FINAL PROGRAM

SCOLIOSIS RESEARCH SOCIETY PRESENTS

IMAST 21ST INTERNATIONAL MEETING ON ADVANCED SPINE TECHNIQUES

Sponsored by the Scoliosis Research Society (SRS)

VALENCIA spain

JULY 16-19 2014

PALACIO DE CONGRESOS DE VALENCIA

http://www.srs.org/imast/2014/

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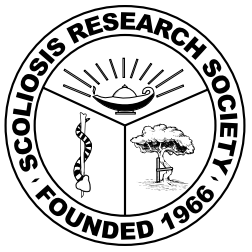
General Information



The Scoliosis Research Society gratefully acknowledges DePuy Synthes
for their overall support of IMAST.

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21st IMAST Venue

Palacio de Congresos de Valencia
Avda. Cortes Valencianas
nº 60 46015
Valencia (España)

Future Educational Events

49TH ANNUAL MEETING & COURSE

September 10-13, 2014
Anchorage, AK, USA

3RD SPINE DEFORMITY SOLUTIONS: A HANDS-ON COURSE

October 9-11, 2014
Burr Ridge, IL, USA

22ND INTERNATIONAL MEETING ON ADVANCED SPINE TECHNIQUES

July 8-11, 2015
Kuala Lumpur, Malaysia

50TH ANNUAL MEETING & COURSE

September 30-October 3, 2015
Minneapolis, MN, USA
Celebrating the Past, Present and Future of Spinal Deformity Research

Worldwide Conferences

NOVOSIBIRSK, RUSSIA

In Conjunction with the Russian Association of Spinal Surgeons
November 28-29, 2014

Welcome

Dear Participant,

I would like to personally welcome you to Valencia, one of the oldest and most historically diverse cities in Spain, for what promises to be an inspiring academic meeting. As a Society, we continue to make incredible strides in the field of spinal deformities and are excited to showcase these advancements at the 21st IMAST with our colleagues from around the world.

To continue providing a world-class meeting with the best educational value, we are excited to offer two new Special Symposia on Wednesday, July 16 which will run concurrently from 15:00-16:45. The symposia topics will be "From Disc Degeneration to Deformity" and "Return to Play after Spinal Surgery." After the symposia, we encourage delegates to take part in the Hands-On Workshops (HOWs) which will be followed by the Welcome Reception in the exhibit hall.

In addition to the new Wednesday sessions, the program this year will include the popular complication and debate series, instructional course lectures, roundtable sessions and four- and two-minute podium presentations. Our faculty this year includes many experts from the region along with experts from every discipline of spine. We encourage all delegates to engage in the interactive and innovative program we have planned.

Along with the exciting program, the city of Valencia is sure not to disappoint. Situated on the Mediterranean, it radiates a vibrant atmosphere created by the cultures of the many conquering people who have taken root during the city's extensive history. To accommodate for the late-night dining and excitement of the city we have shifted the program to start later in the morning around 9:00, so be sure to get out and enjoy the city while you are here!

I am honored to serve as your IMAST Chairman again this year. I want to thank those whose leadership and diligent efforts have created such a successful meeting, including Steven D. Glassman, MD; Kamal N. Ibrahim, MD, FRCS(C), MA; John P. Dormans, MD; David W. Polly, Jr., MD and the IMAST Committee.

With warmest personal regards,

Christopher I. Shaffrey, MD
IMAST Committee Chair

IMAST Mobile & Online App

A mobile and online app will be available to all delegates during the 21st IMAST. The app is designed to provide all the information about IMAST & Valencia in one convenient location and can be accessed from any smart phone or computer with an internet connection. To download the app visit http://eventmobi.com/imast2014 or scan the QR code below with your smart phone.

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

To learn more about the app or how to use the QR code, please refer to the insert in your registration bag or visit www.srs.org/imast/2014/.

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

http://eventmobi.com/imast2014

General Meeting Information

MEETING DESCRIPTION

IMAST gathers leading spine surgeons, innovative researchers, and the most advanced spine technologies for all areas of spine (cervical, thoracic and lumbar), most spinal conditions (degenerative, trauma, deformity and tumor), and a variety of treatment techniques. The IMAST program will include didactic presentations, panel discussions, papers and posters on current research, roundtable sessions, debates, complication series and instructional course lectures, all lead by an international and multidisciplinary faculty. IMAST is sponsored by the Scoliosis Research Society (SRS).

LEARNING OBJECTIVES

Upon completion of IMAST, participants should be able to:

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

TARGET AUDIENCE

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

ACCREDITATION STATEMENT

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

CREDIT DESIGNATION

The Scoiosis Research Society (SRS) designates this live activity for a maximum of 16.25 *AMA PRA Category 1 Credit(s)*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

DISCLOSURE OF CONFLICT OF INTEREST

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

FDA STATEMENT (UNITED STATES)

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

INSURANCE/LIABILITIES AND DISCLAIMER

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

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

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

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

General Meeting Information

CME INFORMATION

CME certificates will be available to pre-registered delegates upon the opening of the meeting at www.srs.org/imast/2014/. Delegates who registered on-site may access their certificates after August 1, 2014. Certificates are NOT available to delegates registering on-site until August 1.

Delegates should log on to the website listed above and enter their last name and the ID# listed at the top of the IMAST registration confirmation form. The system will then ask delegates to indicate which sessions they attended, and then will generate a PDF certificate which may be printed or saved to the delegate's computer. Session attendance is saved in the database, and certificates may be accessed again, in the event the certificate is lost or another copy is required.

Please note that certificates will not be mailed or emailed after the meeting. The online certificate program is the only source for this documentation. Please contact SRS at meetings@srs.org for any questions. SRS asks that all CME certificates be claimed no later than November 1, 2014.

New this Year** - Certificates of attendance will be emailed to each delegate upon checking in at the registration desk at the meeting. Delegates will not receive a paper copy of the certificate in their registration materials. If you would like a paper copy, please stop at the registration desk before the close of the meeting.

Evaluations will be available to all attendees at the commencement of the meeting. Evaluations are available at www.srs.org/imast/2014/.

Session Information

INSTRUCTIONAL COURSE LECTURES (ICLs)

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

DEBATES

The debates will continue this year with four (4) sessions featuring multiple debates per session. Expert faculty will be assigned to different treatment options available for specific conditions for each debate. Debate topics and faculty are listed in the Meeting Agenda, beginning on p. 37.

COMPLICATIONS SERIES

The complications series presents a variety of illustrative case presentations, demonstrating the most common and worst complications encountered, as well as strategies to prevent and manage them. Interaction between faculty and participants will focus on treatment options with an emphasis on reducing further morbidity and improving eventual outcomes. Complication topics and faculty are listed in the Meeting Agenda, beginning on p. 37.

TWO-MINUTE POINT PRESENTATIONS

Two-Minute Point Presentations will continue in the abstract portion of the program this year. These four (4) lightning rounds were selected from the abstracts submitted to the 2014 meetings. The sessions will follow a similar format to the traditional podium presentations, however, with a limited number of slides and time.

NEW! – SPECIAL SYMPOSIA

We encourage delegates to take part in the following afternoon activities on Wednesday, July 16.

Special Symposia – 15:00-16:45 (sessions run concurrently)
1A. From Disc Degeneration to Deformity
1B. Return to Play after Spinal Surgery

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

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

General Meeting Information

ATTIRE

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

E-POSTERS

There are nearly 100 E-Posters available for your review on the E-Poster kiosks inside the café located across from the registration desk. The E-Posters are also available on the CD-ROM included with your registration materials.

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

EXHIBITS & HANDS-ON WORKSHOPS

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

Each one-hour Hands-On Workshop (HOW) is supported and programmed by a single-supporting company and will feature presentations on topics and technologies selected by the corporate supporter. Breakfast, lunch, or cocktails and snacks will be served just outside the HOWs, as noted in the program. Please note that HOWs are non-CME sessions.

INTERNET ACCESS

Wireless Internet access is available throughout the meeting space of the Palacios de Congressos de Valencia (PCV)

To log on select…

Network = IMAST2014
Password = spine2014

Note: Internet cookies must be enabled to connect

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

INTERNET KIOSKS

Delegates without laptops may access complimentary Internet kiosks inside the café across from the registration area.

Internet Kiosks are supported, in part, by a grant from K2M.

LANGUAGE

Presentations and course materials will be provided in English.

NO SMOKING POLICY

Smoking is not permitted during any IMAST activity or event.

PRESENTATION UPLOAD AREA

LOCATION: AUDITORIUM 2, SPEAKER READY ROOM, MAIN LEVEL

Presenters may upload their PowerPoint presentations in the Speaker Ready Room located at the entrance of Auditorium 2 on the main level of the convention center.

Hours:

Wednesday, July 16	14:00-21:00 (during the Welcome Reception)
Thursday, July 17	7:45-18:30
Friday, July 18	8:00-18:00
Saturday, July 19	8:30-13:00

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

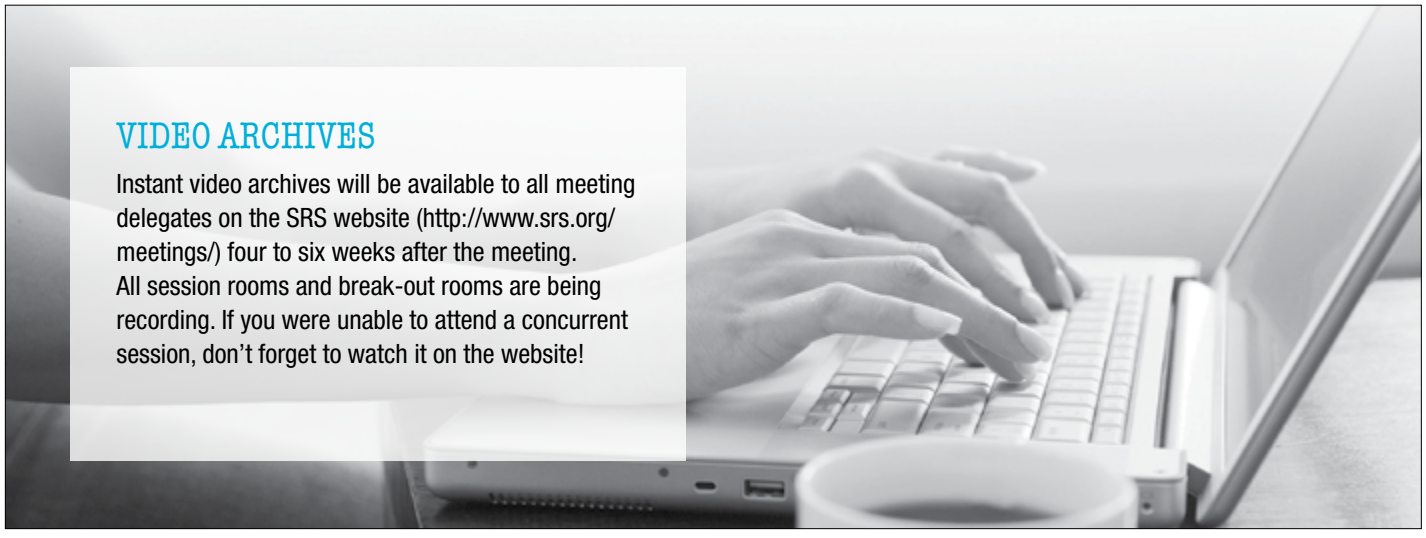
REGISTRATION DESK HOURS

LOCATION: MAIN LEVEL LOBBY

Wednesday, July 16	14:00-21:00
Thursday, July 17	7:45-18:30
Friday, July 18	8:00-18:30
Saturday, July 19	8:30-13:00

VIDEO RECORDING PROHIBITED

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



VIDEO ARCHIVES

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

Social Events

WELCOME RECEPTION

All registered delegates and registered guests are invited to pick up their registration materials and to attend the IMAST Welcome Reception on Wednesday, July 16 from 19:00-21:00. The reception will be hosted in the Exhibit Hall in the Main Foyer of the Palacio de Congresos de Valencia, where beverages and light hors d' oeuvres will be served. Registered guests may purchase a Welcome Reception ticket for $20 USD at the time of registration. Dress for the Welcome Reception is business casual.

We encourage delegates to take part in the following afternoon activities before the Welcome Reception on Wednesday, July 16.

15:00 – 16:45 **NEW- Special Symposia**
1A. From Disc Degeneration to Deformity
1B. Return to Play after Spinal Surgery

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

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

COURSE RECEPTION

IMAST delegates and registered guests are invited to take part in a closing reception at Masia de Xamandreu on Friday, July 18 from 20:00 – 23:00. Join us in this spacious villa that hosts many beautiful gardens and orange orchards for an evening of fine Spanish wine and delicious cuisine from the area, including Paella and a traditional dish from Valencia. Tickets are $25 USD each for registered delegates and $30 USD each for registered guests and must be purchased at the time of registration. A limited number of tickets may be available on-site, but organizers strongly encourage delegates to purchase tickets in advance. Business casual is appropriate for the Course Reception but please keep in mind a majority of the event will be held outside.

New this Year! - Prospective members and new Active and Candidate members are invited to attend a networking session prior to the start of the Course Reception at Masia de Xamandreu. Buses will depart the Palacio de Congresos de Valencia at 19:30 for those that would like to participate and admission is included with your Course Reception ticket which can be purchased for $25 USD.

Do not miss this opportunity to learn more about the SRS and network with members of the Board of Directors, Fellowship Committee and other leaders from the Society!

OPTIONAL TOURS

SRS is proud to be partnering with Dekon Congress & Tourism to offer the below optional tours for the 21st IMAST. Registration for all tours will be handled through Dekon. Please note SRS is unable to assist with tour reservations.

To check the availability of a tour on-site, please visit Dekon's registration desk located next to the registration desk in the main lobby.

Tours	Available Days	Time	Duration	Price per Person
Guided Tour around the Historic Centre	Monday to Saturday	10:30	2 hours 15 minutes	17,00 €
Historic Centre Tour- 1	Monday to Saturday	18:00	2 hours	12,00 €
Historic Centre Tour- 2	Tuesday to Sunday	11:00	2 hours	15,00 €
Historic Centre and Tapas Tour- 1	Saturday	18:00	2 hours 15 minutes	18,00 €
Historic Centre and Tapas Tour- 2	Monday to Saturday	20:00	2 hours	39,00 €
Historic Centre + Paella D.O.	Tuesday to Saturday	10:30	2 hours 15 minutes	44,00 €
Central Market Culinary Tour	Monday to Saturday	10:00	2 hours	29,00 €

Boat Tours	Available Days	Price per Person
A Day on the Sea	Monday to Sunday	39,00 €
Valencia Sunset	Monday to Sunday	20,00 €

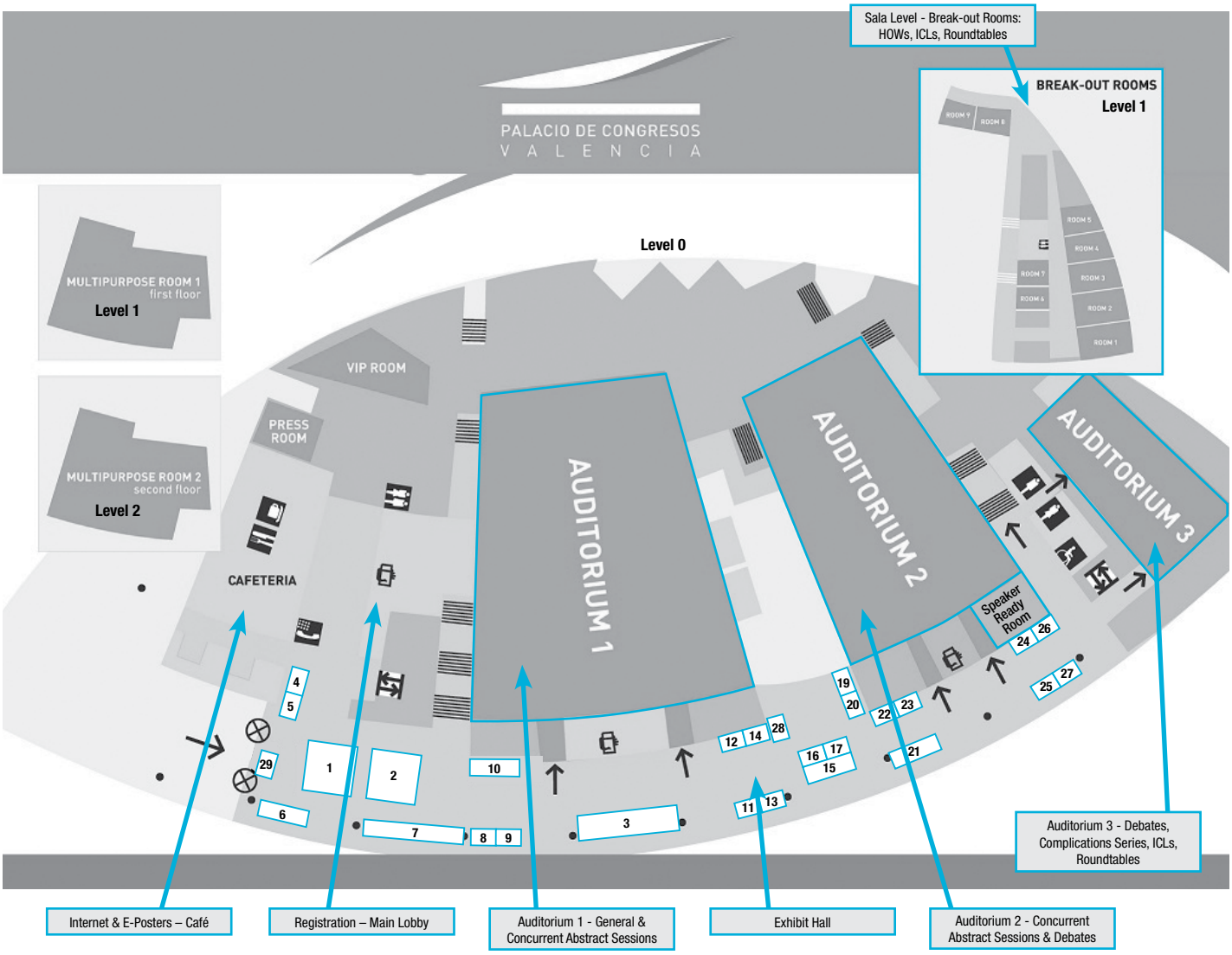
Entrance Tickets	Available Days	Price per Person
Bioparc Valencia	Monday to Sunday	23,80 €
City of Arts and Sciences Entrance to Hemisferic	Monday to Sunday	8,80 €
City of Arts and Sciences Entrance to Science Museum	Monday to Sunday	8,00 €
City of Arts and Sciences Entrance to Oceanografic	Monday to Sunday	27,90 €
City of Arts and Sciences Entrance to Hemisferic + Museum + Oceanografic	Monday to Sunday	36,25 €

Meeting Overview

	Tuesday, July 15	Wednesday, July 16	Thursday, July 17	Friday, July 18	Saturday, July 19
Morning		**8:00-12:00** Exhibit Setup/ Exhibitor Registration **8:00-14:00** Board of Directors Meeting	***7:45-8:45** Hands-On Workshops with Breakfast **7:45-18:30** Delegate Registration Open **8:30-9:00** Breakfast & Exhibit Viewing **9:00-10:30** General Session: Whitecloud Clinical Award Nominees & Presidential Address **10:30-10:55** Refreshment Break & Exhibit Viewing **10:55-12:10** Concurrent Sessions 2A-C: Abstract Sessions & Debates Series	***8:00-9:00** Hands-On Workshops with Breakfast **8:00-18:30** Delegate Registration Open **8:30-9:15** Breakfast & Exhibit Viewing **9:15-10:15** Concurrent Sessions 6A-C: Abstract Sessions & Debate Series **10:15-10:35** Refreshment Break & Exhibit Viewing **10:35-12:00** Concurrent Sessions 7A-C: Abstract Sessions & Complication Series	**8:30-13:00** Delegate Registration Open **9:15-10:15** Concurrent ICLs 11A-C **10:15-10:30** Refreshment Break **10:30-11:30** Concurrent Sessions 12A-B: Debate Series & Two-Minute Point Presentations **11:30-11:45** Walking Break
Afternoon	**14:00-18:00** Exhibit Setup	**12:00-14:00** Exhibit Setup **14:00-21:00** Delegate Registration Open **15:00-16:45** **NEW- Special Symposia** 1A: From Disc Degeneration to Deformity 1B: Return to Play after Spinal Surgery 16:45-17:00 Walking Break	***12:25-13:25** Lunch Exhibit Viewing Hands-On Workshops **13:40-14:40** Concurrent Sessions 3A-D: ICLs & Two-Minute Point Presentations **14:40-14:55** Refreshment Break & Exhibit Viewing **14:55-15:50** Concurrent Sessions 4A-C: Abstract Sessions & Complication Series **15:50-16:05** Walking Break & Exhibit Viewing **16:05-17:05** Concurrent Sessions 5A-D: Roundtable & Abstract Sessions	***12:15-13:15** Lunch Exhibit Viewing Hands-On Workshops **13:30-14:30** Concurrent Sessions 8A-E: Roundtable Sessions & Two-Minute Point Presentations **14:30-14:45** Walking Break **14:45-15:45** Concurrent Sessions 9A-D: Abstract Sessions & Debate Series **15:45-16:00** Refreshment Break & Exhibit Viewing **16:00-17:00** Concurrent Sessions 10A-E: ICLs & Two-Minute Point Presentations	**11:45-13:00** General Session 13: Complication Series **13:00** Adjourn
Evening		***17:00-19:00** Hands-On Workshops with Beverages & Snacks ***19:00-21:00** Welcome Reception in Exhibit Hall	**17:05-17:30** Walking Break ***17:30-18:30** Hands-On Workshops with Beverages and Snacks **Free Evening**	**17:00-17:30** Walking Break ***17:30-18:30** Hands-On Workshops with Beverages & Snacks ***20:00-23:00** Course Reception	

**Denotes Non-CME Session*

Palacios de Congresos de Valencia Floorplans



Author Disclosures

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

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(e) Advisory Board or Panel **(f)** Salary, Contractual Services **(g)** Other Financial Or Material Support (royalties, patents, etc.)

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Meeting Agenda

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

Medtronic

14:00 – 21:00 Registration Open
MAIN LEVEL LOBBY

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

A. From Disc Degeneration to Deformity

ROOM: AUDITORIUM 2
MODERATORS: *D. Kojo Hamilton, MD and Han Jo Kim, MD*

15:00 – 15:15 **How Does Disc Degeneration Result in Adult Degenerative Deformity?**
Jeffrey C. Wang, MD

15:15 – 15:30 **Radiographic Analysis across the Spectrum of Adult Degenerative Deformity**
Frank J. Schwab, MD

15:30 – 15:45 **Discussion**

15:45 – 16:00 **When is Decompression versus Decompression and Limited Fusion Appropriate in the Setting of Adult Degenerative Deformity?**
John R. Dimar, II, MD

16:00 – 16:15 **Role of Minimally Invasive Surgery for Adult Degenerative Deformity**
Gregory M. Mundis, Jr., MD

16:15 – 16:30 **What is the Role for Ponte, PSO and VCR for Adult Degenerative Deformity?**
Ferran Pellisé Urquiza, MD, PhD

16:30 – 16:45 **Discussion**

B. Return to Play after Spinal Surgery

ROOM: AUDITORIUM 3
MODERATORS: *David W. Polly, Jr., MD and Christopher I. Shaffrey, MD*

15:00 – 15:15 **Cervical Disc Herniation in the Professional Athlete**
Todd J. Albert, MD

15:15 – 15:30 **Concussion during Sports Injury: When Can you Return to Play?**
Michael G. Fehlings, MD, PhD, FRCSC, FACS

15:30 – 15:45 **Discussion**

15:45 – 16:00 **Role for Surgery and Return to Play after Transient Quadriparesis**
K. Daniel Riew, MD

16:00 – 16:15 **Bracing, Pars Repair and Fusion for Spondylolysis: Return to Play**
Hubert Labelle, MD

16:15 – 16:30 **Return to Sports after Fusion for AIS**
Lawrence G. Lenke, MD

16:30 – 16:45 **Discussion**

16:45 – 17:00 Walking Break

17:00 – 19:00 *Hands-On Workshops
(See "Exhibits and Hands-On Workshops" (HOW) section on page 213 for more information.)

