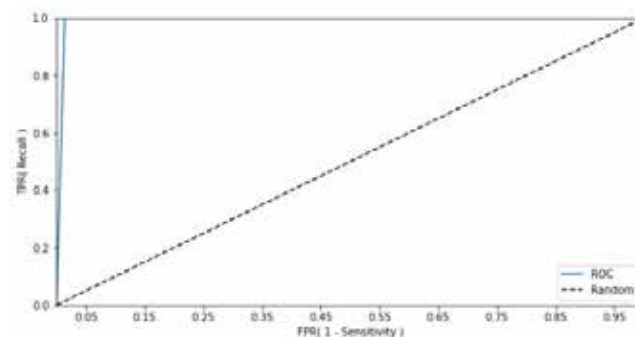
The AUC value of the developed random forest model showing was 0.99.

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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), Global Education Courses, a Global Outreach Program, the Research Education Outreach (REO) Fund which provides grants for spine deformity research, and development of patient education materials.

WEBSITE INFORMATION

For the latest information on SRS meetings, programs, activities, and membership please visit www.srs.org. The SRS Website Committee works to ensure that the website information is accurate, accessible, and tailored for target audiences. Site content is varied and frequently uses graphics to stimulate ideas and interest. Content categories include information for medical professionals, patients/public, and SRS members.

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