19:00 – 21:00 Welcome Reception
EXHIBIT HALL, MAIN LEVEL FOYER

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

7:45 – 18:30 Registration Open
MAIN LEVEL LOBBY

7:45 – 8:45 *Hands-On Workshops with Breakfast
(See "Exhibits and Hands-On Workshops" (HOW) section on page 213 for more information.)

8:30 – 18:30 Exhibits Open
MAIN LEVEL FOYER

8:30 – 9:00 Exhibit Viewing & Breakfast
MAIN LEVEL FOYER

9:00 – 10:30 Session 1: General Session and Whitecloud Award Nominees
ROOM: AUDITORIUM 1
MODERATORS: *Steven D. Glassman, MD and Enrique Izquierdo, MD*
The general session is supported, in part, by a grant from Medtronic.

9:00 – 9:05 **Welcome Address**
Christopher I. Shaffrey, MD
IMAST Committee Chair

9:05 – 9:09 **†Paper #1: Morbidity and Mortality of Complex Spine Surgery: A Prospective Cohort Study in 679 Patients Validating the SAVES System in a European Population**
Sven Karstensen, BSc; Tanvir Bari; Martin Gehrchen, MD, PhD; John Street, MD, PhD; Benny Dahl, MD, PhD, DMSci

9:09 – 9:13 **†Paper #2: Should our Elderly Spinal Deformity Patients Have the Same Targets for Correction and is there an Optimal Alignment Target that Results in Less PJK?**
Themistocles S. Protopsaltis, MD; Stephen P. Maier, BA; Justin S. Smith, MD, PhD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Thomas J. Errico; Shay Bess, MD; Eric Klineberg, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

9:13 – 9:17 **†Paper #3: Clinical Results and Functional Outcome of Lumbo-Sacral Three-Column Osteotomies in Adult Spinal Deformity Patients**
Haruki Funao, MD; Floreana A. Naef; Jaykar R. Panchmatia, MA, MPH, MB, BChir, MRCS, FRCS; David Li, MS; Richard L. Skolasky, ScD; Khaled Kebaish, MD; Jaysson T. Brooks, MD

9:17 – 9:24 **Discussion**

9:24 – 9:28 **†Paper #4: Adolescent Idiopathic Scoliosis Patients are at Increased Risk for Pulmonary Hypertension which Reverses after Scoliosis Surgery**
Vishal Sarwahi, MD; Rachel E. Borlack, BS; Aviva G. Dworkin, BS; Dan Wang, MS; Sarika Kalantre, MD

9:28 – 9:32 **†Paper #5: The Motion Sparing Benefits of Selective Thoracic Fusion for Adolescent Idiopathic Scoliosis**
Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Maty Petcharaporn, BS; Suken A. Shah, MD; Amer F. Samdani, MD; Randal R. Betz, MD; Baron S. Lonner, MD; Firoz Miyanji, MD, FRCSC; Peter O. Newton, MD
This presentation is the result of a project funded, in part, by an SRS Research Grant

9:32 – 9:36 **†Paper #6: A Prospective Comparison of Wiltse versus Midline Approaches in Degenerative Conditions of the Lumbar Spine**
R. Andrew Glennie, MD, FRCSC; Juliet Batke, BSc; Charles G. Fisher, MD, MHSc, FRCSC; Michael Boyd, MD; John Street, MD, PhD

9:36 – 9:43 **Discussion**

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

9:43 – 9:47 †Paper #7: Relative Benefit of TLIF versus PSF at Five-Year Follow Up Stratified by Diagnostic Indication
Calvin C. Kuo, MD; Leah Y. Carreon, MD, MSc; Benjamin A. Schell; Steven D. Glassman, MD

9:47 – 9:51 †Paper #8: Clinical Outcomes of Minimally Invasive versus Open Single-Level TLIF: A Propensity—Matched Cohort Study
Mladen Djurasovic, MD; David P. Rouben, MD; Steven D. Glassman, MD; Michael T. Casnellie, MD; Leah Y. Carreon, MD, MSc

9:51 – 9:55 †Paper #9: Increased Incidence of Pseudarthrosis after Unilateral Instrumented Transforaminal Lumbar Interbody Fusion in Patients with Lumbar Spondylosis
Branko Skovrlj, MD; Yakov Gologorsky, MD; Jeremy Steinberger, MD; Max Moore; Frank M. Moore, MD; Alfred Steinberger; Marc Arginteanu

9:55 – 10:02 Discussion

10:02 – 10:07 Introduction of SRS President
John P. Dormans, MD, SRS President-Elect

10:07 – 10:22 Keynote Address
Steven D. Glassman, MD, SRS President

10:22 – 10:26 Preview of 49th SRS Annual Meeting & Course – Anchorage, Alaska, USA
Steven D. Glassman, MD

10:26 – 10:30 Preview of 22nd IMAST– Kuala Lumpur, Malyasia
Local Hosts: Mun Keong Kwan, MBBS, MS(Ortho); Harwant Singh, MD, PhD

10:30 – 10:55 Refreshment Break & Exhibit Viewing

MAIN LEVEL FOYER

The refreshment break is supported, in part, by a grant from NuVasive.

10:55 – 12:10 Concurrent Sessions 2A-C: Abstract Sessions & Debates Series

2A. Whitecloud Basic Research Award Nominees & Top Scoring Abstracts

ROOM: AUDITORIUM 1

MODERATORS: *Frank J. Schwab, MD and Michael J. Yaszemski, MD, PhD*

10:55 – 10:59 *Paper #10: Two-Year Results of a Multicenter, Blinded, Pilot Study of a Novel Peptide in Promoting Lumbar Spine Fusion
Zeeshan Sardar, MD, CM; Peter Jarzem, MD

10:59 – 11:03 *Paper #11: Role of Implant Costs in the Long-Term Cost Effectiveness of Surgical Treatment of Adult Spinal Deformity (ASD)
Chessie Robinson, MA; Ian McCarthy, PhD; Michael F. O'Brien, MD; Munish C. Gupta, MD; Christopher P. Ames, MD; Virginie Lafage, PhD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Khaled Kebaish, MD; Justin S. Smith, MD, PhD; Richard Hostin, MD; International Spine Study Group

11:03 – 11:07 *Paper #12: Implant Materials Generate Different Peri-Implant Inflammatory Factors: PEEK Promotes Fibrosis and Micro-Textured Titanium Promotes Osteogenic Factors
Rene Olivares-Navarrete, DDS, PhD; Sharon L. Hyzy, MS; Paul J. Slosar, MD; Barbara D. Boyan, PhD; Zvi Schwartz, PhD

11:07 – 11:13 Discussion

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

11:13 – 11:17 ***Paper #13: Incremental Cost Effectiveness of Adult Spinal Deformity Surgery by Classification of Deformity**
Ian McCarthy, PhD; Michael F. O'Brien, MD; Chessie Robinson, MA; Munish C. Gupta, MD; Christopher P. Ames, MD; Virginie Lafage, PhD; Robert A. Hart, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Khaled Kebaish, MD; Justin S. Smith, MD, PhD; Eric Klineberg, MD; Richard Hostin, MD; International Spine Study Group

11:17 – 11:21 ***Paper #14: Ultralow Dose Radiation 3D Intraoperative Imaging: How Low Can We Go? An O-Arm, CT Scan, Cadaveric Study**
Monica M. Payares, MD; Vishal Sarwahi, MD; Adam L. Wollowick, MD; Terry D. Amaral, MD

11:21 – 11:25 ***Paper #15: Biological Endophenotypes Classification in AIS Patients: Association with Non-Rigid Brace Outcomes**
Julie Joncas, BSc; Marie Beausejour; Alain Moreau, PhD; Ginette Larouche; Jean-Marc Mac-Thiong, MD, PhD; Hubert Labelle, MD; Marjolaine Roy-Beaudry, MSc; Stefan Parent, MD, PhD

11:25 – 11:32 **Discussion**

11:32 – 11:36 **Paper #16: Efficacy and Safety of Riluzole in Acute Spinal Cord Injury (SCI): Rationale and Design of AOSpine Phase III Multicenter Double-Blinded Randomized Controlled Trial (RISCIS)**
Michael G. Fehlings, MD, PhD; Branko Kopjar, MD, PhD, MS; Robert Grossman

11:36 – 11:40 **Paper #17: The Minimum Clinically Important Difference (MCID) in SRS-22R Appearance, Activity and Pain Domains after Surgical Treatment of Adult Spinal Deformity**
Charles H. Crawford, MD; Steven D. Glassman, MD; Keith H. Bridwell, MD; Sigurd H. Berven, MD; Leah Y. Carreon, MD, MSc

11:40 – 11:44 **Paper #18: Post-Operative Spine Dressing Changes are Unnecessary: Our 15-Year Experience with an Institutional Dressing Change Protocol**
Lance K. Mitsunaga, MD; Sukhraj Bains; Nirmal Singh, D.ABNM; Kamran Majid, MD; Ravi S. Bains, MD

11:44 – 11:51 **Discussion**

11:51 – 11:55 **Paper #19: Clinical Significance of Direct Vertebral Rotation (DVR) for Adolescent Idiopathic Scoliosis: An Analysis of Intraoperative CT Scans**
Shoji Seki, MD, PhD; Yoshiharu Kawaguchi, MD, PhD; Masato Nakano, MD, PhD; Hiroto Makino, MD; Hayato Mine; Tomoatsu Kimura, MD, PhD

11:55 – 11:59 **Paper #20: Probing, Tapping, Toggling: Are we Inserting Pedicle Screws Correctly?**
Robert S. Lee, BSc, MBBS, FRCS (Tr&Orth); Addisu Mesfin, MD; Vishal Prasad, FRCS (Tr&Orth); Julie L. Reigrut, MS; John A. Schmidt, PhD

11:59 – 12:03 **Paper #21: Autologous Iliac Bone Graft with Anterior Plating is Advantageous Over the Stand-Alone Cage for Restoration of Segmental Kyphosis in Single-Level Cervical Disc Disease**
Seung Heon Yang; Chun Kee Chung, MD, PhD; Chi Heon Kim, MD, PhD; Seil Sohn, MD

12:03 – 12:10 **Discussion**

2B. Early Onset Scoliosis Abstracts

ROOM: AUDITORIUM 2

MODERATORS: *Laurel C. Blakemore, MD and Francisco Javier Sanchez Perez-Grueso, MD*

10:55 – 10:59 **Paper #22: Case-Matched Comparison of Spinal Fusion versus Growing Rods for Progressive Idiopathic Scoliosis in Skeletally Immature Patients**
Jeff Pawelek; Burt Yaszay, MD; Stacie Nguyen, MPH; Peter O. Newton, MD; Gregory M. Mundis, MD; Behrooz A. Akbarnia, MD; Harms Study Group; Growing Spine Study Group

10:59 – 11:03 **Paper #23: Shilla Growth Guidance Graduates**
Kwan J. Park, MD; Richard E. McCarthy, MD; Frances L. McCullough, MNSc

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

11:03 – 11:07	**Paper #24: Early Results of Growth Modulation Surgery for Thoracic Scoliosis in Skeletally Immature Patients using a Braided UHMWPE Tether Implanted by a Thoracoscopic-Assisted Technique** *John Nathaniel M. Ruiz, MD, MRCS; Gabriel Liu, MSc FRCSED(Orth); Hee-Kit Wong, MD*
11:07 – 11:13	**Discussion**
11:13 – 11:17	**Paper #25: Is Neuromonitoring Necessary for VEPTR Expansion and Implant Exchanges in Early Onset Scoliosis?** *John T. Smith, MD; Man Hung, PhD*
11:17 – 11:21	**Paper #26: Deep Surgical Site Infection Rates for VEPTR Patients at Eight Major Centers: A Six-Year Retrospective Cohort Analysis** *Sumeet Garg, MD; Micaela Cyr; Michael Glotzbecker, MD; Patrick M. Carry, BA; John T. Smith, MD; Jeffrey R. Sawyer, MD; Joshua M. Pahys, MD; Scott J. Luhmann, MD; John M. Flynn, MD; Ron El-Hawary, MD, MSc, FRCSC; Michael G. Vitale, MD, MPH; Children's Spine Study Group*
11:21 – 11:25	**Paper #27: Metallosis is a Complication of Growth Guidance and Sliding Devices for Early Onset Scoliosis** *Elena Lukina; Alaksandr Laka, PhD; Mikhail Kollerov; Mykhamad Sampiev, PhD; Peter Mason, PhD; Paul G. Wagstaff, BSc MSc Hon DSc; Wai Weng Yoon, BSc (Hons), MBBS, MRCS, FRCS (Tr&Orth); Hilali H. Noordeen, FRCS; Gordon W. Blunn, PhD*
11:25 – 11:32	**Discussion**
11:32 – 11:36	**Paper #28: Is There an Optimal Time to Distract Dual Growing Rods?** *Michael D. Paloski, DO; Paul D. Sponseller, MD; Behrooz A. Akbarnia, MD; George H. Thompson, MD; David L. Skaggs, MD, MMM; Jeff Pawelek; Phuong T. Nguyen, MA; Susan M. Odum, PhD; Growing Spine Study Group*
11:36 – 11:40	**Paper #29: The Use of Ultrasound in Magnetic Growth Rod Lengthening Measurement: A Prospective Study in Patients with a Minimum Follow Up of Two Years** *Wai Weng Yoon, BSc (Hons), MBBS, MRCS, FRCS (Tr&Orth); Angela C. Chang, MBBS; Philippa A. Tyler, MBBS, BSc, MRCS, FRCR; Sajid Butt; Sameer Raniga, FRCR, MD, DNB; Hilali H. Noordeen, FRCS*
11:40 – 11:44	**Paper #30: Can a "Final Fusion" Procedure be Avoided in Early Onset Scoliosis Patients who Reach Skeletal Maturity after Growing-Rod Treatment?** *Amit Jain, MD; Paul D. Sponseller, MD; Urvij Modhia, MBBS, MD; Suken A. Shah, MD; George H. Thompson, MD; Jeff Pawelek; Behrooz A. Akbarnia, MD; Growing Spine Study Group*
11:44 – 11:51	**Discussion**
11:51 – 11:55	**Paper #31: The Tethering Effect of a Braided UHMWPE Device Implanted by a Thoracoscopic-Assisted Technique in Skeletally Immature Patients with Thoracic Idiopathic Scoliosis** *Hee-Kit Wong, MD; John Nathaniel M. Ruiz, MD, MRCS; Gabriel Liu, MSc. FRCSED(Orth)*
11:55 – 11:59	**Paper #32: The Effectiveness of Pre-Operative Halo-Gravity Traction (HGT) in Early Onset Scoliosis (EOS) Severe Kyphoscoliosis: Clinical and Radiographic Study** *Augusto. A. Covaro, MD; Norberto Ventura, MD, PhD; Ana M. Ey Batlle, MD; Imma Vilalta, MD; Melisa Stitzman Wengrowicz, MD; Juan Mazzeo; Agustin Barrionuevo*
11:59 – 12:03	**Paper #33: Sublaminar Wires in Growing Constructs for EOS with Severe Curves: Effective in Diminishing Proximal Anchor Pullout** *Anna M. McClung, BSN, RN; Charles E. Johnston, MD; Brandon A. Ramo, MD; Daniel J. Sucato, MD, MS; Growing Spine Study Group*
12:03 – 12:10	**Discussion**

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

2C. Debate Series #1

ROOM: AUDITORIUM 3

MODERATORS: *Benny T. Dahl, MD, PhD, DMSci and Regis W. Haid, Jr., MD*

10:55 – 11:32 **Debate 1: Cervical Spinal Cord Compression with T2 Signal Change: Observe or Operate?**
Observe: Todd J. Albert, MD
Operate: Michael J. Fehlings, MD, PhD, FRCSC, FACS

11:32 – 12:10 **Debate 2: Pathological Loss of Lumbar Lordosis with Positive Sagittal Imbalance: Minimally Invasive versus Open Treatment**
Minimally Invasive: Juan S. Uribe, MD
Open Treatment: Sigurd H. Berven, MD

12:10 – 12:25 Walking Break

12:25 – 13:25 Exhibit Viewing & Lunch

MAIN LEVEL FOYER

*Hands-On Workshops with Lunch – Sala Level (Level 1)

(See "Exhibits and Hands-On Workshops" section on page 213 for more information.)

13:25 – 13:40 Walking Break

13:40 – 14:40 Concurrent Sessions 3A-D: Instructional Course Lectures & Two-Minute Point Presentations

3A. Adult Deformity: Clinical & Radiographic Evaluation Instructional Course Lecture

ROOM: AUDITORIUM 1

MODERATORS: *Christopher I. Shaffrey, MD and Mark Weidenbaum, MD*

13:40 – 13:50 **Basics of Radiographic Assessment of Spino-Pelvic Alignment**
Justin S. Smith, MD, PhD

13:50 – 14:00 **The SRS-Schwab Classification**
Frank J. Schwab, MD

14:00 – 14:10 **Assessment of Spinal Flexibility in the Pre-Operative Planning for Adult Spinal Deformity Surgery**
Benny T. Dahl, MD, PhD, DMSci

14:10 – 14:20 **The Role of Radiographic and Clinical Parameters in Determining Whether to Stop Instrumentation in the Lower Thoracic versus the Upper Thoracic Spine**
Ferran Pellisé Urquiza, MD, PhD

14:20 – 14:40 **Discussion**

3B. Management of Primary Spine Tumors Instructional Course Lecture

ROOM: SALA 1&2

MODERATORS: *Daniel M. Sciubba, MD and D. Kojo Hamilton, MD*

13:40 – 13:50 **How Classification Impacts Surgical Decision Making for Spine Tumor Resection**
Christopher P. Ames, MD

13:50 – 14:00 **Surgical Resection Techniques for the Mobile Spine**
Peter S. Rose, MD

14:00 – 14:10 **Decision Making for Sacretomy versus Partial Sacretomy**
Michael J. Yaszemski, MD, PhD

14:10 – 14:20 **Reconstruction following Primary Spine Tumor Resection**
Antonio Martin, MD

14:20 – 14:40 **Discussion**

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

3C. AIS: Clinical & Radiographic Evaluation Instructional Course Lecture

ROOM: AUDITORIUM 2

MODERATORS: *Peter O. Newton, MD and Francisco Javier Sanchez Perez-Grueso, MD*

13:40 – 13:50 **Role of 3D Classification in AIS**
Hubert Labelle, MD

13:50 – 14:00 **How the Lenke Classification Typically Guides Fusion Levels**
Teresa Bas, MD, PhD

14:00 – 14:10 **When Can Stopping Short Predictably Give Good Results in AIS?**
Suken A. Shah, MD

14:10 – 14:20 **Evaluation and Management of Atypical Curve Patterns**
Amer F. Samdani, MD

14:20 – 14:40 **Discussion**

3D. Two-Minute Point Presentations

ROOM: AUDITORIUM 3

MODERATORS: *Shay Bess, MD and Praveen V. Mummaneni, MD*

13:40 – 13:42 **Paper #34: Peak Timing and Associated Risk Factors for Specific Complications following Adult Spinal Deformity (ASD) are Identifiable: A Guide for Surgeons and Patients**
Shay Bess, MD; Breton Line, BSME; Virginie Lafage, PhD; Christopher P. Ames, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Behrooz A. Akbarnia, MD; Eric Klineberg, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group

13:42 – 13:44 **Paper #35: Is Age Associated With Increased Complications Rates in Adult Scoliosis Surgery? A Review of 5,591 Cases from the Scoliosis Research Society Database 2004-2007**
Branko Skovrlj, MD; Samuel K. Cho, MD; Motasem Al Maaieh; John Caridi, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Yongjung J. Kim, MD

13:44 – 13:46 **Paper #36: Predictors of Revision Surgery in Adult Spinal Deformity and Impact on Patient-Reported Outcomes and Satisfaction Two-Year Follow Up**
Peter G. Passias, MD; Sun Yang, BA; Alex Soroceanu, MD, CM, MPH, FRCSC; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Shay Bess, MD; Eric Klineberg, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

13:46 – 13:48 **Paper #37: Three-Column Osteotomies in Elderly Patients: Is it Worth it?**
Vincent Challier, MD; Shian Liu, BS; Christopher P. Ames, MD; Khaled Kebaish, MD; Ibrahim Obeid; Richard Hostin, MD; Eric Klineberg, MD; Oheneba Boachie-Adjei, MD; Justin S. Smith, MD, PhD; Behrooz A. Akbarnia, MD; Kristina Bianco, BA; Themistocles S. Protopsaltis, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

13:48 – 13:50 **Paper #38: Characterizing Complications of Anterior Column Realignment (ACR) for Adult Sagittal Deformity**
Ali Bagheri, MD; Gregory M. Mundis, MD; Stacie Nguyen, MPH; Ramin Bagheri, MD; Robert K. Eastlack, MD; Drew Brown, MD; Navid R. Arandi; Behrooz A. Akbarnia, MD

13:50 – 13:52 **Paper #39: Does Tranexamic Acid Effectively Reduce Bleeding after Single Level Spinal Fusion Surgery in Patients who are Taking Low Dose Aspirin?**
Kyu-Jung Cho, MD; Young-Tae Kim

13:52 – 14:00 **Discussion**

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

14:00 – 14:02 **Paper #40: Risk Factors Associated with 30-Day Readmissions after Instrumented Spine Surgery in 14,941 Patients**
Kern H. Guppy, MD, PhD; Paul Akins, MD, PhD; Jessica Harris, MS, RD; Julie L. Alvarez, MPH; Yuexin Chen, BS; Elizabeth Paxton; Johannes A. Bernbeck, MD

14:02 – 14:04 **Paper #41: Revisions and Junctional Failures of Short versus Long Fusions for Adult Spinal Deformity Treated by Three-Column Osteotomy**
Shian Liu, BS; Emmanuelle Ferrero; Christopher P. Ames, MD; Khaled Kebaish, MD; Ibrahim Obeid; Richard Hostin, MD; Eric Klineberg, MD; Oheneba Boachie-Adjei, MD; Justin S. Smith, MD, PhD; Gregory M. Mundis, MD; Stephen P. Maier, BA; Themistocles S. Protopsaltis, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

14:04 – 14:06 **Paper #42: Selection of Lower Instrumented Vertebra in Treating Lenke Type 2A Adolescent Idiopathic Scoliosis**
Kai Cao, MD, PhD; Kota Watanabe; Noriaki Kawakami, MD, DMSc; Taichi Tsuji, MD; Ikuho Yonezawa, MD, PhD; Masafumi Machida, MD; Mitsuru Yagi, MD, PhD; Shinjiro Kaneko, MD, PhD; Naobumi Hosogane; Yoshiaki Toyama; Morio Matsumoto, MD

14:06 – 14:08 **Paper #43: Screw Placement at the Apex Alters Surgical Outcomes of Moderate Lenke 1 Adolescent Idiopathic Scoliosis**
Xin Zheng; Yong Qiu; Weijun Wang; Bangping Qian, MD; Zhu Ze-Zhang

14:08 – 14:10 **Paper #44: Characterization of Significant Neurophysiologic Intraoperative Monitoring Events in Severe Spinal Deformity Surgery**
Daniel Zuchelli, BS; Benjamin T. Bjerke-Kroll, MD, MS; Venu M. Nemani, MD, PhD; Ronald G. Emerson, MD; Jennifer Ayamga, Mphil; Oheneba Boachie-Adjei, MD; FOCOS Research Associates

14:10 – 14:12 **Paper #45: Sagittal Cervical Alignment in Patient with Adolescent Idiopathic Scoliosis**
Mitsuru Yagi, MD, PhD; Masakazu Takemitsu; Masafumi Machida, MD; Takashi Asazuma, MD, PhD

14:12 – 14:20 **Discussion**

14:20 – 14:22 **Paper #46: Complications after 10-Year Experience in Lumbar Lateral Access Surgery**
Leonardo Oliveira, BSc; Rodrigo A. Amaral; Luis Marchi, MSc; Luiz Pimenta, MD, PhD

14:22 – 14:24 **Paper #47: Perioperative Stroke in Patients Undergoing Elective Spinal Surgery: A Retrospective Analysis using the Japanese Diagnosis Procedure Combination Database**
Junichi Ohya; Hirotaka Chikuda, MD, PhD; Katsushi Takeshita, MD; Hideo Yasunaga; Sakae Tanaka

14:24 – 14:26 **Paper #48: Adult Spinal Deformity Surgeons are Unable to Accurately Predict Post-Operative Spinal Alignment: Initial Analysis of a Three-Phase Study**
Virginie Lafage, PhD; Frank J. Schwab, MD; Justin K. Scheer, BS; Eric Klineberg, MD; Daniel M. Sciubba, MD; Lukas P. Zebala, MD; Richard Hostin, MD; Ibrahim Obeid; Tyler Koski, MD; Michael P. Kelly, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; International Spine Study Group

14:26 – 14:28 **Paper #49: Factors Causing Failure in Navigation-Assisted Pedicle Screw Placement in Scoliosis: Why is Screw Deviation Rate not Zero Percent Even with O-Arm Based Navigation?**
Tsutomu Akazawa, MD; Toshiaki Kotani; Tsuyoshi Sakuma, MD, PhD; Shohei Minami

14:28 – 14:30 **Paper #50: Sagittal Alignment following Lumbar Three-Column Osteotomy: Does the Level of Resection Matter?**
Barthelemy Liabaud, MD; Emmanuelle Ferrero; Christopher P. Ames, MD; Khaled Kebaish, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Munish C. Gupta, MD; Oheneba Boachie-Adjei, MD; Justin S. Smith, MD, PhD; Robert A. Hart, MD; Bassel G. Diebo, MD; Themistocles S. Protopsaltis, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

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

14:30 – 14:32 **Paper #51: Clinical Manifestation and Surgical Treatment in Spinal Lesion Associated with Mucopolysaccharidosis**
Rodrigo G. Remondino, MD; Carlos A. Tello, MD; Ida Alejandra Francheri, MD; Mariano A. Noel, MD; Eduardo Galaretto, MD; Ernesto Bersusky, MD; Lucas Piantoni, MD

14:32 – 14:40 **Discussion**

14:40 – 14:55 Walking Break

14:55 – 15:50 Concurrent Sessions 4A-C: Abstract Sessions & Complication Series

4A. Adolescent Idiopathic Scoliosis Abstracts

ROOM: AUDITORIUM 1

MODERATORS: *Morio Matsumoto, MD and Daniel J. Sucato, MD, MS*

14:55 – 14:59 **Paper #52: The "3D Sagittal Profile" in Adolescent Idiopathic Scoliosis: Loss of Thoracic Kyphosis Revealed**
Peter O. Newton, MD; Emily Osborn, MD; Josh Doan, MEng; Tracey Bastrom, MA; Fredrick G. Reighard, MPH

14:59 – 15:03 **Paper #53: Sexual Function in Women with a History of Bracing or Surgical Correction of Adolescent Idiopathic Scoliosis**
Leon Kaplan; Tal Falick-Michaeli, MD; Yair Barzilay, MD; Amir Hashroni, MD, PhD; Eyal Itshayek, MD; Joshua E. Schroeder, MD
This presentation is the result of a project funded, in part, by an SRS Research Grant

15:03 – 15:07 **Paper #54: Modeling Thoracic Volume for Adolescent Idiopathic Scoliosis**
Charles Gerald T. Ledonio, MD; A. Noelle Larson, MD; David W. Polly, MD; Benjamin Rosenstein, BBmE; David J. Nuckley, PhD

15:07 – 15:13 **Discussion**

15:13 – 15:17 **Paper #55: Retrospective Analysis of Feasibility and Performance of Robotic-Guidance for Placement of Pedicle Screws in 223 Adolescents with Idiopathic Scoliosis (AIS)**
Dennis P. Devito, MD; Sajan K. Hegde, MD; Isador Lieberman, MD, MBA, FRCSC; S. Samuel Bederman, MD, PhD, FRCSC; Raymund Woo, MD

15:17 – 15:21 **Paper #56: How Do Implant Costs Impact Access to Pediatric Spinal Deformity Surgery? An International Survey of Spine Surgeons**
Sreeharsha V. Nandyala, BA; Richard M. Schwend, MD

15:21 – 15:25 **Paper #57: Assessment of Breast Asymmetry in Adolescent Idiopathic Scoliosis using an Automated 3D Body Surface Measurement Technique**
Joyce Ramsay; Lama Seoud; Farida Cheriet, PhD; Julie Joncas, BSc; Isabelle Turgeon, BSc; Philippe Debanné, MASc.; Isabelle Trop, MD, MPH; Hubert Labelle, MD; Stefan Parent, MD, PhD

15:25 – 15:31 **Discussion**

15:31 – 15:35 **Paper #58: Failure and Success in Vertebral Body Stapling**
Joshua M. Pahys, MD; Amer F. Samdani, MD; Michael Auriemma; Elias Dakwar, MD; Randal R. Betz, MD; Patrick J. Cahill, MD

15:35 – 15:39 **Paper #59: Risk Factors of Proximal Junctional Kyphosis in Adolescent Idiopathic Scoliosis: The Pelvis and Other Considerations**
Baron S. Lonner, MD; Peter O. Newton, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Harry L. Shufflebarger, MD; Jahangir Asghar, MD; Paul D. Sponseller, MD; Randal R. Betz, MD; Burt Yaszay, MD; Yuan Ren, PhD

15:39 – 15:43 **Paper #60: Improving the Prediction of Spontaneous Lumbar Curve Correction (SLCC) with Selective Thoracic Fusions: A Study on 306 AIS Patients**
Heiko Koller, MD; Oliver Meier, MD

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

15:43 – 15:50 **Discussion**

4B. Complications & Infections Abstracts

ROOM: AUDITORIUM 2

MODERATORS: *John R. Dimar, II, MD and Stefan Parent, PhD*

14:55 – 14:59 **Paper #61: A Logistic Regression Model to Predict Complications in Complex Deformity Spine Surgery**
Ferran Pellise, MD; Alba Vila-Casademunt; Lidia Mora; Maria J. Colomina; Montse Domingo-Sàbat; Ibrahim Obeid; Francisco J. S. Pérez-Grueso, MD; Ahmet Alanay; Emre Acaroglu, MD; European Spine Study Group (ESSG)

14:59 – 15:03 **Paper #62: Predictors of Infections and Medical Complications in the Setting of Adult Spinal Deformity Surgery**
Alex Soroceanu, MD, CM, MPH, FRCSC; Douglas C. Burton, MD; Justin S. Smith, MD, PhD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Behrooz A. Akbarnia, MD; Christopher P. Ames, MD; Thomas J. Errico; Shay Bess, MD; Munish C. Gupta, MD; Vedat Deviren, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

15:03 – 15:07 **Paper #63: The Effect of Complications and Reoperation on Recovery Kinetics in 149 Adult Spinal Deformity Patients with Two-Year Follow Up: An Area Under the Curve Analysis**
Christopher P. Ames, MD; Justin K. Scheer, BS; Gregory M. Mundis, MD; Eric Klineberg, MD; Robert A. Hart, MD; Michael P. Kelly, MD; Vedat Deviren, MD; Douglas C. Burton, MD; Ian McCarthy, PhD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Virginie Lafage, PhD; Justin S. Smith, MD, PhD; International Spine Study Group

15:07 – 15:13 **Discussion**

15:13 – 15:17 **Paper #64: Does Chronic Kidney Disease Affect the Mortality Rate in Patients Undergoing Instrumented Spine Fusion? Long-Term Follow Up of a Multicenter Spinal Registry**
Lance K. Mitsunaga, MD; Kamran Majid, MD; Ravi S. Bains, MD; Jessica Harris, MS, RD; Julie L. Alvarez, MPH; Yuexin Chen, BS; Liz W. Paxton

15:17 – 15:21 **Paper #65: The Effect of Esophageal Contents on Post-Operative Dysphagia Following Primary Anterior Cervical Discectomy and Fusion Surgery: A Randomized Prospective Study**
Daniel Huttman, MD; Warren D. Yu, MD; Joseph R. O'Brien, MD, MPH

15:21 – 15:25 **Paper #66: Readmission, Reoperation and Index Length of Stay Resulting from Specific Complications following Adult Deformity Surgery**
Jayme R. Hiratzka, MD; D. K. Hamilton, MD; Eric Klineberg, MD; Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Shay Bess, MD; Justin K. Scheer, BS; Virginie Lafage, PhD; Frank J. Schwab, MD; Douglas C. Burton, MD; Richard Hostin, MD; Ian McCarthy, PhD; Shannon Hiratzka, MpH; Robert A. Hart, MD; International Spine Study Group

15:25 – 15:31 **Discussion**

15:31 – 15:35 **Paper #67: Prospective Analysis of Location of RhBMP-2 Use in Adult Spinal Deformity (ASD) Surgery Does Not Correlate with Site Specific Complications and Generates Greater Fusion Rates at Minimum Two-Year Follow Up**
Shay Bess, MD; Breton Line, BSME; Virginie Lafage, PhD; Christopher P. Ames, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Behrooz A. Akbarnia, MD; Eric Klineberg, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group

15:35 – 15:39 **Paper #68: Pre-Warming to Prevent Intra-Operative Hypothermia: A Positive Impact on Peri-Operative Outcomes in Spinal Deformity Surgery**
Firoz Miyanji, MD, FRCSC; Matthias Görges, PhD; Christopher Reilly; Wesley Cheung; Amer F. Samdani, MD; Suken A. Shah, MD; Peter O. Newton, MD; Simon Whyte

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

15:39 – 15:43 **Paper #69: Evaluation of the Alarm Criteria of Transcranial Electrical Stimulation Muscle Evoked Potential in Spinal Corrective Surgery for Different Clinical Diagnosis of Scoliosis: Multi-Institution Survey by the Monitoring Committee of the Japanese Society for Spine Surgery and Related Research**
Kei Yamada, MD, PhD; Yukihiro Matsuyama, MD; Sho Kobayashi, PhD; Ken Nagahama; Kanichiro Wada; Akio Muramoto; Nobuaki Tadokoro, MD; Tsukasa Kanchiku; Hiroshi Iwasaki, MD; Shoji Seki, MD, PhD; Yujiro Hirao; Atsuko Saruwatari, MD; Muneharu Ando; Naoya Yamamoto; Satoshi Sumiya

15:43 – 15:50 **Discussion**

4C: My Worst Complication Series: Strategies to Prevent/Manage #1

ROOM: AUDITORIUM 3

Moderators: F. Chumhur Oner, MD, PhD and Michael J. Yaszemski, MD, PhD

14:55 – 15:13 **Tumor**
Daniel Sciubba, MD

15:13 – 15:31 **Cervical Trauma**
Teresa Bas, MD, PhD

15:31 – 15:50 **Adult Deformity**
David W. Polly, Jr., MD

15:50 – 16:05 Refreshment Break & Exhibit Viewing

MAIN LEVEL FOYER

16:05 – 17:05 Concurrent Sessions 5A-D: Abstract & Roundtable Sessions

5A: Cervical Spine Trauma Roundtable

ROOM: SALA 1&2

MODERATORS: *Michael G. Fehlings, MD, PhD, FRCSC, FACS and K. Daniel Riew, MD*

Case Presenters:

16:05 – 16:20 *Regis W. Haid, Jr., MD*
16:20 – 16:35 *Vincent Traynelis, MD*
16:35 – 16:50 *F. Cumhur M. Oner, MD, PhD*
16:50 – 17:05 *Alexander R. Vaccaro, III, MD, PhD*

5B: Adolescent Idiopathic Scoliosis Roundtable

ROOM: AUDITORIUM 2

MODERATORS: *Lawrence G. Lenke, MD and Suken A. Shah, MD*

Case Presenters:

16:05 – 16:20 *Francisco Javier Sanchez Perez-Grueso, MD*
16:20 – 16:35 *Peter O. Newton, MD*
16:35 – 16:50 *Daniel J. Sucato, MD, MS*
16:50 – 17:05 *Amer F. Samdani, MD*

5C: Adult Degenerative Scoliosis Roundtable

ROOM: AUDITORIUM 3

MODERATORS: *Henry F.H. Halm, MD and Rajiv K. Sethi, MD*

Case Presenters:

16:05 – 16:20 *Steven D. Glassman, MD*
16:20 – 16:35 *Frank J. Schwab, MD*
16:35 – 16:50 *Michael Mayer, MD, PhD*
16:50 – 17:05 *Han Jo Kim, MD*

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

5D. Innovative and Diagnostic Methods Abstracts

ROOM: AUDITORIUM 1

MODERATORS: *Hani Mhaidli, MD, PhD and Mark Weidenbaum, MD*

16:05 – 16:09 **Paper #70: Effect of ROTEM-Guided Hemostatic Therapy in Adult Deformity Surgery (ADS)**
Bhiken I. Naik, MBBCh, MD; Justin S. Smith, MD, PhD; Marcel Durieux, MD, PhD; Edward Nemergut, MD; Thomas Pajewski, MD, PhD; David L. Bogdonoff, MD; Zhiyi Zuo, MD, PhD; Pamela Clark, MD; Christopher I. Shaffrey, MD

16:09 – 16:13 **Paper #71: Biomechanical Performance of Various Cement Augmented Cannullated Pedicle Screw Designs for Osteoporotic Bones**
Tolga Tolunay; Kağan Arslan; Onur Yaman; Sedat Dalbayrak; Teyfik Demir, PhD

16:13 – 16:17 **Paper #72: Kinetics of Inflammatory Markers and Correlation with Various Factors after Uneventful Spinal Surgeries: A Prospective Observational Study**
Saumyajit Basu, MD; Amitava Biswas, MS(orth)

16:17 – 16:23 **Discussion**

16:23 – 16:27 **Paper #73: Current Evidence Regarding Diagnostic Methods for Pediatric Lumbar Spondylolysis: A Report from the Scoliosis Research Society Evidence-Based Medicine Committee**
Charles Gerald T. Ledonio, MD; Charles H. Crawford, MD; Shay Bess, MD; Jacob M. Buchowski, MD, MS; Douglas C. Burton, MD; Serena Hu; Baron S. Lonner, MD; David W. Polly, MD; Justin S. Smith, MD, PhD; James O. Sanders, MD

16:27 – 16:31 **Paper #74: Cervical Extension Magnetic Resonance Imaging in Evaluating Cervical Spondylotic Myelopathy**
Sungjoon Lee; Chi Heon Kim, MD, PhD; Chun Kee Chung, MD, PhD

16:31– 16:35 **Paper #75: Pre-Operative Analysis of Paraspinal Muscle Atrophy: Insight into Correlations with Stenosis Severity and Health-Related Quality of Life**
Daniel S. Mulconrey, MD; Patrick T. O'Leary, MD; David Holt, BS; Daniel J. Liechti, BSE

16:35 – 16:39 **Paper #76: Use of Magnetic Resonance Neurography for Imaging the Lumbar Plexus: A Pre-Operative Tool for the Lateral Transpsoas Approach**
John C. Quinn, MD; J. L. Chazen, MD; Kristen Fruauff, MD; Frank P. Cammisa, MD; Darren R. Lebl, MD

16:39 – 16:46 **Discussion**

16:46 – 16:50 **Paper #77: Finite Element Analysis of Lordosis Restoration with Anterior Longitudinal Ligament Release and Lateral Hyperlordotic Cage Placement**
Juan Uribe, MD; Jeffrey E. Harris; Alexander Turner, PhD; Gregory Mundis, Jr., MD; Behrooz A. Akbarnia, MD

16:50 – 16:54 **Paper #78: Cumulative Radiation Exposure with EOS® Imaging Compared to Standard Spine Radiographs**
T. David Luo; Anthony A. Stans, MD; Beth A. Schueler, PhD; A. Noelle Larson, MD

16:54 – 16:58 **Paper #79: Utilizing the Accelerometer of Your Mobile Phone for Quantitative Measurement of Spinal Range of Movement: A Reliability and Validity Study**
Tsz-Ping Lam, MB, BS; Bobby K. Ng, MD; Kwong Man Lee, PhD; Alec Lik Hang Hung; Echo Ka Ling Tsang; Jack C. Cheng, MD

16:58 – 17:05 **Discussion**

17:05 – 17:30 Walking Break & Exhibit Viewing

HOW Refreshment Break – Sala Level (Level 1)

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

(See "Exhibits and Hands-On Workshops" section on page 213 for more information.)

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

8:00 – 18:30 Registration Open
MAIN LEVEL LOBBY

8:00 – 9:00 * Hands-On Workshops with Breakfast
(See "Exhibits and Hands-On Workshops" section on page 213 for more information.)

8:30 – 17:30 Exhibits Open
MAIN LEVEL FOYER

8:30 – 9:15 Exhibit Viewing & Breakfast
MAIN LEVEL FOYER

9:15 – 10:15 Concurrent Sessions 6A-C: Abstract Sessions & Debate Series

6A. Adult Deformity Abstracts

ROOM: AUDITORIUM 1
MODERATORS: *Sigurd H. Berven, MD and Shay Bess, MD*

9:15 – 9:19 **Paper #80: Adult Spinal Deformity Treated with Minimally Invasive Techniques: Two-Year Multicenter Clinical and Radiographic Outcomes Study Comparing Circumferential MIS and Hybrid Surgery**
Gregory M. Mundis, MD; Behrooz A. Akbarnia, MD; Praveen V. Mummaneni, MD; Adam S. Kanter, MD; David O. Okonkwo, MD, PhD; Paul Park, MD; Juan S. Uribe, MD; Vedat Deviren, MD; Neel Anand, MD; Michael Y. Wang, MD; Frank La Marca, MD; Richard G. Fessler, MD, PhD; Stacie Nguyen, MPH; Robert K. Eastlack, MD; International Spine Study Group

9:19 – 9:23 **Paper #81: Comparison of Best versus Worst Clinical Outcomes for Adult Spinal Deformity (ASD) Surgery: A Prospective, Multicenter Assessment with Minimum Two-Year Follow Up**
Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Themistocles S. Protopsaltis, MD; Eric Klineberg, MD; Munish C. Gupta, MD; Richard Hostin, MD; Kai-Ming Fu, MD, PhD; Alex Soroceanu, MD, CM, MPH, FRCSC; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group

9:23 – 9:27 **Paper #82: Are Established Targets for Spinal Deformity Correction Valid? Pre- to Post-Operative Analysis using the T1 Pelvic Angle (TPA), a Novel Radiographic Parameter of Sagittal Deformity**
Themistocles S. Protopsaltis, MD; Anthony J. Boniello, BS; Justin S. Smith, MD, PhD; Peter G. Passias, MD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Thomas J. Errico; Shay Bess, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

9:27 – 9:34 **Discussion**

9:34 – 9:38 **Paper #83: The Effect of Patient Age on Recovery Kinetics in 149 Adult Spinal Deformity Patients with Two-Year Follow Up: A Novel Area Under the Curve Analysis**
Christopher P. Ames, MD; Justin K. Scheer, BS; Gregory M. Mundis, MD; Eric Klineberg, MD; Robert A. Hart, MD; Michael P. Kelly, MD; Vedat Deviren, MD; Stacie Nguyen, MPH; Ian McCarthy, PhD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Virginie Lafage, PhD; Justin S. Smith, MD, PhD; International Spine Study Group

9:38 – 9:42 **Paper #84: Surgical Site Infection in Adult Degenerative Scoliosis: Risk Factors and Countermeasures**
En Xie, PhD, MD; Yu Sheng Dou

9:42 – 9:46 **Paper #85: Biomechanical Demands on S2AI Sacral and Pelvic Instrumentation in Long Fusion Constructs with and without Interbody Supplementation**
Shay Bess, MD; William Camisa, MSME; Seong Yi, MD, PhD; Akira Washiya; Jeremi M. Leasure, MS (Eng); Douglas C. Burton, MD; Khaled Kebaish, MD; Christopher P. Ames, MD

9:46 – 9:53 **Discussion**

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9:53 – 9:57 **Paper #86: Segmental Pelvic Correlation (SPeC): Analysis of the Relationship between Lumbar Segmental Lordosis and Pelvic Morphology**
Hanny A. Anwar; Karthig Rajakulendran; Tejas Yarashi, MBChB; Sean Molloy, FRCS(Orth)

9:57 – 10:01 **Paper #87: Instrumentation Strategies to Reduce the Risks of Proximal Junctional Kyphosis in Adult Scoliosis: A Detailed Biomechanical Analysis**
Carl-Éric Aubin, PhD, PEng; Marco Cammarata, MaSc; Xiaoyu Wang, PhD; Jean-Marc Mac-Thiong, MD, PhD

10:01 – 10:05 **Paper #88: A New Evidence-Based Protocol for Prevention of Post-Operative Surgical Site Infections Substantially Reduces Infection Rate in Long Posterior Instrumented Spine Procedures for Deformity**
Polina Osler, MS; Tyler Herzog, BS; Brian E. Grottkau, MD; Kirkham B. Wood, MD

10:05 – 10:15 **Discussion**

6B. Trauma & Tumor Abstracts

ROOM: AUDITORIUM 2

MODERATORS: *Adam S. Kanter, MD and Carlos Villanueva, MD, PhD*

9:15 – 9:19 **Paper #89: Current Surgical Practice for Traumatic Spinal Cord Injury in Central Cord Syndrome Patients in Canada**
Jerome Paquet; Brian M. Drew, MD; Michael G. Fehlings, MD, PhD; Henry Ahn, MD, PhD, FRCSC; Najmedden Attabib, MD, FRCSC; Chris S. Bailey, MD; Sean Christie; Neil Duggal, MD, MSc, FRCSC, FACS; Joel Finkelstein, MSc, MD, FRCSC; Daryl R. Fourney, MD, FRCSC, FACS; R. John Hurlbert, MD, PhD, FRCSC, FACS; Michael G. Johnson; Brian K. Kwon; Stefan Parent, MD, PhD; Eve C. Tsai, MD, PhD; Marcel F. Dvorak, MD, FRCSC; Vanessa Noonan, PhD, PT; Carly S. Rivers, PhD

9:19 – 9:23 **Paper #90: Current Treatment of Individuals with Traumatic Spinal Cord Injury: Do We Need Age-Specific Guidelines?**
Henry Ahn, MD, PhD, FRCSC; Chris S. Bailey, MD; Sean Christie; Neil Duggal, MD, MSc, FRCSC, FACS; Michael G. Fehlings, MD, PhD; Joel Finkelstein, MSc, MD, FRCSC; Daryl R. Fourney, MD, FRCSC, FACS; R. John Hurlbert, MD, PhD, FRCSC, FACS; Brian K. Kwon; Andrea Townson; Eve C. Tsai, MD, PhD; Najmedden Attabib, MD, FRCSC; Jason Chen, MS; Marcel F. Dvorak, MD, FRCSC; Vanessa Noonan, PhD, PT; Carly S. Rivers, PhD

9:23 – 9:27 **Paper #91: The Reliability and Validity of the Thoracolumbar Injury Classification System in Pediatric Spine Trauma**
Jason W. Savage, MD; Timothy Moore, MD; Paul Arnold; Wellington Hsu, MD; Alpesh A. Patel, MD; Kathryn J. McCarthy, MD; Gregory D. Schroeder, MD; Alexander R. Vaccaro, MD, PhD; John R. Dimar, II, MD; Paul Anderson, MD

9:27 – 9:34 **Discussion**

9:34 – 9:38 **Paper #92: Spinal Fractures in Patients with Diffuse Idiopathic Skeletal Hyperostosis: Posterior Element Injury Causes Late Neurological Deterioration**
Eijiro Okada, MD; Kota Watanabe; Mitsuru Yagi, MD, PhD; Shinjiro Kaneko, MD, PhD; Yoshiaki Toyama; Morio Matsumoto, MD

9:38 – 9:42 **Paper #93: The Impact of Early Surgical Timing for Complete Spinal Cord Injury**
Étienne Bourassa-Moreau, MD; Stefan Parent, MD, PhD; Jean-Marc Mac-Thiong, MD, PhD

9:42 – 9:46 **Paper #94: Survival after Spinal Metastasis from Breast Cancer Depends on Tumor Subtype**
Miao Wang, MD, PhD; Anders B. Jensen, PhD; Søren S. Morgen, MD; Chunsen Wu, PhD; Ming Sun, MD; Haisheng Li, MD, PhD; Benny Dahl, MD, PhD, DMSci; Cody E. Bunger

9:46 – 9:53 **Discussion**

9:53 – 9:57 **Paper #95: The Role of Pre-Operative Vascular Embolization in Surgery for Spinal Metastases**
Naresh S. Kumar, MBBS, FRCS (Orth&Tr), DM; Barry W. Tan, MBBS; Aye Sandar Zaw, MBBS, MPH; Gopinathan Anil

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

9:57 – 10:01 **Paper #96: Implantation of Liquid Nitrogen Frozen Tumor Tissue after Posterior Decompression and Stabilization for Metastatic Spinal Tumors**
Kazuya Shinmura; Hideki Murakami; Satoru Demura, MD; Satoshi Kato, MD; Katsuhito Yoshioka, MD; Hiroyuki Hayashi; Noriaki Yokogawa; Takayoshi Ishii; Takashi Igarashi; Xiang Fang; Hiroyuki Tsuchiya

10:01 – 10:05 **Paper #97: Invasiveness Reduction of Recent Total En Bloc Spondylectomy: Assessment of the Learning Curve**
Takayoshi Ishii; Hideki Murakami; Satoru Demura, MD; Satoshi Kato, MD; Katsuhito Yoshioka, MD; Hiroyuki Hayashi; Noriaki Yokogawa; Takashi Igarashi; Xiang Fang; Hiroyuki Tsuchiya

10:05 – 10:15 **Discussion**

6C. Debate Series # 2

ROOM: AUDITORIUM 3

MODERATORS: *Richard G. Fessler, MD, PhD and Raja Y. Rampersaud, MD, FRCSC*

9:15 – 9:45 **Debate 1: SI Joint Arthritis is a Common Entity Requiring Surgical Intervention**
Pro: David W. Polly, Jr., MD
Con: Todd J. Albert, MD

9:45 – 10:15 **Debate 2: Transpoas versus MIS TLIF: Which is the Best Technique for Degenerative Spondylolisthesis**
Transpsoas: Gregory M. Mundis, Jr., MD
MIS TLIF: James D. Schwender, MD

10:15 – 10:35 Refreshment Break & Exhibit Viewing

MAIN LEVEL FOYER

10:35 – 12:00 Concurrent Sessions 7A-C: Abstract Sessions & Complication Series

7A. Cervical Spine Abstracts

ROOM: AUDITORIUM 2

MODERATORS: *Jeffrey D. Coe, MD and K. Daniel Riew, MD*

10:35 – 10:39 **Paper #98: Reliability Assessment of a Novel Cervical Deformity Classification System**
Justin S. Smith, MD, PhD; Robert K. Eastlack, MD; Donald J. Blaskiewicz, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Shay Bess, MD; Han Jo Kim, MD; Eric Klineberg, MD; Michael F. O'Brien, MD; Todd J. Albert, MD; Michael G. Fehlings, MD, PhD; Virginie Lafage, PhD; Christopher P. Ames, MD; K. D. Riew, MD; International Spine Study Group

10:39 – 10:43 **Paper #99: Post-Operative Cervical Deformity in 215 Thoracolumbar Adult Spinal Deformity Patients: Prevalence, Risk Factors and Impact on Patient-Reported Outcome and Satisfaction at Two-Year Follow Up**
Peter G. Passias, MD; Justin S. Smith, MD, PhD; Alex Soroceanu, MD, CM, MPH, FRCSC; Anthony J. Boniello, BS; Justin K. Scheer, BS; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Munish C. Gupta, MD; Eric Klineberg, MD; Virginie Lafage, PhD; Christopher P. Ames, MD; International Spine Study Group

10:43 – 10:47 **Paper #100: Upper Cervical Compensation and Maintenance of Horizontal Gaze in 150 Thoracolumbar Deformity Patients with and without Deformity**
Renaud Lafage, MS; Virginie Lafage, PhD; Justin S. Smith, MD, PhD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Thomas J. Errico; Shay Bess, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Themistocles S. Protopsaltis, MD; International Spine Study Group

10:47 – 10:54 **Discussion**

10:54 – 10:58 **Paper #101: Collar Fixation versus no Fixation after Cervical Laminoplasty: A Randomized Controlled Trial**
Tetsuro Hida; Yoshihito Sakai, PhD; Kenyu Ito; Sadayuki Ito; Shiro Imagama, MD; Atsushi Harada

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10:58 – 11:02 **Paper #102: Self-Designed Posterior Atlas Polyaxial Lateral Mass Screw-Plate Fixation for Unstable Atlas Fracture**
Dingjun Hao; Baorong He; Liang Yan

11:02 – 11:06 **Paper #103: Cervical Interfacet Spacers and Maintenance of Cervical Lordosis**
Lee A. Tan, MD; David C. Straus, MD; Vincent C. Traynelis, M.D.

11:06 – 11:13 **Discussion**

11:13 – 11:17 **Paper #104: Correlation of Myelopathy to Regional Neck Disability: A Surgical Approach-Specific Analysis in 217 Patients**
Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Shian Liu, BS; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Paul Arnold; Vincent Challier, MD; Jens Chapman, MD; Themistocles S. Protopsaltis, MD; Frank J. Schwab, MD; Justin K. Scheer, BS; Eric Massicotte, MD, MSc FRCSC; S. Tim Yoon; Virginie Lafage, PhD; Michael G. Fehlings, MD, PhD

11:17 – 11:21 **Paper #105: Cervical Spondylotic Myelopathy: Does Surgical Approach Influence Post-Operative Sagittal Alignment and Outcomes?**
Michael G. Fehlings, MD, PhD; Justin S. Smith, MD, PhD; Vincent Challier, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Paul Arnold; Jens Chapman, MD; Themistocles S. Protopsaltis, MD; Virginie Lafage, PhD; Shian Liu, BS; Renaud Lafage, MS; Frank J. Schwab, MD; Eric Massicotte, MD, MSc FRCSC; S. Tim Yoon; Christopher P. Ames, MD

11:21 – 11:25 **Paper #106: The Impact of Dynamic Alignment, Motion and Center of Rotation on Myelopathy Grade and Regional Disability in Cervical Spondylotic Myelopathy**
Shian Liu, BS; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Themistocles S. Protopsaltis, MD; Virginie Lafage, PhD; Vincent Challier, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Paul Arnold; Jens Chapman, MD; Frank J. Schwab, MD; Eric Massicotte, MD, MSc FRCSC; S. Tim Yoon; Michael G. Fehlings, MD, PhD; Christopher P. Ames, MD

11:25 – 11:29 **Paper #107: Impact of Regional and Focal Cervical Alignment on Myelopathy Severity: Report of 151 Patients**
Themistocles S. Protopsaltis, MD; Michael G. Fehlings, MD, PhD; Shian Liu, BS; Justin S. Smith, MD, PhD; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Paul Arnold; Jens Chapman, MD; Renaud Lafage, MS; Vincent Challier, MD; Frank J. Schwab, MD; Eric Massicotte, MD, MSc FRCSC; S. Tim Yoon; Christopher P. Ames, MD

11:29 – 11:36 **Discussion**

11:36 – 11:40 **Paper #108: Changes in Foraminal Area with Anterior Decompression versus Keyhole Foraminotomy in the Cervical Spine: A Cadaveric Investigation**
Jacqueline Nguyen, MD; Bryant Chu, BS; Calvin C. Kuo, MD; Jeremi M. Leasure, MS (Eng); Dimitriy Kondrashov, MD

11:40 – 11:44 **Paper #109: Area Under the Curve: Analysis of Approach Related Recovery Time in 165 Operative Cervical Spondylotic Myelopathy Patients with Two- Year Follow Up**
Vincent Challier, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Paul Arnold; Shian Liu, BS; Justin K. Scheer, BS; Jens Chapman, MD; Themistocles S. Protopsaltis, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Eric Massicotte, MD, MSc FRCSC; S. Tim Yoon; Michael G. Fehlings, MD, PhD; Christopher P. Ames, MD

11:44 – 11:48 **Paper #110: Intra-Operative Assessment of the Maximal Insertional Torque for Lateral Mass Screws: Magerl Technique versus Roy-Camille Technique**
Takuya Mishiro, MD, PhD; Koichi Sairyo, MD; Akira Shinohara; Takashi Chikawa, MD, PhD; Hirofumi Kosaka, MD, PhD

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

11:48 – 11:52 **Paper #111: Sagittal Alignment of Cervical Spine in Adult Idiopathic Scoliosis**
Bilal Aykac, MD; Selim Ayhan, MD; Selcen Yuksel, PhD; Umit O. Guler, MD; Ferran Pellise, MD; Ahmet Alanay; Francisco J. S. Pérez-Grueso, MD; Emre Acaroglu, MD; European Spine Study Group (ESSG)

11:52 – 12:00 **Discussion**

7B: Lumbar Degnerative & Spondylolisthesis Abstracts

ROOM: AUDITORIUM 3

MODERATORS: *Munish C. Gupta, MD and Carlos Villanueva, MD, PhD*

10:35 – 10:39 **Paper #112: MASTERS-D: One-Year Follow Up of a Prospective Multicenter Observational Data-Monitored Study of Minimally Invasive Fusion to Treat Degenerative Lumbar Disorders**
Paulo Pereira, MD; David Buzek, MD; Wolfgang Senker, MD; Arek Kosmala, MD; Ulrich Hubbe, MD; Neil A. Manson, MD, FRCSC; Wout Rosenberg, MD; Roberto Assietti, MD; Frederic Martens; Khai Lam, MD; Giovanni Barbanti Brodano; Peter Durny, MD; Zvi M. Lidar, MD; Kai M. Scheufler, MD; Walter A. Richter, MD; Pawel Sloniewski, MD; Salvador Fuster, MD; Vassilios Vougioukas, MD; Marc Schroder, MD; Joerg Franke, PhD

10:39 – 10:43 **Paper #113: Effect of Superior Adjacent Segment Degeneration after Lumbar Posterolateral Fusion using Two Different Pedicle Screw Insertion Positions with Nine-Year Minimum Follow Up**
Dingjun Hao; Baorong He; Liang Yan

10:43 – 10:47 **Paper #114: Risks Factors for Re-Operation in Patients Treated Surgically for Degenerative Spondylolisthesis: A Subanalysis of the Eight-Year Data from the SPORT Trial**
Michael C. Gerling, MD; Dante M. Leven, DO; Virginie Lafage, PhD; Peter G. Passias, MD; Kristina Bianco, BA; Alexandra Lee, RN; Jon D. Lurie, MD; Tor D. Tosteson, ScD; Wenyan Zhao, PhD; Kevin F. Spratt, PhD; Thomas J. Errico

10:47 – 10:54 **Discussion**

10:54 – 10:58 **Paper #115: Evoked Electromyography (EMG) throughout Retraction to Monitor Nerve Integrity During the Minimally Invasive Lateral Transpsoas Interbody Fusion: Preliminary Results from a Prospective, Multicenter Study**
Robert E. Isaacs, MD; Jim A. Youssef, MD; Juan S. Uribe, MD; Solas Degenerative Study Group

10:58 – 11:02 **Paper #116: Effect of Teriparatide on Posterior Lumbar Interbody Fusion in Patients with Osteoporosis**
Keung Nyun Kim

11:02 – 11:06 **Paper #117: Impact of Surgical Approach on Clinical Outcomes in the Treatment of Lumbar Pseudarthrosis**
Roger K. Owens, MD; Mladen Djurasovic, MD; Charles H. Crawford, MD; Steven D. Glassman, MD; John R. Dimar, MD; Leah Y. Carreon, MD, MSc

11:06 – 11:13 **Discussion**

11:13 – 11:17 **Paper #118: Life Quality Improvement and Patient Satisfaction after Instrumented Lumbar Fusion in the Elderly Compared with Young Population**
Felix Tome-Bermejo, MD, PhD; Luis Alvarez; Angel R. Pinera, MD; Carmen Duran; Belen Lopez-San Roman

11:17 – 11:21 **Paper #119: The Radiographic Analysis of the Indirect Decompression after Anterior Lumbar Interbody Fusion (ALIF) or Direct Lateral Interbody Fusion (DLIF)**
ChongSuh Lee, MD, PhD; Sungsoo Chung; Sejun Park, MD; KeunHo Lee; Junho Kim; Jin-Hyok Kim, MD, PhD; Junyoung Lee

11:21 – 11:25 **Paper #120: Degenerative Spondylolisthesis versus Spinal Stenosis: As-Treated Analysis of the Spine Patient Outcomes Research Trial**
En Xie, PhD, MD; Yu Sheng Dou

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11:25 – 11:29 **Paper #121: Drastic Reduction with One-Level Fusion in Treatment of High-Grade L5 Spondylolisthesis can Restore Global Spinopelvic Alignment**
Hiroshi Moridaira; Hiroshi Taneichi, MD; Satoshi Inami; Daisaku Takeuchi; Yo Shiba, MD; Makoto Ohe, MD; Yutaka Nohara, MD

11:29 – 11:36 **Discussion**

11:36 – 11:40 **Paper #122: Clinical Outcomes Ten Years after Lumbar Fusion for Degenerative Spondylolisthesis**
Andrew J. Cordiale, DO; Leah Y. Carreon, MD, MSc; Erin L. Adams, BS; Kelly R. Bratcher, RN, CCRP; Steven D. Glassman, MD

11:40 – 11:44 **Paper #123: Spino-Pelvic Alignment following Surgical Correction Developmental Spondylolisthesis using a Standardized Reduction Technique: A Prospective Study**
Jesse Shen; Hubert Labelle, MD; Jean-Marc Mac-Thiong, MD, PhD; Julie Joncas, BSc; Stefan Parent, MD, PhD

11:44 – 11:48 **Paper #124: A Prospective Trial Comparing L4L5 Instrumented Posterolateral Fusion for Degenerative Spondylolisthesis Performed with Local Bone Graft Alone versus Posterior Iliac Crest Graft and Local Bone versus Beta Tricalcium Phosphate and Local Bone Graft**
Saumyajit Basu, MD; Gaurav R. Dhakal, MS(Orth)

11:48 – 11:52 **Paper #125: Sagittal Spinopelvic Parameters in Patients with Degenerative Lumbar Spondylolisthesis**
Chang Ju Hwang, MD, PhD; Won Kyeong Kim; Dong-Ho Lee, MD, PhD; Jung-Ki Ha; Mi Young Lee; So Jung Yoon; Choon Sung Lee, MD, PhD

11:52 – 12:00 **Discussion**

7C. My Most Common Major Complication Series: Strategies to Prevent/Manage #2

ROOM: AUDITORIUM 1

MODERATORS: *Vincent Traynelis, MD and Ferran Pellisé Urquiza, MD, PhD*

10:35 – 10:55 **Cervical Deformity**
Christopher P. Ames, MD

10:55 – 11:15 **Cervical Trauma**
Rick C. Sasso, MD

11:15 – 11:35 **MIS Thoracolumbar Degenerative & Deformity**
Juan S. Uribe, MD

11:35 – 11:55 **Pediatric Deformity**
Kamal N. Ibrahim, MD, FRCS(C), MA

12:00 – 12:15 Walking Break

12:15 – 13:15 Exhibit Viewing

* Hands-On Workshops with Lunch – Sala Level (Level 1)
(See "Exhibits and Hands-On Workshops" section on page 213 for more information.)

13:15 – 13:30 Walking Break

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

13:30 – 14:30 Concurrent Sessions 8A-E: Roundtable Sessions & Two-Minute Point Presentations

8A. MIS Deformity Roundtable

ROOM: AUDITORIUM 2

MODERATORS: *Praveen V. Mummaneni, MD and James D. Schwender, MD*

Case Presenters:

13:30 – 13:45 *Juan S. Uribe, MD*
13:45 – 14:00 *Gregory M. Mundis, Jr., MD*
14:00 – 14:15 *Richard G. Fessler, MD, PhD*
14:15 – 14:30 *Raja Y. Rampersaud, MD, FRCSC*

8B. Thoracolumbar Trauma Roundtable

ROOM: SALA 1&2

MODERATORS: *Alexander R. Vaccaro, III, MD, PhD and Carlos Villanueva, MD, PhD*

Case Presenters:

13:30 – 13:45 *John C. France, MD*
13:45 – 14:00 *Chumhur Oner, MD, PhD*
14:00 – 14:15 *Justin S. Smith, MD, PhD*
14:15 – 14:30 *Carlos Villanueva, MD, PhD*

8C. Cervical Degenerative Disease & CSM Roundtable

ROOM: AUDITORIUM 1

MODERATORS: *Morio Matsumoto, MD and Vincent C. Traynelis, MD*

Case Presenters:

13:30 – 13:45 *Michael G. Fehlings, MD, PhD, FRCSC, FACS*
13:45 – 14:00 *Todd J. Albert, MD*
14:00 – 14:15 *Jeffrey D. Coe, MD*
14:15 – 14:30 *Regis W. Haid, Jr., MD*

8D. Infection Roundtable

ROOM: SALA 3&4

MODERATORS: *Kamal N. Ibrahim, MD, FRCS(C), MA and Amer F. Samdani, MD*

Case Presenters:

13:30 – 13:45 *Kenneth M.C. Cheung, MD*
13:45 – 14:00 *David S. Marks, FRCS*
14:00 – 14:15 *Benny T. Dahl, MD, PhD, DMSci*
14:15 – 14:30 *Hani Mhaidli, MD, PhD*

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8E. Two-Minute Point Presentations

ROOM: AUDITORIUM 3

MODERATORS: *Jeffrey A. Goldstein, MD and Munish C. Gupta, MD*

13:30 – 13:32 **Paper #126: Fine-Tuned Surgical Planning in Adult Spinal Deformity: Determining the Lumbar Lordosis Necessary by Accounting for both Thoracic Kyphosis and Pelvic Incidence**
Frank J. Schwab, MD; Bassel G. Diebo, MD; Justin S. Smith, MD, PhD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Matthew E. Cunningham, MD, PhD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Shay Bess, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Themistocles S. Protopsaltis, MD; Virginie Lafage, PhD; International Spine Study Group

13:32 – 13:34 **Paper #127: Posterior Surgical Correction with or without Interbody in Matched Curves Provides Similar Correction in Adult Spinal Deformity**
Eric Klineberg, MD; Munish C. Gupta, MD; Stacie Nguyen, MPH; Christopher P. Ames, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Themistocles S. Protopsaltis, MD; Behrooz A. Akbarnia, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Frank J. Schwab, MD; Vedat Deviren, MD; Han Jo Kim, MD; Shay Bess, MD; International Spine Study Group

13:34 – 13:36 **Paper #128: Impact of Obesity on Complications and Patient-Reported Outcomes in Adult Spinal Deformity Surgery**
Alex Soroceanu, MD, CM, MPH, FRCSC; Douglas C. Burton, MD; Justin S. Smith, MD, PhD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Gregory M. Mundis, MD; Vedat Deviren, MD; Thomas J. Errico; Shay Bess, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

13:36 – 13:38 **Paper #129: High Post-Operative C2-7 SVA is Associated with Proximal Junctional Kyphosis**
Han Jo Kim, MD; Themistocles S. Protopsaltis, MD; Stacie Nguyen, MPH; Matthew E. Cunningham, MD, PhD; Peter G. Passias, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Gregory M. Mundis, MD; Eric Klineberg, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group

13:38 – 13:40 **Paper #130: Adverse Events have Limited Impact on Clinical Outcome following Surgery for Adult Spinal Deformity**
D. K. Hamilton, MD; Jayme R. Hiratzka, MD; Shannon Hiratzka, MpH; Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Behrooz A. Akbarnia, MD; Oheneba Boachie-Adjei, MD; Shay Bess, MD; Justin K. Scheer, BS; Virginie Lafage, PhD; Frank J. Schwab, MD; Robert A. Hart, MD; International Spine Study Group

13:40 – 13:42 **Paper #131: Perioperative Complications do not Affect Patient Satisfaction following Adult Spinal Deformity Surgery**
D. K. Hamilton, MD; Jayme R. Hiratzka, MD; Shannon Hiratzka, MpH; Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Behrooz A. Akbarnia, MD; Oheneba Boachie-Adjei, MD; Shay Bess, MD; Justin K. Scheer, BS; Virginie Lafage, PhD; Frank J. Schwab, MD; Robert A. Hart, MD; International Spine Study Group

13:42 – 13:50 **Discussion**

13:50 – 13:52 **Paper #132: The Effect of Antifibrinolytic Therapy on Complications, Blood Product Utilization and Fusion in Adult Spinal Deformity**
Alex Soroceanu, MD, CM, MPH, FRCSC; Thomas J. Errico; Justin S. Smith, MD, PhD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Shay Bess, MD; Munish C. Gupta, MD; Vedat Deviren, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

13:52 – 13:54 **Paper #133: Having a Regular Doctor Prevents Late Referrals for AIS**
Marie Beausejour; Lise Goulet; Debbie E. Feldman, PhD; Marjolaine Roy-Beaudry, MSc; Hubert Labelle, MD

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13:54 – 13:56	**Paper #134: Unplanned Hospital Readmissions following Pediatric Spinal Fusion Surgery: Rate and Associated Factors** *Amit Jain, MD; Emmanuel N. Menga, MD; Paul D. Sponseller, MD*
13:56 – 13:58	**Paper #135: Spinal Velocity Provides more Accurate Assessment of Curve Progression than Height Velocity in Progressive Female Idiopathic Scoliosis** *Saihu Mao, Doctor; Shi Benlong; Zhu Ze-Zhang; Bangping Qian, MD; Feng Zhu; Zhen Liu; Leilei Xu; Xu Sun, MD, PhD; Yong Qiu, MD*
13:58 – 14:00	**Paper #136: A New Classification System of Spinal Cord Function for Guiding Surgical Strategies of Severe Spinal Deformity** *Yang Junlin, PhD; Huang Zifang, PhD; Yin Junqiang, PhD; Li Fobao, PhD; Deng Yaolong*
14:00 – 14:02	**Paper #137: Does Planned Staging for Posterior-Only Vertebral Column Resections in Spinal Deformity Surgery Increase Perioperative Complications?** *Jeffrey L. Gum, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Brenda A. Sides, MA; Johnny Zhao, BA; David B. Bumpass, MD; Patrick A. Sugrue, MD; Isaac Karikari, MD; Ra'Kerry K. Rahman, MD; Leah Y. Carreon, MD, MSc*
14:02 – 14:10	**Discussion**
14:10 – 14:12	**Paper #138: Is Age Associated With Increased Complications Rates in Cervical Spine Surgery? A Review of 11,765 Cases from the Scoliosis Research Society Database 2004-2007** *Branko Skovrlj, MD; Samuel K. Cho, MD; Motasem Al Maaieh; John Caridi, MD; Yongjung J. Kim, MD; K. Daniel Riew, MD*
14:12 – 14:14	**Paper #139: Re-Operation Rate after Surgery for Spinal Stenosis without Spondylolisthesis: A Nation-Wide Cohort Study** *Chi Heon Kim, MD, PhD; Chun Kee Chung, MD, PhD*
14:14 – 14:16	**Paper #140: Alarm Point of Transcranial Electrical Stimulation Motor Evoked Potential for Intraoperative Spinal Cord Monitoring in Patients with Pre-Operative Paralysis** *Sho Kobayashi, PhD; Yukihiro Matsuyama, MD; Shigenori Kawabata, MD, PhD; Muneharu Ando; Zenya Ito; Yasushi Fujiwara; Tsukasa Kanchiku; Akio Muramoto, MD; Kazunobu Kida; Kei Yamada, MD, PhD; Kanichiro Wada; Naoya Yamamoto; Takanori Saito, Professor; Toshikazu Tani, MD*
14:16 – 14:18	**Paper #141: Seventy-Two Percent of Spine Fusion Patients Have Post-Operative Fevers, but the Fevers are not Clinically Relevant** *Gideon Blumstein, MS; Lindsay Andras, MD; Derek A. Seehausen, BA; Liam R. Harris, BS; Patrick A. Ross, MD; David L. Skaggs, MD, MMM*
14:18 – 14:20	**Paper #142: Pelvic Derotation for Correction of Fixed Sagittal Imbalance: A Novel Technique** *Michael D. Kasten, MD; David M. Prior, MD*
14:20 – 14:22	**Paper #143: How Do Individuals with Fused Spinal Segments for Adolescent Idiopathic Scoliosis Compensate for the Loss of Spinal Range of Motion During Running?** *Kathy Simpson, PhD; Rumit S. Kakar, PT; Yumeng Li; Yang-Chieh Fu; Marika Walker; Cathleen Brown Crowell, PhD; Timothy S. Oswald, MD* ***This presentation is the result of a project funded, in part, by an SRS Research Grant***
14:22 – 14:30	**Discussion**
14:30 – 14:45	**Walking Break & Exhibit Viewing**

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14:45 – 15:45 Concurrent Sessions 9A-D: Abstract Sessions, Debate Series & ICLs

9A: Kyphosis, Congenital & Neuromuscular Deformity Abstracts

ROOM: AUDITORIUM 1

MODERATORS: *Paul D. Sponseller, MD and Daniel J. Sucato, MD, MS*

14:45 – 14:49 **Paper #144: A Controlled Anterior Sequential Interbody Dilation Technique for Correction of Cervical Kyphosis**
Darryl Lau, MD; Rishi Wadhwa, MD; Hai Le; Praveen V. Mummaneni, MD

14:49 – 14:53 **Paper #145: Partial Pedicle Subtraction Osteotomy (PPSO): A Modification for PSO in Treatment of Sagittal Deformities**
Ahmed M. Elbadrawi, MD; Mohamed Wafa, MD

14:53 – 14:57 **Paper #146: The Rib Construct: An Effective Method for Management of Severe Thoracic Kyphosis**
AlaaEldin A. Ahmad, MD; Richard H. Gross, MD

14:57 – 15:04 **Discussion**

15:04 – 15:08 **Paper #147: Post-Operative Coronal Imbalance after Posterior Three-Column Osteotomy for Congenital Fixed Thoracolumbar Kyphoscoliosis: Incidence and Risk Factors**
Xu Sun, MD, PhD; Yong Qiu; Leilei Xu; Zhen Liu; Zhu Ze-Zhang; Bangping Qian, MD; Feng Zhu

15:08 – 15:12 **Paper #148: Anterior-Only Approach to Spina Bifida (MM) Scoliosis**
Glenn N. Boyce, MBBS; Susan S. Thomas, MA; Joseph I. Krajbich, MD

15:12 – 15:16 **Paper #149: Hemivertebra Resection Combined with Wedge Osteotomy for the Treatment of Severe Rigid Congenital Kyphoscoliosis in Adolescence**
Ding-Jun Hao, MD, PhD; Zhongkai Liu, MD

15:16 – 15:20 **Paper #150: Concave Side Opening Wedge Osteotomy with Growing Rod for the Treatment of Congenital Scoliosis in Young Children**
Tamás F. Fekete, MD; Daniel Haschtmann, MD; Frank S. Kleinstueck, MD; Martin Sutter, MD; Andreas Eggspuehler; Dezsoe J. Jeszenszky, MD, PhD

15:20 – 15:27 **Discussion**

15:27 – 15:31 **Paper #151: Positional Brachial Plexus Injury following Corrective Osteotomies for Thoracolumbar Kyphosis Secondary to Ankylosing Spondylitis: Incidence, Risk Factors and Prognosis**
Bangping Qian, MD; Yong Qiu, MD; Zhu Ze-Zhang

15:31 – 15:35 **Paper #152: Selective Thoracic Fusion in the Scoliosis Associated with Syringomyelia and Chiari Malformation Type 1**
Keyi Yu, MD; Jianxiong Shen, MD; Jianguo Zhang, MD

15:35 – 15:39 **Paper #153: Restoring Sagittal Balance Improves Clinical Outcomes for Non-Ambulatory Cerebral Palsy Patients with Spinal Deformity**
Kushagra Verma, MD, MS; Suken A. Shah, MD; Geraldine I. Neiss, PhD; Petya Yorgova, MS; Leok-Lim Lau; Firoz Miyanji, MD, FRCSC; Burt Yaszay, MD; Peter O. Newton, MD; Maty Petcharaporn, BS; Tracey Bastrom, MA; Unni G. Narayanan, MBBS, MSc, FRCS(C); Paul D. Sponseller, MD

15:39 – 15:45 **Discussion**

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9B: Debate Series #3

ROOM: AUDITORIUM 2

MODERATORS: *Douglas C. Burton, MD and Regis W. Haid, Jr., MD*

14:45 – 15:15 **Debate 1: MIS verus Hybrid versus Open for Moderate Degenerative Scoliosis**
MIS: Richard G. Fessler, MD, PhD
Hybrid: Adam S. Kanter, MD
Open: Douglas C. Burton, MD

15:15 – 15:45 **Debate 2: Multilevel Cervical Disc Herniation**
Arthroplasty: Jeffrey A. Goldstein, MD
Anterior Discectomy and Fusion: Rick C. Sasso, MD
Laminoplasty: Morio Matsumoto, MD

9C: Safety Instructional Course Lecture

ROOM: AUDITORIUM 3

MODERATORS: *John P. Dormans, MD and Steven D. Glassman, MD*

14:45 – 14:55 **Pre-Operative Safety Strategies in Complex Spine Surgery**
Sigurd H. Berven, MD

14:55 – 15:05 **Intra-Operative Safety Strategies for Three-Column Osteotomy**
Lawrence G. Lenke, MD

15:05 – 15:15 **Multidiscplinary Approaches to Adult Spinal Deformity Cases**
Rajiv K. Sethi, MD

15:15 – 15:25 **When to Say "No"**
Keith H. Bridwell, MD

15:25 – 15:45 **Discussion**

9D: Spanish Spine Society Instructional Course Lecture

ROOM: SALA 1 & 2

MODERATORS: *Teresa Bas, MD, PhD and Hani Mhaidli, MD, PhD*

14:45 – 14:55 **Cauda Equina System**
Paloma Bas Hermida, MD

14:55 – 15:05 **Acute Spinal Infectious Emergencies**
Enrique Izquierdo, MD

15:05 – 15:15 **Spine Metastases Emergency**
Antonio Martin, MD

15:15 – 15:25 **Surgical Delay and Communted TL Fractures**
Ferran Pellisé Urquiza, MD, PhD

15:25 – 15:45 **Discussion**

15:45 – 16:00 **Refreshment Break & Exhibit Viewing**
MAIN LEVEL FOYER

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

16:00 – 17:00 Concurrent Sessions 10A-E: Instructional Course Lectures & Two-Minute Point Presentations

10A: Pediatric Deformity: Surgical Planning & Techniques Instructional Course Lecture

ROOM: AUDITORIUM 1

MODERATORS: *John P. Dormans, MD and Kamal N. Ibrahim, MD, FRCS(C), MA*

16:00 – 16:10 **How 3D Classification is Changing Surgical Approach**
Peter O. Newton, MD

16:10 – 16:20 **Advances in the Treatment of Congenital Scoliosis**
Laurel C. Blakemore, MD

16:20 – 16:30 **Advances in the Treatment of Neuromuscular Scoliosis**
Paul D. Sponseller, MD

16:30 – 16:40 **Advances in the Treatment of Scheuermann's Kyphosis**
Stefan Parent, MD, PhD

16:40 – 17:00 **Discussion**

10B: Adult Deformity II: Surgical Planning & Techniques Instructional Course Lecture

ROOM: AUDITORIUM 2

MODERATORS: *Henry F.H. Halm, MD and Justin S. Smith, MD, PhD*

16:00 – 16:10 **Techniques to Reduce Blood Loss and Intra-Operative Complications**
Christopher I. Shaffrey, MD

16:10 – 16:20 **Anterior, Transpsoas, Posterior-Only: How to Choose the Best Approach**
Juan S. Uribe, MD

16:20 – 16:30 **Planning the PSO Technique to Give the Best Result**
Shay Bess, MD

16:30 – 16:40 **Role for Vertebral Column Resection in Adult Spinal Deformity**
Lawrence G. Lenke, MD

16:40 – 17:00 **Discussion**

10C: MIS Approaches for Degenerative Disease Instructional Course Lecture

ROOM: SALA 1&2

MODERATORS: *Adam S. Kanter, MD and James D. Schwender, MD*

16:00 – 16:10 **Techniques to Maximize Decompression through an MIS Approach**
Raja Y. Rampersaud, MD, FRCSC

16:10 – 16:20 **Techniques to Maximize Lumbar Lordosis in Degenerative Disease through an MIS Approach**
Richard G. Fessler, MD, PhD

16:20 – 16:30 **Role for Transpsoas Approach in Degenerative Disease**
Praveen V. Mummaneni, MD

16:30 – 16:40 **Are there any Limits to Deformity Correction through MIS Techniques?**
Gregory M. Mundis, Jr., MD

16:40 – 17:00 **Discussion**

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10D: Management of Spondylolisthesis Instructional Course Lecture

ROOM: SALA 3&4

MODERATORS: *Douglas C. Burton, MD and Kenneth M.C. Cheung, MD*

16:00 – 16:10 **Surgical Approaches for Degenerative Spondylolsithesis in the Elderly**
John C. France, MD

16:10 – 16:20 **Management of Isthmic Spondylolisthesis in Childhood**
Daniel J. Sucato, MD, MS

16:20 – 16:30 **Management of Spondylolysis and Low-Grade Spondylolisthesis in the Elite Athlete**
David W. Polly, Jr., MD

16:30 – 16:40 **How Classification Impacts Treatment of High-Grade Spondylolisthesis**
Hubert Labelle, MD

16:40 – 17:00 **Discussion**

10E: Two-Minute Point Presentations

ROOM: AUDITORIUM 3

MODERATORS: *Rajiv K. Sethi, MD and Mark Weidenbaum, MD*

16:00 – 16:02 **Paper #154: Do Ponte Osteotomies Enhance Correction in AIS? An Analysis of 191 Lenke 1A and 1B Curves**
Amer F. Samdani, MD; James T. Bennett, MD; Anuj Singla, MD; Firoz Miyanji, MD, FRCSC; Baron S. Lonner, MD; Suken A. Shah, MD; Harry L. Shufflebarger, MD; Jahangir Asghar, MD; Joshua M. Pahys, MD; Michelle C. Marks, PT, MA; Peter O. Newton, MD; Randal R. Betz, MD; Patrick J. Cahill, MD

16:02 – 16:04 **Paper #155: Monitoring the Thoracic/Thoracolumbar Scoliosis Curves Progression using Surface Topography Asymmetry Analysis of the Torso in Adolescents**
Amin Komeili, MSc; Eric C. Parent, PT, MSc, PhD; Marwan El-Rich, PhD; Samer Adeeb

16:04 – 16:06 **Paper #156: The Optimal Surgical Approach for Lenke 5 Curves: Is the Anterior Approach Ready for a Comeback?**
Firoz Miyanji, MD, FRCSC; Tracey Bastrom, MA; Amer F. Samdani, MD; Burt Yaszay, MD; Jahangir Asghar, MD; Suken A. Shah, MD; Randal R. Betz, MD; Harry L. Shufflebarger, MD; Peter O. Newton, MD

16:06 – 16:08 **Paper #157: IONM Alerts during Surgery for AIS: Triggering Events and the Surgeon's Response**
Jahangir Asghar, MD; Joshua M. Pahys, MD; Amer F. Samdani, MD; Firoz Miyanji, MD, FRCSC; Burt Yaszay, MD; Harry L. Shufflebarger, MD

16:08 – 16:10 **Paper #158: Characteristics and Surgical Treatment of Scoliosis in the 22q11 Deletion Syndrome: An Analysis of 1067 Patients**
Dino Colo, MD; John P. Dormans, MD; Moyo Kruyt, MD, PhD; Elaine H. Zackai; Alice G. Bailey; Donna M. McDonald-McGinn, MS, CGC; Denis S. Drummond, MD; Rene M. Castelein, MD, PhD

16:10 – 16:12 **Paper #159: Long-Term Effects of Eight Weeks of Spinal Stabilization Exercises in Adolescents with Idiopathic Scoliosis and Low Back Pain**
Karina A. Zapata, PT, DPT, PhD; Sharon Wang-Price, PhD; Daniel J. Sucato, MD, MS

16:12 – 16:20 **Discussion**

16:20 – 16:22 **Paper #160: The Lumbar Pelvic Angle (LPA), the Lumbar Component of the Fan of Spinopelvic Alignment, Correlates with HRQOL and PI-LL Mismatch and Predicts Global Alignment**
Themistocles S. Protopsaltis, MD; Kristina Bianco, BA; Justin S. Smith, MD, PhD; Peter G. Passias, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Shay Bess, MD; Eric Klineberg, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

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16:22 – 16:24 **Paper #161: Assessment of Impact of Long-Cassette Standing X-Rays on Surgical Planning for Lumbar Pathology: An International Survey of Spine Surgeons**
Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Regis W. Haid, Jr., MD; Themistocles S. Protopsaltis, MD; Eric Klineberg, MD; Justin K. Scheer, BS; Vedat Deviren, MD; Robert A. Hart, MD; Shay Bess, MD; Paul Arnold; Jens Chapman, MD; Michael G. Fehlings, MD, PhD; Christopher P. Ames, MD

16:24 – 16:26 **Paper #162: Posterior Column Reconstruction Improves Fusion Rates at the Level of the Osteotomy in Pedicle Subtraction Osteotomies**
Stephen J. Lewis, MD, MSc, FRCSC; Sofia Magana, BSc; Chandan Mohanty; David Burns, MD, BaSc, Shadi Shihata, MB, ChB, FRCSC

16:26 – 16:28 **Paper #163: Efficiency in Adult Spinal Deformity (ASD) Surgery: A Multicenter Comparison of Resource Use**
Ian McCarthy, PhD; Michael F. O'Brien, MD; Chessie Robinson, MA; Munish C. Gupta, MD; Christopher P. Ames, MD; Virginie Lafage, PhD; Robert A. Hart, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Khaled Kebaish, MD; Justin S. Smith, MD, PhD; Eric Klineberg, MD; Richard Hostin, MD; International Spine Study Group

16:28 – 16:30 **Paper #164: Comparison of Reliability of the SRS-Schwab Classification between Idiopathic and Degenerative Scoliosis in Adults**
Zhen Liu; Yong Qiu, MD; Yong Liu; Feng Zhu; Zhu Ze-Zhang; Bangping Qian, MD; Xu Sun, MD, PhD; Long Jiang

16:30 – 16:32 **Paper #165: A Report of 52 Cases of Three-Column Osteotomies of the Upper Thoracic Spine and Cervicothoracic Junction: Complications, Outcomes and Differential Impact on Spinal Pelvic Parameters, Cervical Sagittal Alignment and General Health Status**
Christopher P. Ames, MD; Haruki Funao, MD; Ehsan Tabaraee, MD; Justin K. Scheer, BS; Vedat Deviren, MD; Khaled Kebaish, MD

16:32 – 16:40 **Discussion**

16:40 – 16:42 **Paper #166: Analysis of Deglutition after Occipitocervical Arthrodesis for Cervical Deformity in Rheumatoid Arthritis**
Hirotaka Haro, MD; Koji Fujita, MD; Tetsuro Ohba; Shigeto Ebata

16:42 – 16:44 **Paper #167: High Incidence of Cervical Deformity and Instability Requires Surveillance in Loeys-Dietz Syndrome**
Sara K. Fuhrhop, BS; Mark J. McElroy, MS; Harry Dietz, MD; Paul D. Sponseller, MD

16:44 – 16:46 **Paper #168: Impact of Ethnicity on Adult Spinal Deformity (ASD) Surgical Outcomes: An Analysis of Japanese and North American Databases**
Virginie Lafage, PhD; Morio Matsumoto, MD; Naobumi Hosogane, MD; Justin S. Smith, MD, PhD; Themistocles S. Protopsaltis, MD; Yu Yamato; Yukihiro Matsuyama, MD; Hiroshi Taneichi, MD; Shian Liu, BS; Emmanuelle Ferrero; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Christopher P. Ames, MD; International Spine Study Group

16:46 – 16:48 **Paper #169: Prognosis for Intra-Operative Spinal Cord Injury in Severe Spinal Deformity Surgery in the Developing World**
Oheneba Boachie-Adjei, MD; Benjamin T. Bjerke-Kroll, MD, MS; Daniel Zuchelli, BS; Venu M. Nemani, MD, PhD; Jennifer Ayamga, Mphil; Ronald G. Emerson, MD; FOCOS Research Associates

16:48 – 16:50 **Paper #170: Peri-Operative Complications of Total En Bloc Spondylectomy: Adverse Effects of Pre-Operative Irradiation**
Noriaki Yokogawa; Hideki Murakami; Satoru Demura, MD; Satoshi Kato, MD; Katsuhito Yoshioka, MD; Hiroyuki Hayashi; Takayoshi Ishii; Takashi Igarashi; Xiang Fang; Hiroyuki Tsuchiya

16:50 – 16:52 **Paper #171: Accuracy of Automated Onsite GeneXpert PCR Testing for Spinal Tuberculosis**
Robert N. Dunn, FCS (SA) Orth; Michael Held, MD, FCS (Orth); Maritz Laubcher, MBChB, Dip PEC, FCS SA (Orth)

16:52 – 17:00 **Discussion**

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

17:00 – 17:30	HOW Refreshment Break SALA LEVEL (LEVEL 1)
17:30 – 18:30	*Afternoon Hands-On Workshops with Beverages, Snacks *(See "Exhibits and Hands-On Workshops" section on page 213 for more information.)*
19:30 – 23:00	Course Reception *Please see page 6 for more information.*

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

8:30 – 13:00 Registration Open
MAIN LEVEL LOBBY

Exhibits Closed

E-Poster and Internet Café Open
CAFE

8:30 – 9:15 Breakfast
MAIN LEVEL FOYER

9:15 – 10:15 Concurrent Sessions 11A-C: Instructional Course Lectures

11A: Management of Lumbar DDD

ROOM: AUDITORIUM 1
MODERATORS: *Jeffrey D. Coe, MD and Praveen V. Mummaneni, MD*

9:15 – 9:25	**What is the Biologic Basis of Lumbar DDD and Can it be Reversed?** *Jeffery C. Wang, MD*
9:25 – 9:35	**What is the Appropriate Clinical and Radiographic Evaluation for Surgical Selection in Lumbar DDD?** *John R. Dimar, II, MD*
9:35 – 9:45	**What are the Outcomes of Fusion Surgery for Lumbar DDD?** *Alexander R. Vaccaro, III, MD*
9:45 – 9:55	**Is There Still a Role for Arthroplasty in Lumbar DDD?** *Jeffrey A. Goldstein, MD*
9:55 – 10:15	**Discussion**

11B: Management of Metastatic Spine Disease

ROOM: AUDITORIUM 3
MODERATORS: *Munish C. Gupta, MD and Christopher I. Shaffrey, MD*

9:15 – 9:25	**The Impact of Tumor Burden and Medical Condition on the Decision to Pursue Surgical Management** *John C. France, MD*
9:25 – 9:35	**Role of En Bloc Resection in Metastatic Disease** *Peter S. Rose, MD*
9:35 – 9:45	**Surgical Approach and Role for Instrumentation in Metastatic Spine Disease** *Morio Matsumoto, MD*
9:45 – 9:55	**Role for Vertebroplasty and Radiation for Radiosensitive Metastases** *Laurence D. Rhines, MD*
9:55 – 10:15	**Discussion**

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

11C: Emerging Technologies in Spine Surgery

ROOM: AUDITORIUM 2

MODERATORS: *Henry F.H. Halm, MD and Rick C. Sasso, MD*

9:15 – 9:25 **Emerging Technologies in Complex Cervical Reconstruction**
K. Daniel Riew, MD

9:25 – 9:35 **Emerging Technologies in Spinal Cord Injury**
Michael G. Fehlings, MD, PhD, FRCSC, FACS

9:35 – 9:45 **Emerging Technologies in Pediatric Spinal Deformity**
Suken A. Shah, MD

9:45 – 9:55 **Advances in the Surgical Treatment of Adult Spinal Deformity**
Michael Mayer, MD, PhD

9:55 – 10:15 **Discussion**

10:15 – 10:30 Refreshment Break
MAIN LEVEL FOYER

10:30 – 11:30 Concurrent Sessions 12A-B: Debate Series & Two-Minute Point Presentations

12A: Two-Minute Point Presentations

ROOM: AUDITORIUM 2

MODERATORS: *David S. Marks, FRCS and David W. Polly, Jr., MD*

10:30 – 10:32 **Paper #172: Anterior Posterior versus Posterior-Only Correction in Adult Spinal Deformity Matched Curves: Similar Correction with More Intra-Operative, but Fewer Late Implant Complications**
Eric Klineberg, MD; Munish C. Gupta, MD; Stacie Nguyen, MPH; Christopher P. Ames, MD; Douglas C. Burton, MD; Michael P. Kelly, MD; Gregory M. Mundis, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Frank J. Schwab, MD; Thomas J. Errico; Richard Hostin, MD; Han Jo Kim, MD; Shay Bess, MD; International Spine Study Group

10:32 – 10:34 **Paper #173: Radiographic Parameters Associated with Revision for Proximal Junctional Kyphosis**
Fred H. Nicholls, MD, MA, FRCSC; Murat S. Eksi, MD; Christopher P. Ames, MD; Sigurd H. Berven, MD; Shane Burch, MD; Dean Chou, MD; Gokhan H. Demirkiran; Praveen V. Mummaneni, MD; Murat Pekmezci, MD; Bobby Tay, MD; Vedat Deviren, MD

10:34 – 10:36 **Paper #174: A Prospective Randomized Trial on Anterior Cervical Discectomy and Fusion with Anterior Plating and Stand-Alone Cage: Interim Analysis of the Difference in the Canal Encroachment by Fusion Mass**
Soo Eon Lee, MD; Chun Kee Chung, MD, PhD; Chi Heon Kim, MD, PhD

10:36 – 10:38 **Paper #175: Radiographic Characteristics of Bony Septum of Split Spinal Cord Malformation in Patients Presenting with Congenital Scoliosis: A Retrospective Study of 40 Cases**
Ding-Jun Hao, MD PhD; He Bao-Rong, MM; Hua Hui, MD

10:38 – 10:40 **Paper #176: Radiographic Markers of Disc Degeneration Following Surgery for Adolescent Idiopathic Scoliosis: A Ten-Year Follow Up Evaluation**
Baron S. Lonner, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Peter O. Newton, MD; Randal R. Betz, MD; Amer F. Samdani, MD; Daniel Lefton, MD; Karen Chen, MD

10:40 – 10:42 **Paper #177: A Novel Measurement of Post-Operative Axial Plane Rotation in Adolescent Idiopathic Scoliosis using Plain Radiographs**
Benjamin T. Bjerke-Kroll, MD, MS; Grant D. Shifflett, MD; Sravisht Iyer; Peter D. Fabricant, MD; Zoe B. Cheung, MS; Peter B. Derman, MD; Han Jo Kim, MD

10:42 – 10:50 **Discussion**

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

10:50 – 10:52 **Paper #178: Why Lumbar Artificial Disc Replacements (ADR) Fail**
Kenneth A. Pettine, MD; Fernando Techy, MD

10:52 – 10:54 **Paper #179: Halo-Gravity Traction Improves Thoracic Kyphosis Correction for Those Early Onset Scoliosis Patients Undergoing Growing Spine Techniques**
Patrick A. Sugrue, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Michael P. Kelly, MD; Scott J. Luhmann, MD; Brenda A. Sides, MA; David B. Bumpass, MD; Isaac Karikari, MD; Jeffrey L. Gum, MD

10:54 – 10:56 **Paper #180: Reconstruction of Wide Laminectomy Defects with Femoral Strut Allograft (FSA) following Three-Column Osteoteomies (3CO)**
Meric Enercan; Sinan Kahraman; Ayhan Mutlu; Mesut Kilic, MD; Erden Erturer; Cagatay Ozturk, MD; Ahmet Alanay; Azmi Hamzaoglu, MD

10:56 – 10:58 **Paper #181: Prospective, Multicenter Assessment of Non-Operative Treatment Outcomes and Conversion to Operative Treatment for Adult Spinal Deformity: Minimum Two-Year Follow Up**
Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Themistocles S. Protopsaltis, MD; Eric Klineberg, MD; Munish C. Gupta, MD; Kai-Ming Fu, MD, PhD; Richard Hostin, MD; Vedat Deviren, MD; Robert A. Hart, MD; Douglas C. Burton, MD; Shay Bess, MD; Christopher P. Ames, MD; International Spine Study Group

10:58 – 11:00 **Paper #182: Four Rods Prevent Rod Breakage and Pseudarthrosis in Pedicle Subtraction Osteotomies**
Sachin Gupta; Murat S. Eksi, MD; Blythe Durbin-Johnson, PhD; Christopher P. Ames, MD; Vedat Deviren, MD; Munish C. Gupta, MD

11:00 – 11:02 **Paper #183: A Minimally Disruptive Muscle Sparring Approach in MIS its Effect on Patient Outcomes: A Comparision to the Open Approach**
Donald W. Kucharzyk; Dushan Budimir, BS, RA

11:02 – 11:10 **Discussion**

11:10 – 11:12 **Paper #184: Prospective FDA IDE Clinical Safety Trial of a Scoliosis Growth Modulation Clip/Screw Device: One-Year Results**
Eric Wall, MD; Joseph E. Reynolds, MBA; Viral Jain, MD; Donita Bylski-Austrow, PhD; George H. Thompson, MD; Paul Samuels; Sean J. Barnett, MD, MS; Alvin H. Crawford, MD

11:12 – 11:14 **Paper #185: Anterior Column Realignment (ACR): Minimum Two-Year Follow Up of Clinical and Radiographic Outcomes**
Drew Brown, MD; Gregory M. Mundis, MD; Navid R. Arandi; Ali Bagheri, MD; Stacie Nguyen, MPH; Robert K. Eastlack, MD; Ramin Bagheri, MD; Behrooz A. Akbarnia, MD

11:14 – 11:16 **Paper #186: Two-Level Spinal Osteotomy for Severe Thoracolumbar Kyphosis in Ankylosing Spondylitis: Experience with 48 Patients**
Yonggang Zhang, PhD; GuoQuan Zheng; Yan Wang, MD

11:16 – 11:18 **Paper #187: Outcomes of Lumbar Spine Surgery in Patients with Parkinson's Disease**
Branko Skovrlj, MD; Javier Guzman, BS; Samuel K. Cho, MD; John Caridi, MD

11:18 – 11:20 **Paper #188: Laminoplasty versus Laminectomy and Fusion to Treat Cervical Spondylotic Myelopathy: Outcomes of the Prospective Multicenter AOSpine International CSM Study**
Michael G. Fehlings, MD, PhD; Branko Kopjar, MD, PhD, MS; Shashank S. Kale, MCh Neurosurgery; Helton L. Defino, MD; Giuseppe Barbagallo; Ronald H. Bartels, MD,PhD; Paul Arnold; Mehmet Zileli, MD; Gamaliel Tan, MBBS, FRCS; Osmar J. Moraes, MD; Yasutsugu Yukawa, MD; Massimo Scerrati, Head of Neurosyrgery, Ancona; Tomoaki Toyone, MD, PhD; Masato Tanaka, MD; Ciaran Bolger

11:20 – 11:22 **Paper #189: Surgery in Pott's Disease: Experience of 135 Cases**
Md. Shah Alam, MS, FRCS, FCPS

11:22 – 11:30 **Discussion**

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

12B: Debate Series # 4

ROOM: AUDITORIUM 1

MODERATORS: *Christopher P. Ames, MD and Kenneth M.C. Cheung, MD*

10:30 – 10:50 **Debate 1: Thoracolumbar Fractures without Neurological Deficits are Best Treated with MIS Techniques**
Pro: Rajiv K. Sethi, MD
Con: John C. France, MD

10:50 – 11:10 **Debate 2: Which Motion-Sparing Procedure is Best for Lateral Cervical Disc Herniation with Radiculopathy?**
Arthoplasty: Rick C. Sasso, MD
Foraminotomy: Vincent Traynelis, MD

11:10 – 11:30 **Debate 3: Is BMP Needed for Complex Revision Lumbar Spine Fusion?**
Pro: Jeffrey C. Wang, MD
Con: Sigurd H. Berven, MD

11:30 – 11:45 Walking Break

11:45 – 13:00 Session 13: My Worst Complication Series: Strategies to Prevent/Manage #3

ROOM: AUDITORIUM 1

MODERATORS: *Shay Bess, MD and D. Kojo Hamilton, MD*

11:45 – 12:00 **Cervical Degenerative Disease**
K. Daniel Riew, MD

12:00 – 12:15 **Complex Tumor Resection**
Peter S. Rose, MD

12:15 – 12:30 **Spondylolisthesis**
Hubert Labelle, MD

12:30 – 12:45 **Spine Trauma**
F. Chumhur Oner, MD, PhD

12:45 – 13:00 **Pediatric Deformity**
David S. Marks, FRSC

13:00 Adjourn

**denotes non-CME session*

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Paper Abstracts

VALENCIA spain JULY 16-19 2014

PALACIO DE CONGRESOS DE VALENCIA

The Scoliosis Research Society gratefully acknowledges NuVasive
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Paper Abstracts

1. MORBIDITY AND MORTALITY OF COMPLEX SPINE SURGERY: A PROSPECTIVE COHORT STUDY IN 679 PATIENTS VALIDATING THE SAVES SYSTEM IN A EUROPEAN POPULATION

Sven Karstensen, BSc; Tanvir Bari; Martin Gehrchen, MD, PhD; John Street, MD, PhD; Benny Dahl, MD, PhD, DMSci
Denmark

Summary: Increased activity in spine surgery mandates valid and reliable recognition of adverse events. To date, the previously validated SAVES system has not been examined for generalizability in either non-Canadian or pediatric populations. This study confirms the generalizability of the system, reaffirms the importance of prospective data collection and demonstrates a significantly higher risk of peri-operative in patients over the age of 65.

Introduction: Until recently the literature examining surgical complications has primarily been retrospective or based on national databases with few variables. The Spine AdVerse Events Severity system (SAVES) has been found reliable and valid in two Canadian centers, to provide precise information regarding all adverse events. The purpose of the present study was to assess the generalizability of the SAVES system in a European population of patients, including pediatric patients, undergoing complex spine surgery.

Methods: All patients undergoing spinal surgery at a tertiary referral center in the period January 1, 2013 through December 31, 2013 were prospectively included. The study was conducted according to the principles of the SAVES system with minor modifications due to institutional factors. The original SAVES form was used, and a research coordinator collected all data prospectively. Once a week all patients were reviewed for additional events, validation of the data and clarification of any questions. The survival status was registered on January 31, 2014 to obtain 30-day survival.

Results: A total of 679 consecutive patients were prospectively studied with 100% SAVES data completed. The in-hospital mortality was 1.3% and the 30-day mortality was 2.7 %; all occurring after emergency procedures. There was no significant difference between lengths of stay after elective or emergency surgery. The number of intraoperative AE's was 162 and the number of postoperative AE's was 1415; the most frequent event being postoperative electrolyte imbalance. 2.2% of the patients had postoperative infections requiring surgical revision. The frequency of postoperative AE's was significantly higher in patients 65 years or older compared to young individuals (P=0.002).

Conclusion: Our results confirm that a rigorous prospective system improves adverse event recognition, and our data confirms the generalizability of the SAVES system to non-Canadian populations including pediatric patients.

2. SHOULD OUR ELDERLY SPINAL DEFORMITY PATIENTS HAVE THE SAME TARGETS FOR CORRECTION AND IS THERE AN OPTIMAL ALIGNMENT TARGET THAT RESULTS IN LESS PJK?

Themistocles S. Protopsaltis, MD; Stephen P. Maier, BA; Justin S. Smith, MD, PhD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Thomas J. Errico; Shay Bess, MD; Eric Klineberg, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group
USA

Summary: Elderly patients have higher rates of PJK and complications. Current targets for deformity correction (SVA <5cm, PT <20 deg, PI-LL<9) are derived from adult databases that include the entire age spectrum and baseline data. A novel radiographic parameter of sagittal alignment, the TPA, has been proposed with a postoperative target <15 degrees. Post-operative and pre-operative alignment parameters corresponding to thresholds of disability differ for the elderly and younger patients suggesting the need for different targets of correction.

Introduction: Targets for deformity correction have been proposed from adult deformity databases. Published alignment targets are based on broad age ranges of adults using baseline data. This study investigates post-operative alignment parameters and HRQOL to determine the validity of such alignment targets among elderly and middle-aged (MA) patients.

Methods: Multicenter, prospective, analysis of consecutive ASD patients. Inclusion criteria: ASD, age>18, and any of the following: scoliosis Cobb angle >20 deg, SVA>5 cm, thoracic kyphosis>60 deg, and PT greater than 25 deg. Clinical measures of disability included ODI, SRS and SF36. Baseline and 2-yr follow-up radiographic and HRQL outcomes evaluated.

Results: 520 ASD patients were enrolled (mean age 53.7). 407 patients underwent deformity correction with 2 year follow up. The operative patients were subanalyzed by age: elderly (ED: >65yo, n=67) and middle age (MA: 40-60yo, n=99). At 2 years postop, Elderly patients were more poorly aligned by TPA (23° vs 15°), SVA (5.9 vs 4.4 cm), PT (25.3° vs 19.6°) and PI-LL (12.1° vs 3.7°) with all p<0.01. Utilizing a linear regression analysis, alignment thresholds were identified in the elderly and MA corresponding to severe disability (ODI=40) for TPA (ED 27.3° vs MA 19.0°) and SVA (8.2cm vs 4.0cm) and mild disability (ODI=20) for SVA (5.5 cm vs 1.7cm), and TPA (24° vs 14.6°). Patients were classified as well aligned (WA) or poorly aligned (PA) based on their age group; for elderly WA: TPA<20° vs PA: TPA>20°; for middle age WA: TPA°<15 vs PA: TPA°>15. PJK within 2 years follow up was more common among the elderly (56% vs 42%) but not related to alignment (elderly: 56% WA vs 55% PA; MA: 42% WA vs 41% PA).

Conclusion: Elderly spinal deformity patients have larger global deformities and higher rates of PJK. Rates of PJK did not differ in either age group based on the adequacy of postoperative alignment at 2 years. Based on this data, targets for deformity correction are different for the elderly (TPA<24; SVA<5.5) compared to middle aged patients (TPA <15; SVA<2cm).

Paper Abstracts

3. CLINICAL RESULTS AND FUNCTIONAL OUTCOME OF LUMBO-SACRAL THREE-COLUMN OSTEOTOMIES IN ADULT SPINAL DEFORMITY PATIENTS

Haruki Funao, MD; Floreana A. Naef; Jaykar R. Panchmatia, MA, MPH, MB, BChir, MRCS, FRCS; David Li, MS; Richard L. Skolasky, ScD; Khaled Kebaish, MD; Jaysson T. Brooks, MD
USA

Summary: Three column osteotomy of L5 or the sacrum (LS3CO) can be technically challenging yet may be required in patient with lumbo-sacral deformity. A new anatomical spinopelvic parameter, named lumbo-sacral angle (LSA) was defined to evaluate lumbo-sacral sagittal alignment below S1. LS3CO resulted in significant improvements in lumbo-sacral kyphosis, and sagittal balance in the immediate post-operative period and at final follow-up. Clinical outcome also showed significant improvement. Patients who remained sagittaly imbalanced had a significantly worse outcome.
Introduction: Although 3 column osteotomies are technically demanding, they are effective in correcting rigid spinal deformities. However, the outcomes associated with three column osteotomies at L5 or the sacrum (LS3CO) have not yet been evaluated. The aim of this study are to quantify sagittal balance following LS3CO, and identify predictors of poor postoperative clinical outcome.
Methods: A retrospective review from a prospectively collected database was performed. Patients undergoing LS3CO were included. The lumbo-sacral sagittal alignment below S1, was evaluated using a new angle named LSA, which is defined as the angle between T12, and the perpendicular line connecting the endplates of S3-S4. Radiographic/clinical assessment was conducted with a minimum 2-year follow-up. Statistical analyses were performed using one way ANOVA.
Results: A total of 25 patients met inclusion criteria. Mean age was 56.3 (21-76) years. 18 were females, mean BMI was 24.5. The initial diagnoses were: L5 fracture (2), sacral fracture (5) distal to a long fusion; pseudoarthrosis at lumbosacral area (10); high-grade spondylolisthesis (4); and flat back with sagittal imbalance (4). PSO was performed in 24 patients, (L5; 18, S1; 6), and VCR in 1 patient (L5). All patients were fused to the pelvis. Mean fused levels were 6.4 (3-10) vertebrae. Mean radiographic changes were (pre/post/final); thoracic kyphosis (TK) (25.2/32.0/35.9°), lumbar lordosis (LL) (-34.4/-50.9/-49.1°), LSA (0.5/22.2/21.5°), pelvic tilt (27.7/23.2/24.1°), and SVA (17.7/6.2/7.3cm). SRS 22 domains were improved; (pre/final); activity (2.6/3.5), pain (2.4/3.4), self-image (2.4/3.3) ($P<0.01$), mental (3.0/3.5) ($P=0.08$), and satisfaction (2.5/3.3) ($P<0.05$). ODI also showed a significant decrease (62.7/40.1) ($P<0.01$). SVA>5cm was associated with less improvement in SRS22 satisfaction, and LSA<20° showed significantly lower SRS22 activity at final follow-up ($P=0.01$). 11 patients required surgery; PJK (5), pseudoarthrosis (3), junctional stenosis (2), and neurologic deficit (1).
Conclusion: Although technically demanding, LS3CO resulted in improved clinical and radiological outcomes. Patients who remained sagittaly imbalanced had a significantly worse functional outcome.

4. ADOLESCENT IDIOPATHIC SCOLIOSIS PATIENTS ARE AT INCREASED RISK FOR PULMONARY HYPERTENSION WHICH REVERSES AFTER SCOLIOSIS SURGERY

Vishal Sarwahi, MD; Rachel E. Borlack, BS; Aviva G. Dworkin, BS; Dan Wang, MS; Sarika Kalantre, MD
USA

Summary: This is the first study to document evidence of pulmonary hypertension(pulm HT) in AIS patients, the severity of which directly correlates with the size of the curve. Pulmonary hypertension, which can potentially be fatal, reverts to normal after corrective scoliosis surgery. These findings provide direct evidence of immediate benefit of scoliosis surgery and can change the entire scoliosis treatment paradigm.
Introduction: Pulm HT has high mortality. Incidence of structural cardiac disease and pulm HT in AIS patients has been infrequently studied.
Methods: Retrospective review of AIS pts with PSF from '09 -'12 was done. 2D echos where reviewed for structural heart disease, aortic root size, and Tricuspid regurgitant jet velocity (TRV). Right ventricular systolic pressure (RVSP) was estimated using the Bernoulli's equation (4*(TRV)2 + right atrial pressure). RVSP > 25mm Hg was indicates pulmonary hypertension.
2D echo of 100 aged matched health adolescents served as control. Spearman correlation and Logistic Regression analysis was done.
Results: 160 pts had spinal fusion surgery in the study period. Of these, 120 had AIS and 107 AIS pts(72F:35M) had screening 2D echos. Average age was 14.8 ± 2.2 years. Average Cobb angle was 50.9±12.3°. 2 AIS pts had ASD, 2 had VSD, and 3 had MVP, while 64 pts had mild to trivial mitral regurgitation.
24 AIS pts had higher incidence of mild tricuspid regurgitation ($p<0.001$) and higher TRV/ RVSP (>25 mm Hg) ($p=0.04$) indicating pulmonary HT. Spearman correlation coefficient between cobb angle and RVSP was 0.32 in AIS ($p=0.04$). This is a significant correlation between increasing cobb and worsening RVSP. Logistic Regression showed an odds ratio of 3.29 for elevated TRV (meaning increased pulmonary HT) in AIS ($p = 0.007$).
18 out of 24 AIS patients with elevated TRV/RVSP had 2D echo at 2 year post-op. All had normal RVSP (mean 20.4 mm Hg), which shows reversal of pulmonary HT to normal values.
Conclusion: Screening 2D echo identifies structural heart defects and pulm HT. Scoliosis surgery prevents progression and reverses pulm HT, avoiding potentially fatal compromise.

5. THE MOTION SPARING BENEFITS OF SELECTIVE THORACIC FUSION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Maty Petcharaporn, BS; Suken A. Shah, MD; Amer F. Samdani, MD; Randal R. Betz, MD; Baron S. Lonner, MD; Firoz Miyanji, MD, FRCSC; Peter O. Newton, MD
USA

Summary: In this prospective study, the motion in the unfused distal segments in patients who had a selective thoracic fusion was evaluated with attention to residual lumbar curve magnitude. In 136 patients, summed motion in the unfused segments and motion at the apex of the residual curve did not correlate with residual lumbar curve

deformity. The motion sparing benefits of selective thoracic fusion was supported by the finding of unchanged mobility from any residual lumbar deformity.

Introduction: Performing a selective thoracic fusion in adolescent idiopathic scoliosis (AIS) primary thoracic curves spares vertebral motion segments and optimizes post-operative functional mobility for the patient. However, the patient is sometimes left with a residual lumbar deformity. The aim of this study was to evaluate the effect of the residual curve on motion of the unfused segments.

Methods: Patients were offered inclusion into this IRB approved prospective study at their routine 2-13 year post-operative visits at one of 5 centers. Coronal motion was assessed by standardized radiographs acquired in maximum right and left bending positions and intervertebral angles were measured via digital radiographic measuring software. Summed motion in all unfused segments and motion at the apex of the lumbar curve was evaluated. Patients treated with a selective fusion (SF), defined as lowest instrumented vertebrae of L1 or above, were assessed for alterations in motion with regards to magnitude of the residual lumbar curve with Pearson correlation.

Results: The data for 136 patients with SF were included. The average length of follow-up (F/U) was 5±3 years (range 2 to 13) and the average age of the patients at F/U was 19±3 years (range 13 to 26). The average post-operative residual lumbar curve magnitude at current F/U was 16±8 degrees (range 0 to 37). No correlations were found with distal summed motion in the unfused segments or motion at the apex of the curve and the size of the residual lumbar curve (Table 1).

Conclusion: Sparing vertebral segments so motion can be shared across more levels has been previously shown as beneficial. Patient satisfaction has been previously correlated with a lower deformity flexibility quotient (residual deformity divided by the number of unfused motion segments). Motion in the unfused distal segments in the years following a selective thoracic fusion for AIS is preserved and not affected by the magnitude of the residual lumbar curve at an average of 5 year follow up.

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

6. A PROSPECTIVE COMPARISON OF WILTSE VERSUS MIDLINE APPROACHES IN DEGENERATIVE CONDITIONS OF THE LUMBAR SPINE

R. Andrew Glennie, MD, FRCSC; Juliet Batke, BSc; Charles G. Fisher, MD, MHSc, FRCSC; Michael Boyd, MD; John Street, MD, PhD
Canada

Summary: Two prospective cohorts of Wiltse and Midline degenerative thoracolumbar patients were enrolled and followed for three years. Outcomes such as infection, pseudarthrosis, adjacent segment degeneration and hardware failure rates were compared for both groups

Introduction: The majority of single and two level lumbar degenerative conditions have traditionally been treated with an open midline approach. The Wiltse approach has gained popularity in the past decade as a less traumatic muscle splitting approach. Little is known however, about surgical and patient outcomes comparing both approaches. To determine whether there is any significant difference in surgical site infection (SSI), fusion rate, length of stay, wound complications and re-operation rate when comparing the two procedures.

Methods: Patients admitted to Vancouver General Hospital requiring a midline (n=255) or wiltse (n=103) approach for a two to three level instrumented fusion of the lumbar spine for degenerative or deformity spine conditions between March 2005 and January 2009, were identified. The cases were matched for age, sex, comorbidities and number of levels fused. There was a minimum of 3 years follow-up for all patients and statistical analysis was performed using Fisher's exact test and one sided p-values

Results: Mean age ($p<0.001$), length of hospital stay ($p=0.008$) and intra-operative blood loss ($p<0.001$) were significantly lower in the Wiltse group. The rate of SSI was significantly different in the midline group 19/255 (7.4%) versus the Wiltse group 1/103 (1.0%) ($p=0.018$). The rate of additional surgical procedures was higher in midline group ($p=0.025$; Odds Ratio: 0.47 (CI 0.23-0.95). Delayed wound complication and adjacent segment failure was also higher in the midline group. Radiographic pseudoarthrosis rate was higher in the Wiltse group (25% v. 7%). Blood transfusion was similar for each group ($p<0.001$)

Conclusion: The Wiltse approach may be a more viable option in those patients at risk for wound breakdown or infection. Blood loss with each procedure is lower statistically with the Wiltse group but unlikely of clinical significance given the similar rate of blood transfusion. Pseudarthrosis is of genuine concern, however, this does not seem to translate into need for further surgical procedures.

7. RELATIVE BENEFIT OF TLIF VERSUS PSF AT FIVE-YEAR FOLLOW UP STRATIFIED BY DIAGNOSTIC INDICATION

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USA

Summary: In a propensity-matched cohort, HRQOLs at five years post-op were very similar in patients with spondylolisthesis treated by either TLIF or PSF. We previously reported that two-year post-op HRQOL improvements were similar in disc pathology patients treated with either TLIF or PSF. However, at five years post-op the PSF cohort did not appear to be as good as the patients treated by TLIF. In patients with post-decompression instability, TLIF generated somewhat better outcomes at both two and five years post-op.

Introduction: A previous study demonstrated that at two years post-op, HRQOLs were not significantly different after TLIF compared to PSF in our patients with spondylolisthesis or disc pathology, but that TLIF resulted in better outcomes in patients with post-decompression instability. The purpose of this study is to determine if those findings held true at five years post-op.

Methods: 63 patients with degenerative spondylolisthesis, 37 patients with disc pathology and 23 patients with post-decompression instability who underwent one or two level TLIF, and had five-year postoperative HRQOL measures, were propensity-matched to a cohort of PSF patients based on age, number of surgical levels, body mass index, sex, smoking status, workers' compensation status, and preoperative HRQOLs including ODI, SF-36 PCS, SF-36 MCS, back and leg pain scores.

Results: There was a statistically significant improvement in HRQOLs at five years after surgery compared to baseline in all cohorts. Although the differences seen in ODI, SF-36PCS, back and leg pain scores between patients who had a TLIF vs PSF were not statistically significant, improvement in ODI with TLIF was notably greater compared to PSF in patients with disc pathology (14.0 vs 6.9) and post-decompression (11.8 vs. 6.7). ODI at five years post-op was similar in patients with spondylolisthesis (11.1 vs 13.1).
Conclusion: HRQOL outcomes at five years post-op were essentially equivalent in patients with spondylolisthesis treated with either TLIF or PSF. At two years post-op, HRQOL improvements had also been similar for disc pathology patients treated with either TLIF or PSF. However, at five years post op, improved outcomes were less well sustained in patients treated with PSF compared to TLIF. In patients with post-decompression instability, TLIF generated better outcomes at both two and five years after surgery compared to PSF. This study provides additional evidence to suggest that the most appropriate surgical procedure for a given patient is dependent upon the specific pathology. Larger cohorts will be needed to better define which patients derive sustained benefit from the additional resources associated with TLIF.

Change from baseline to five-years after surgery for different HRQOL measures in different subgroups

	Spondylolisthesis			Disc Pathology			Post-Decompression		
	PSF	TLIF	p-value	PSF	TLIF	p-value	PSF	TLIF	p-value
N	63	63		37	37		23	23	
Back Pain	2.4	2.4	0.890	2.0	2.0	0.782	2.1	2.3	0.799
Leg Pain	3.2	2.5	0.224	1.7	2.5	0.214	1.2	1.8	0.576
ODI	13.1	11.1	0.533	6.9	14.0	0.139	6.7	11.8	0.301
SF36 PCS	5.3	4.4	0.684	2.5	7.0	0.191	1.0	0.1	0.730
SF36 MCS	4.5	3.3	0.997	4.3	3.8	0.814	4.4	6.3	0.342

8. CLINICAL OUTCOMES OF MINIMALLY INVASIVE VERSUS OPEN SINGLE-LEVEL TLIF: A PROPENSITY MATCHED COHORT STUDY

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Summary: In a propensity-matched case control study, both MIS TLIF and Open TLIF lead to significant improvements in outcomes. However at one year post-op MIS TLIF compared to Open TLIF had greater improvements in ODI; and at two years post-op had greater improvements in ODI, Pain and SF-36 PCS. Perioperative advantages of MIS TLIF such as less muscle dissection and faster recovery continues to be beneficial one to two years after surgery.
Introduction: Transforaminal Lumbar Interbody Fusion (TLIF) can be performed through an open or minimally invasive (MIS) approach. MIS TLIF has gained popularity due to perioperative benefits such as less muscle dissection, lower blood loss and faster recovery. Studies of intermediate term outcomes have yielded conflicting results. This study compares intermediate term outcomes in patients undergoing Open or MIS TLIF.
Methods: Patients who underwent one to two-level MIS TLIF and had complete baseline, one- and two-year outcomes data were identified from the surgical database of two spine centers. These patients were propensity-matched to a cohort of Open TLIF patients based on age, number of surgical levels, body mass index, sex, smoking status, workers' compensation status, and pre-operative outcome measures. The MIS TLIF group consisted of 64 patients, mean age of 52 years, with 22 spondylolisthesis, 33 disc pathology, 8 post-decompression and 1 non-union patient. The Open TLIF group consisted of 64 patients mean age of 54 years, with 39 spondylolisthesis, 15 disc pathology, 7 post-decompression and 3 nonunion patients. Changes in Pain score, ODI and SF-36 PCS were compared at one and two years using t-test, with significance set at $p<0.01$.
Results: Both MIS TLIF and Open TLIF lead to significant improvements in Pain, ODI and SF-36 PCS ($p<0.01$). At one-year, both groups had similar improvements in Pain (36.9 vs 30.8, $p=0.178$) and SF-36 PCS (9.9 vs 7.5, $p=0.231$), but the MIS TLIF group had a statistically significantly greater improvement in ODI compared to the Open TLIF group (30.7 vs 15.1, $p<0.000$). At two-years, both groups had similar improvements in SF-36 PCS (12.1 vs 7.5, $p=0.033$), but the MIS TLIF group had a statistically significantly greater improvement in Pain (40.2 vs 27.0, $p=0.005$) and ODI (33.1 vs 15.4, $p<0.000$) compared to the Open TLIF group.
Conclusion: Both MIS TLIF and Open TLIF lead to significant improvements in outcomes. However at one year post-op MIS TLIF compared to Open TLIF had greater improvements in ODI; and at two years post-op had greater improvements in ODI, Pain and SF-36 PCS. Perioperative advantages of MIS TLIF such as less muscle dissection and faster recovery continues to be beneficial one to two years after surgery.

9. INCREASED INCIDENCE OF PSEUDARTHROSIS AFTER UNILATERAL INSTRUMENTED TRANSFORAMINAL LUMBAR INTERBODY FUSION IN PATIENTS WITH LUMBAR SPONDYLOSIS

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Summary: TLIF is an effective treatment for lumbar spondylosis, however unilateral constructs were 7 times more likely to suffer from pseudoarthrosis and require reoperation.
Introduction: TLIF with pedicular instrumentation is a well-established procedure employed to treat lumbar spondylosis with or without spondylolisthesis. Available studies comparing unilateral versus bilateral constructs have produced conflicting data regarding patient outcomes and hardware complications.
Methods: 80 patients randomized prospectively were entered into either bilateral or unilateral pedicle screw instrumentation groups, with 40 enrolled into each group. Demographic data collected from both groups included sex, age, body-mass index, tobacco use, and workman's compensation/litigation status. Operative data included segments operated, number of levels, estimated blood loss (EBL), length of stay (LOS), and perioperative complications. Long term analysis of hardware malfunction, wound dehiscence, and pseudarthrosis were recorded. All patients had preoperative baseline and six month postoperative Medical Outcomes Short Form-36 (MOS SF-36) health outcomes scores recorded.
Results: Patient follow-up ranged from 37 to 63 months (mean of 52 months). No patients were lost to follow-up. Patients in the unilateral pedicle screw group were slightly younger than those in the bilateral pedicle screw group (Mean age 42 vs. 47, $p=0.02$). Otherwise, there was no significant difference in demographic data

between the two groups, the mean number of lumbar levels operated, or distribution of the levels operated. Patients in the bilateral pedicle screw instrumentation group had increased EBL, but similar LOS. There was a significantly increased incidence of pseudarthrosis (7 patients, 17.5%) in patients undergoing unilateral instrumentation compared with bilateral instrumentation (1 patient, 2.5%) (p =0.02). In all, eight patients in the unilateral instrumentation cohort were offered reoperation compared to one in the bilateral group (p=0.03) All patients had significant improvement in the physical component of the SF-36 (p<0.001).

Conclusion: TLIF with either unilateral or bilateral segmental pedicular instrumentation is an effective treatment for lumbar spondylosis. TLIF with bilateral constructs may be superior biomechanically, as patients with unilateral constructs were 7 times more likely to suffer from pseudarthrosis and require reoperation.

Table 2. Operative Data

	Unilateral	Bilateral	p-value
No. of patients	40	40	
EBL (cc)	396.3	502.5	<0.001
LOS (days)	3.75	3.83	0.69
Neurologic injury	0/40	0/40	1.00
Pseudoarthrosis	7/40 (17.5%)	1/40 (2.5%)	0.05
Cage migration	0/40	0/40	1.00
Screw breakage	0/40	0/40	1.00
Wound dehiscence	1/40 (2.5%)	0/40	1.00
Number of Levels			
1	26	17	0.07
2	14	23	0.07
Specific Levels			
L2-3	0	1	0.31
L3–4	1	1	1.00
L4–5	9	7	0.78
L5–S1	16	8	0.09
L3-5	2	2	1.00
L4-S1	12	21	0.07

EBL: Estimated blood loss, LOS: Length of Stay

10. TWO-YEAR RESULTS OF A MULTICENTER, BLINDED, PILOT STUDY OF A NOVEL PEPTIDE IN PROMOTING LUMBAR SPINE FUSION

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Summary: This is a multicenter, prospective, randomized, blinded control trial (Evidence Level: I) comparing effectiveness of B2A Peptide Enhanced Ceramic Granules and Iliac crest autograft (ICBG) in achieving fusion in patients undergoing Transforaminal Lumbar Interbody Fusion (TLIF). Our results indicate that at 24 months, the higher concentration of B2A achieved higher fusion rate than control and was equivalent to control in terms of functional scores.

Introduction: Fusion failure in TLIF procedures is a challenging problem that can lead to poor functional outcomes. B2A is a synthetic peptide that has proven efficacy in achieving fusion in animal studies, with no reports of heterotopic ossification. The purpose of this study was to assess the safety and effectiveness of B2A Peptide Enhanced Ceramic Granules in achieving fusion at 24 months after surgery. The 1 year data was presented at the IMAST meeting previously.

Methods: This is a multicenter, prospective pilot study. Skeletally mature patients (18 to 70 year-old) with Degenerative Lumbar Disease at L2-S1 requiring single level TLIF were randomized to 3 groups: ICBG, B2A concentration 150µg and B2A concentration 750µg. Twenty Four patients (9 Control, 8 B2A 150, 7 B2A 750) were enrolled between 2009-2010. The patients had preoperative screening low back pain or leg pain of at least 6cm using a 10cm visual analog back pain scale (VAS) and had at least 20 points (40%) on the Oswestry Disability Index (ODI) questionnaire. Outcome measures included ODI, VAS, and fusion as assessed by CT and dynamic flexion/extension x-rays (interpreted by an independent, blinded radiologist). Patients were evaluated at 6 weeks, 3, 6,12, and 24 months after surgery.

Results: Fusion at 6 months was 33%, 38%, and 71% for ICBG, low and high dose, respectively. At 12 months, fusion was 78%, 50%, and 100% for ICBG, B2A 150 and 750 respectively. This changed to 78%, 63%, and 100% at 24 months for ICBG, B2A 150 and 750 respectively. The mean improvement in ODI from pre-op at 12 months was 36.5 for ICBG, 33.4 for B2A 750 and 20.1 for B2A 150. At 24 months after surgery, the mean improvement in ODI compared to pre-op was 42.0 for ICBG, 32.9 for B2A 750 and 21.2 for B2A 150. There were no significant differences in serum chemistry between groups. No subjects developed antibodies to B2A. Procedure related complications included; 1 adjacent level infection needing reoperation (B2A 750), 1 wound infection that was treated medically (B2A 150).

Conclusion: B2A provides a safe alternative to ICBG and avoids donor site morbidity. B2A 750 showed superior fusion rate to autograft at 24 months. Both B2A groups and autograft were equivalent in improving ODI at all time-points up to 24 months.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

11. ROLE OF IMPLANT COSTS IN THE LONG-TERM COST EFFECTIVENESS OF SURGICAL TREATMENT OF ADULT SPINAL DEFORMITY (ASD)

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USA

Summary: Role of Implant Costs in the Long Term Cost-Effectiveness of Surgical Treatment of Adult Spinal Deformity (ASD)

Introduction: This study evaluates the impact of implant costs on the long term cost-effectiveness of ASD surgery. We examine cost-effectiveness with a Markov model populated by estimates from literature and observed data on hospital costs and outcomes, considering a range of hypothetical reductions in the cost of implants (0-50%).

Methods: We develop a Markov model with parameter uncertainty, incorporating costs and outcome distributions from literature and observed patient data. Mortality rates, revision rates and nonsurgical costs are from literature, while surgical costs and QALYs are from a single-center, retrospective administrative dataset and a multi-

center prospective dataset. Inpatient costs were collected from hospital administrative data and costs of implants were measured as the total amount paid by the hospital for the entire construct. QALYs were calculated from the SF-6D. We project costs and QALYs for the surgical and nonsurgical cohort allowing varied readmission, cost and QALY outcomes over 10-year follow-up. Costs for surgical and nonsurgical patients are intended to reflect the full spectrum of services incurred for surgical or nonsurgical care (e.g., physical therapy, pain management, etc.). Our results are based on 1,000 simulated patients, proceeding through 6-month cycles over 10-year follow-up.

Results: Total surgical costs averaged $179,385 over 10-year follow-up, including average implant costs of $70,514 and average QALYs of 6.3. Nonsurgical costs averaged $40,039 over 10-years with average QALYs of 5.4, resulting in an average ICER from surgical treatment of $153,818 per QALY gained. Over 10-year follow-up, ICERs ranged from $144,722 based on an assumed 10% reduction in implant costs to $108,335 assuming a 50% reduction in implant costs.

Conclusion: Our results illustrate the potential to improve the cost-effectiveness of ASD surgery to within the World Heath Organization's cost-effectiveness acceptability range (3 times GDP or $140,000 in 2010 dollars) based on reductions in implant costs, provided such reductions can be made without negatively impacting health outcomes.

12. IMPLANT MATERIALS GENERATE DIFFERENT PERI-IMPLANT INFLAMMATORY FACTORS: PEEK PROMOTES FIBROSIS AND MICRO-TEXTURED TITANIUM PROMOTES OSTEOGENIC FACTORS

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Summary: Titanium alloy surfaces with complex micron/ submicron scale roughness promote osteoblastic differentiation and foster a specific cellular environment which favors bone formation while PEEK favors fibrous tissue formation.

Introduction: Studies have shown that human mesenchymal stem cells (MSCs) are cultured on PEEK, cells fail to exhibit increased alkaline phosphatase activity or osteocalcin production. In contrast, MSCs cultured on rough-textured titanium (Ti6Al4V) exhibit increased markers of osteoblastic differentiation even in the absence of supplements to stimulate expression of an osteoblast phenotype (1). Histologically, implants fabricated from PEEK have a fibrous connective tissue surface interface whereas Ti-alloy implants demonstrate a close approximation with surrounding bone. (1. Olivares-Navarrete et al., Spine J, 2012)

Methods: Human MSCs were cultured on TCPS, PEEK, smooth Ti-alloy (smooth Ti) or a micro-textured rough Ti-alloy (micro-tex Ti) disks for 7 days. Cell morphology and osteoblastic differentiation were as described (Gittens, Biomaterials, 2012): TCPS=PEEK < smooth Ti-alloy < rough Ti-alloy. mRNAs for pro-inflammatory cytokines were measured and fold changes compared with respect to TCPS. Data were analyzed by ANOVA followed by Student t-test with post hoc analysis.

Results: Cells on PEEK up-regulated mRNAs for chemokine ligand 2 (CCL2), interleukin 1β, IL6, IL8, and tumor necrosis factor (TNF). These favor formation of fibrous tissue. Cells grown on the micro-tex Ti surface had an 8-fold reduction in mRNAs for toll-like receptor 4 (TLR4). The reduction of these cytokines fosters an osteogenic cellular environment. Cells grown on the micro-tex Ti surface had reduced levels of all three pro-inflammatory interleukins favoring osteogenesis versus fibrosis. Cells on PEEK had higher levels of factors strongly associated with cell death/ apoptosis. In contrast, cells on the micro-tex Ti exhibited reduced cell-death cytokine factor levels. All results were significant ($p<0.05$).

Conclusion: These results suggest that fibrous tissue around the surface of PEEK implants is due to several factors: reduced osteoblastic differentiation of progenitor cells and production of an inhibitory inflammatory environment that favors cell death via apoptosis and necrosis. Titanium alloy surfaces with complex micron/ submicron scale roughness promote osteoblastic differentiation and foster a specific cellular environment which favors bone formation.

13. INCREMENTAL COST EFFECTIVENESS OF ADULT SPINAL DEFORMITY SURGERY BY CLASSIFICATION OF DEFORMITY

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Summary: We estimate the cost effectiveness of surgical treatment for Adult Spinal Deformity (ASD) among surgical and nonsurgical patients with similar Schwab classifications. Existing literature confirms the validity of SRS-Schwab classification and its correlation with patient HRQoL measures, however there is no literature analyzing cost-effectiveness with regards to severity of deformity. We find the incremental cost effectiveness varies among sagittal modifier type over projected 5-year follow up.

Introduction: We investigate the incremental cost-effectiveness of ASD surgery relative to nonsurgical treatment by classification of sagittal modifier using the SRS Schwab classification.

Methods: Retrospective study of consecutive surgical and nonsurgical ASD patients. Surgical data was from a single center observational dataset while the nonsurgical data was from a prospective multi-center database. Hospital costs were collected from hospital administrative data and QALYs were calculated from the SF-6D, each discounted at 3.5% per year. We analyzed the incremental cost-effectiveness ratios (ICERs) based on sagittal modifier at baseline. The 3 modifier types are mild (SVA <4 cm, PT < 20°, PI-LL within 10°), moderate (at least 1of SVA 4-9.5 cm, PT 20°-30°; PI-LL 10°-20°, and no severe modifiers); and severe (at least 1 of SVA > 9.5 cm, PT > 30°, PI-LL>20°). The difference in QALYs between the surgical and nonsurgical cohorts at 2-years was projected through 5-year follow-up. 95% confidence intervals were calculated using nonparametric bootstrap methods.

Results: Two-year follow-up was available for 278 patients (168 surgical, 110 non-surgical), predominantly female (n=245, 88 %) with

average age of 52 (18 - 81). Total surgical costs averaged $121,857, including readmissions. The 2-year ICER was least cost-effective for patients with severe sagittal modifiers at $424,978 and most cost-effective for patients with mild modifiers at $206,730. Projected through 5 years, the ICER among patients with severe sagittal modifiers was $151,689, reducing to $73,790 for patients with mild modifiers.

Conclusion: Based on the World Health Organization's suggested upper threshold for cost-effectiveness (3 times GDP, or $140,000), ASD surgery appears cost-effective after a 5-year period for mild and moderate sagittal modifier types. While average 5-year ICERs for severe modifier types are above this threshold, the threshold is included within the confidence interval, indicating the 5-year ICER is not statistically significantly higher than the threshold value. The ICER would be expected to further decrease over extended follow-up.

14. ULTRALOW DOSE RADIATION 3D INTRAOPERATIVE IMAGING: HOW LOW CAN WE GO? AN O-ARM, CT SCAN, CADAVERIC STUDY

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Summary: Purpose is to determine reliability of intraoperative O-arm® at low, very low and ultra-low doses. We found O-arm® imaging at ultra-low and very-low doses can safely be used for intraoperative evaluation.

Introduction: Accurate placement of pedicle screw is crucial because of proximity to vital structures. Malposition of screws may result in significant morbidity and potential mortality. O-arm® provides real-time, intra-op imaging of patient's anatomy and provides higher accuracy in scoliosis surgeries, avoiding risk to vital structure. We hypothesize using low or ultra-low doses to obtain intraop images will accurately assess screw placement, both minimizing radiation exposure and preventing screw misplacement.

Methods: 8 cadavers were instrumented with 6.0 x 30mm and 6.0x40mm screws bilaterally from T1 to S1. Screws were randomly placed using O-arm® navigation into 3 positions: contained within the bone, OUT-anterior/lateral, Out-medial. O-arm® images obtained at 3 dosage settings: low-dose (kvp120/mAs125-lowest manufacturer recommended), very-low dose (kvp120/mAs63) and ultralow dose (kvp120/mAs39). CT scan was performed using institution's low-dose protocol (kvp100/mAs50) and gross dissection to identify screw positions. All images were reviewed by observers.

Results: Overall accuracy of O-arm® (all doses) and CT compared to gross dissection was 82%(+/-). Sensitivity was 84% (+/-6), specificity 82% (+/-9), positive predictive value 72% (+/-7) and negative predictive value 91% (+/-4). There was moderate to substantial interobserver agreement (k=0.54-0.73). Radiation effective doseses for low-dose O-arm® scan is 2.16 msV, very-low dose 1.08 mSv, ultra-low 0.68 mSv and our CT protocol is 1.05 mSv. In comparison, a standard scoliosis XR is 1.00 msV, equivalent to 5 months of background radiation in the US.

Conclusion: Accuracy of pedicle screw placement is similar for O-arm® at all doses and CT compared to gross dissection. Ultra-low and very-low doses can be safely used for intraop navigation and evaluation purposes. Inter-observer reliability was substantial for very-low dose and CT.

15. BIOLOGICAL ENDOPHENOTYPES CLASSIFICATION IN AIS PATIENTS: ASSOCIATION WITH NON-RIGID BRACE OUTCOMES

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Summary: Functional analysis of blood cells derived from AIS patients revealed a differential signaling dysfunction of receptors coupled to G inhibitory proteins allowing their classification into three functional subgroups or biological endophenotypes. Significant differences in the probabilities of non-rigid brace treatment success were found according to the biological endophenotypes of AIS patients, suggesting a genetic predisposition to clinical outcomes. Improving AIS patients' stratification could enhance bracing outcomes for selected patients.

Introduction: Functional analysis of blood cells derived from AIS patients revealed a differential signaling dysfunction of receptors coupled to G inhibitory proteins allowing their classification into three biological endophenotypes (BE). The objective is to evaluate the clinical outcome using a non-rigid brace in regards to their functional classification among three BE.

Methods: A retrospective study was performed with 90 AIS patients previously stratified among three BE according to a cell-based assay allowing their classification into three functional groups (FG1, FG2 or FG3). Patients completed the non-rigid brace treatment following standard prescription criteria. Cobb angles were measured by a single blind observer in brace and at the end of treatment and compared to their initial values. Progression of the curvature was defined by a 6° Cobb increase and treatment was considered a success if final Cobb angle was ≤ 45° or no surgery was required. Association between group classification and treatment outcome was analysed with Chi2 test. Logistic regression models were performed for odds ratio calculation. Group comparability at time of prescription was verified using ANOVA and Chi2 test: no differences for mean Cobb angle, Risser sign, BMI nor age.

Results: The patient distribution is reported in Table 1 (24 in FG1, 27 in FG2, and 39 in FG3). Globally, in all patients who had brace success, the majority were from FG3. There was a clear association between the functional group and the success of the treatment regarding the final Cobb angle ≤ 45°criteria (Chi2 =6.7, p =0.034) and in regards to preventing progression of 6° (Chi2 =15.7, p <0.001). Being classified as FG3 was 4 times (p=0. 028) and 7.6 times (p=0.001) more likely to lead to treatment success than failure compared to FG1, respectively for the ≤ 45° final Cobb and ≤ 6° progression criteria. There was no significant difference in treatment outcomes between groups FG1 and FG2.

Conclusion: Outcomes of bracing were most favorable for patients presenting the FG3 endophenotype. Realizing that brace treatment was found to be effective following the BRAIST study, our results could potentially help clinicians identify those patients at higher risk of brace failure or brace success.

					Cobb at baseline (Mean, std)	Age at baseline (Mean, std)
Final Cobb ≤ 45°						
	success	failure	Odds ratio			
FG1	15 (63%)	9 (38%)	1		26.3 (6.5)	12.8 (1.1)
FG2	17(63%)	10 (37%)	1.02	p=0.973	28.6 (6.9)	12.6 (1.8)
FG3	34 (87%)	5 (13 %)	4.08	p=0.028	25.8 (6.2)	12.7 (1.7)
Total	66 (73%)	24 (27%)	χ^2=6.7 (p=0.034)			
Cobb angle progression ≤ 6°						
	success	failure	Odds ratio			
FG1	5 (21%)	19 (79%)	1			
FG2	8 (30%)	19 (70%)	1.60	p=0.474		
FG3	26 (67%)	13 (33%)	7.60	p=0.001		
Total	39 (43%)	51 (57%)	χ^2= 15.7 (p<0.001)			

Table 1. Statistical analysis of the patient distribution according to brace success criteria

16. EFFICACY AND SAFETY OF RILUZOLE IN ACUTE SPINAL CORD INJURY (SCI): RATIONALE AND DESIGN OF AOSPINE PHASE III MULTICENTER DOUBLE BLINDED RANDOMIZED CONTROLLED TRIAL (RISCIS)

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Summary: This abstract describes the rationale and design for ongoing multi-center double-blinded randomized controlled trial of efficacy and safety of riluzole in patients with acute spinal cord injury.
Introduction: There is convincing evidence from the preclinical realm that the pharmacologic agent riluzole attenuates certain aspects of the secondary injury cascade leading to diminished neurological tissue destruction in animal SCI models. The safety and pharmacokinetic profile of riluzole have been studied in a multicenter pilot study in 36 patients. Efficacy of riluzole in acute human SCI has not been established.
Methods: This Phase II/III multi-center double-blind randomized controlled trial will involve up to 35 sites. A total of 351 patients with acute C4—C8 SCI and ASIA Impairment Grade A, B or C will be randomized 1:1 to riluzole and placebo. Primary outcome is the change in ASIA Total Motor Score between baseline and 180 days. Other measures include ASIA Upper Extremity Motor Score; ASIA Lower Extremity Motor Score; ASIA Sensory Score; ASIA grade; Spinal Cord Independence Measure); SF-36v2; EQ-5D and GRASSP. The statistical design utilizes 2-stage sequential adaptive trial. A sample size of 316 subjects (158 in each arm) will have 90% power to detect 9 points difference in the ASIA Motor Score at one-sided alpha = .025. To account for losses to follow-up of up to 10%, the study will enroll 351 subjects.
Results: Within the Phase 1 study a matched cohort analysis was performed comparing complication rates and neurological outcomes between patients who received riluzole and matched non-riluzole treated patients from a prospective SCI registry. Although the groups experienced similar rates of complications, riluzole treated cervical SCI patients experienced an additional 15.5 points in AMS recovery at 90 days post injury as compared to non-riluzole treated patients. Although the phase I study was underpowered to investigate efficacy the current phase II/III study is poised to definitive address this question. Subject enrollment for this trial began October 1, 2013.
Conclusion: This is a pivotal study of riluzole in acute SCI.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

17. THE MINIMUM CLINICALLY IMPORTANT DIFFERENCE (MCID) IN SRS-22R APPEARANCE, ACTIVITY AND PAIN DOMAINS AFTER SURGICAL TREATMENT OF ADULT SPINAL DEFORMITY

Charles H. Crawford, MD; Steven D. Glassman, MD; Keith H. Bridwell, MD; Sigurd H. Berven, MD; Leah Y. Carreon, MD, MSc
USA

Summary: This study evaluated the MCID threshold values for the SRS22R domains in 1321 patients undergoing surgical correction of adult spinal deformity and showed MCID values of 0.46-1.23 for SRS22R Appearance, 0.24-0.60 for the SRS22R Activity, 0.34-0.79 for SRS22R Pain, 0.21-0.58 for SRS22R Subscore, and 0.47-0.71 for SRS22R Total. These values are useful to quantify the clinical significance of health status change in the management of adult spinal deformity.
Introduction: The Scoliosis Research Society22R (SRS22R) has been shown to be reliable, valid and responsive to change in adult spinal deformity patients. Minimum Clinically Important Difference (MCID) is commonly used to quantify a threshold of improvement that is clinically relevant. This study evaluated the MCID threshold values for the SRS22R domains in patients undergoing surgical correction of adult spinal deformity.
Methods: Patients enrolled in a prospective database of adult spinal deformity undergoing surgical treatment and completed the SRS22R pre-op and the SRS30 one-year post-op were identified. One-year post-operative answers to the last 8 questions of the SRS30 were used as anchors to determine the MCID for the Pain, Appearance and Activity domains, Subscore and Total Score using ROC Curve analysis and distribution based methods.
Results: The sample population consisted of 1321 patients; 83% were females and 10% reported smoking. Mean age was 53±16 years. Mean BMI was 26.3±5.8 kg/m2. There was a statistically significant difference in domain scores among the responses to the anchors ($p<0.001$). Mean pre-op SRS22R Appearance score was 2.50±0.73 which improved to 3.62±0.84 at one year post-op. Mean pre-op SRS22R Activity score was 2.96±0.59 which improved to 3.33±0.80 at one year post-op. Mean pre-op SRS22R Pain score was 2.73±0.92 which improved to 3.60±0.93 at one year post-op. Mean pre-op SRS22R Subscore was 2.56±0.66 which improved to 3.11±0.80 at one year post-op. According to the ROC analysis, MCID was 1.23 for Appearance, 0.60 for Activity, 0.40 for Pain, 0.43 for Subscore, 0.71 for Total score. According to the distribution based methods, MCID was 0.56 and 0.46 for Appearance, 0.24 and 0.50 for Activity, 0.34 and 0.79 for Pain, 0.21 and 0.58 for Subscore, 0.47 and 0.55 for Total score.
Conclusion: The results of the current study in an adult spinal deformity population undergoing surgical treatment show MCID

values of 0.46-1.23 for SRS22R Appearance, 0.24-0.60 for the SRS22R Activity, 0.34-0.79 for SRS22R Pain, 0.21-0.58 for SRS22R Subscore, and 0.47-0.71 for SRS22R Total. These values are useful to quantify the clinical significance of health status change in the management of adult spinal deformity.

18. POST-OPERATIVE SPINE DRESSING CHANGES ARE UNNECESSARY: OUR 15-YEAR EXPERIENCE WITH AN INSTITUTIONAL DRESSING CHANGE PROTOCOL

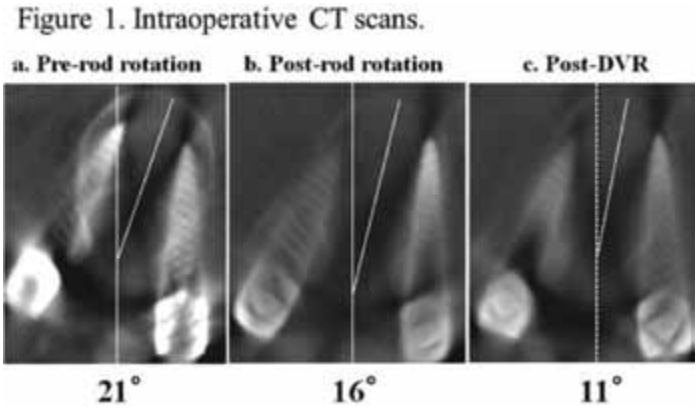
Lance K. Mitsunaga, MD; Sukhraj Bains; Nirmal Singh, D ABNM; Kamran Majid, MD; Ravi S. Bains, MD
USA

Summary: In this retrospective review of a large series of spine surgery patients, we conclude that dressing changes in the immediate postoperative period are not necessary.
Introduction: There is minimal literature regarding when dressing changes should be performed. We present the dressing change protocol adopted by our institution. We previously reported our preliminary results with this dressing change protocol. In this prior study, we showed that our dressing change protocol did not increase surgical site infection (SSI rates) and, in fact, may even decrease them. The purpose of this study was to provide an update of our experience with this dressing change protocol over a 15 year period.
Methods: Effective January 2005, we implemented our universal protocol of no dressing changes for 5 days after surgery. All spine surgery cases involving instrumentation performed at our institution were captured by reviewing a health system administrative database. SSI cases--superficial, deep, and organ space--as defined by the CDC, were identified by reviewing an infection control database. Fischer's exact test was used to compare SSI rates in all instrumented cases from January 1999 to December 2004 (prior to implementation of the dressing change protocol) to those from January 2005 to December 2013 (after the protocol was initiated).
Results: 8,631 instrumented spine fusions were performed by surgeons at a single institution from 1999 to 2013. Overall, after instituting our universal no-dressing change protocol, SSI rates for all cervical, thoracic, and lumbar instrumented cases combined decreased from 3.9% (97/2473) to 0.93% (57/6158) [p<0.0001]. The reduction in SSI rates was most significant for posterior cervical and posterior lumbar surgeries. After our dressing change protocol was implemented, we saw an improvement in SSI rates for posterior cervical instrumented cases from 3.2% (6/186) to 0.50% (4/815) [p=.0041]. Posterior lumbar instrumented fusion SSI rates dropped from 5.5% (65/1179) to 1.1% (32/2890) [p<0.0001].
Conclusion: Dressing changes in the immediate postoperative period are not necessary. Applying a sterile dressing in the operating room may serve as a barrier to nosocomial pathogens during hospitalization. Our data suggests this dressing change protocol may lead to reduced SSI risk. Leaving the original postoperative surgical dressing intact is safe, simple, and cost-effective.

19. CLINICAL SIGNIFICANCE OF DIRECT VERTEBRAL ROTATION (DVR) FOR ADOLESCENT IDIOPATHIC SCOLIOSIS: AN ANALYSIS OF INTRAOPERATIVE CT SCANS

Shoji Seki, MD, PhD; Yoshiharu Kawaguchi, MD, PhD; Masato Nakano, MD, PhD; Hiroto Makino, MD; Hayato Mine; Tomoatsu Kimura, MD, PhD
Japan

Summary: To clearly determine the improvement in degrees in vertebral body rotation with rod rotation or DVR, intraoperative CT scans of the three apical vertebrae of the major curve (20 AIS patients, 60 vertebrae) were taken pre-rod rotation, post-rod rotation and post-DVR. The difference in average improvement of the vertebral body rotation after rod rotation versus after DVR was 4.3 degrees (p<0.05). Segmental DVR has the potential to improve vertebral body rotation.
Introduction: The benefit of the direct vertebral rotation (DVR) technique in improving vertebral body rotation in surgery for adolescent idiopathic scoliosis is unclear.
Methods: Scoliosis surgery was performed in 20 patients with adolescent idiopathic scoliosis (Lenke type I or II: 10, III: 4, V: 6). Mean patient age was 14 years, and 19 patients were female. Operative methods were paravertebral muscle exposure, segmental uniplanar pedicle screwing, segmental facetectomy, rod rotation, and segmental DVR. To clearly determine the improvement in degrees in vertebral body rotation with rod rotation or DVR, intraoperative cone-beam CT scans of the three apical vertebrae of the major curve of the scoliosis (60 vertebrae) were taken pre-rod rotation, post-rod rotation and post-DVR in all patients (Figure 1). The angle of vertebral body rotation in these apical vertebrae was measured and analyzed for statistical significance, with the floor of the operation room used as reference. We also analyzed differences between thoracic curve (Lenke type I, II, III) and thoracolumbar/lumbar curve (Lenke type V) scolioses.
Results: The overall average (60 vertebrae) of vertebral body rotation pre-rod rotation, post-rod rotation and post-DVR was 17.5, 11.5, and 7.2 degrees, respectively. The difference in average improvement of the vertebral body rotation after pedicle screw insertion versus that after rod rotation was 6.0 degrees (p=0.00000075), while that after rod rotation versus after DVR was 4.3 degrees (p=0.0000018). For thoracic curve (Lenke type I, II, III: 42 vertebrae) and thoracolumbar/lumbar curve (Lenke type V: 18 vertebrae) scolioses, average vertebral body rotation with the DVR technique alone was 3.5 and 5.1 degrees, respectively (p<0.05; Mann-Whitney U test).
Conclusion: Both rod rotation and segmental DVR contributed to improving vertebral body rotation. The DVR technique was more useful in thoracolumbar/lumbar curve than thoracic curve scolioses. Segmental DVR has the potential to improve vertebral body rotation in patients with adolescent idiopathic scoliosis.
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.



20. PROBING, TAPPING, TOGGLING: ARE WE INSERTING PEDICLE SCREWS CORRECTLY?

Robert S. Lee, BSc, MBBS, FRCS (Tr&Orth); Addisu Mesfin, MD; Vishal Prasad, FRCS (Tr&Orth); Julie L. Reigrut, MS; John A. Schmidt, PhD
United Kingdom

Introduction: The clinical significance of a failed pedicle screw is often revision surgery and further postoperative complications. This basic research study quantifies the mechanical strength of the bone/screw interface by assessing probe hole diameter, tap sizes and toggling.

Methods: The study used three different densities of reference grade material (foam). All screws were inserted to a depth of 25mm and pulled axially from the foam.

Probe Hole: A series of pilot holes were drilled through the foam blocks. Pilot hole diameters were 1.5, 2.2, 2.7, 3.2, 3.7, 4.2, 5.0 and 6.0 mm in diameter. A 6.5 x 45mm Pedicle Screw (PS) was inserted. (n=720)

Tap Size: A 3.0mm pilot hole was drilled and then tapped with the following size taps: no tap, 3.5mm, 4.5mm, 5.5mm and 6.5mm taps. A 6.5 x 45mm PS was inserted. (n=300).

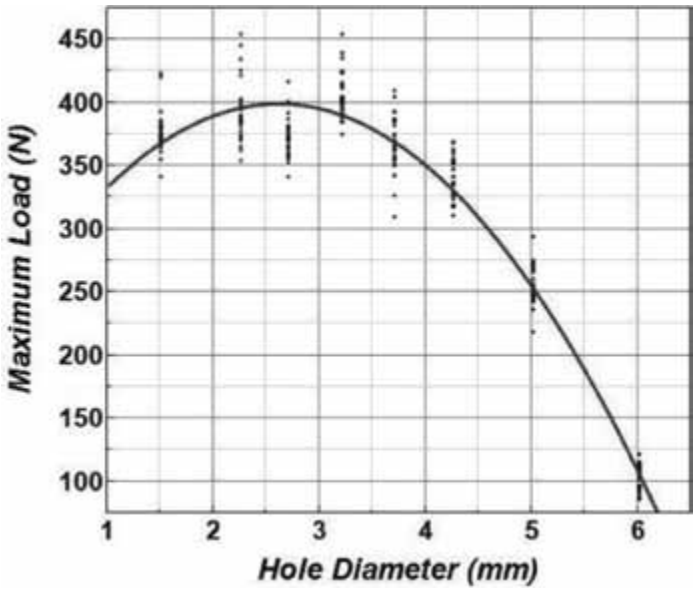
Toggle: Toggle testing consisted of drilling a 3mm pilot hole and inserting a 6.5x45mm PS into the foam blocks and locking a 5.5mm Ti-6Al-4V rod into the PS. The block was rotated 90° so that the rod was held vertically within the tensile tester. The rod was physically moved to preset distances of 0mm, 1.0mm, 2.0mm, and 4.0mm (n=235). Rods were cycled +/- each displacement 5 or 6 times. The block was then rotated 90° and the PS pulled axially.

Results: The optimum size probe/pilot hole is ½ the diameter of the screw. Larger or smaller holes caused a parabolic fall-off of pullout strength ($r2 = 0.954$)

Undertapping by two sizes is recommended. That is, for a 6.5mm OD screw a 4.5mm tap is recommended.

Toggling at a displacement of 4mm showed that while each successive toggle caused damage, 84% of the damage occurs on the first toggling cycle.

Conclusion: The methods and instruments employed during the initial placement of a pedicle screw have a dramatic effect on the ability of the screw to resist toggling. Our findings contradict the traditional way spine surgeons are taught to insert pedicle screws. The proposed recommendations may potentially have an impact on the rates of revision surgery.



Pilot Hole Size vs. Pullout Strength in 0.16 gm/cm3 Foam. Note the non-linear, parabolic shape indicating an optimal probe hole size.

21. AUTOLOGOUS ILIAC BONE GRAFT WITH ANTERIOR PLATING IS ADVANTAGEOUS OVER THE STAND-ALONE CAGE FOR RESTORATION OF SEGMENTAL KYPHOSIS IN SINGLE-LEVEL CERVICAL DISC DISEASE

Seung Heon Yang; Chun Kee Chung, MD, PhD; Chi Heon Kim, MD, PhD; Seil Sohn, MD
Republic of Korea

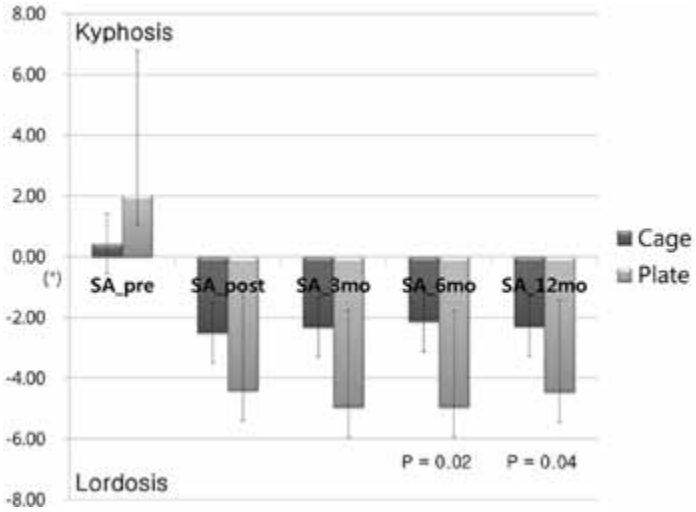
Summary: The stand-alone cage and autologous bone graft with plating had similar clinical outcomes, but stand-alone cage fusion may be disadvantageous from a radiological viewpoint. The segmental angle should be taken into consideration when choosing a fusion method.

Introduction: Anterior cervical discectomy and fusion (ACDF) with autologous iliac bone graft and plating has been a standard method for single-level cervical disc disease. The stand-alone cage was introduced to reduce graft-related morbidity. However, problems due to focal kyphosis at the operated level are emerging. It is hard to derive a conclusive answer from previous studies for the indications of each method. An interim analysis of a prospective randomized study was performed to compare the sagittal alignment between a stand-alone cage (ACDF-cage) and autologous iliac bone graft and plating (ACDF-plate).

Methods: Twenty-nine patients were allocated to the ACDF-cage group (M:F=17:12) and 23 to the ACDF-plate group (M:F=14:9). Cobb's angles at the operated segment (segmental angle, SA; lordosis vs. kyphosis), before and after operation (0, 3, 6 and 12 months) were compared and the determinants for postoperative kyphotic SA at 12 months were analyzed.

Results: The only factor affecting the SA at 12 months was the fusion method ($p = 0.03$; OR, 5.52). Preoperatively, the SA was not different between the groups ($p = 0.18$) and was similar ($p = 0.22$) immediately following the operation. However, the SA was significantly more lordotic at 6 and 12 months ($p < 0.05$) in the ACDF-plate group than in the ACDF-cage group. Such a difference was more

prominent in patients with preoperative segmental kyphosis ($p < 0.05$) but not in patients with segmental lordosis ($p > 0.05$).
Conclusion: The stand-alone cage and autologous bone graft with plating had similar clinical outcomes, but stand-alone cage fusion may be disadvantageous from a radiological viewpoint.



The SA was measured preoperatively, postoperatively, and at 3, 6, and 12 months. Preoperatively, there was no difference in SA between the groups. The SA was more lordotic in the ACDF-plate group at 6 and 12 months. The difference in the SA at each time point from the preoperative SA (SA_dif) was significantly larger in the ACDF-plate group than in the ACDF-cage group during the entire follow-up period. A negative value denotes lordosis.

22. CASE-MATCHED COMPARISON OF SPINAL FUSION VERSUS GROWING RODS FOR PROGRESSIVE IDIOPATHIC SCOLIOSIS IN SKELETALLY IMMATURE PATIENTS

Jeff Pawelek; Burt Yaszay, MD; Stacie Nguyen, MPH; Peter O. Newton, MD; Gregory M. Mundis, MD; Behrooz A. Akbarnia, MD; Harms Study Group; Growing Spine Study Group
USA

Summary: In a case-matched series, skeletally immature patients who had spinal fusion for progressive idiopathic scoliosis experienced similar gains in spinal and thoracic height compared to patients who had growing rod surgery. Growing rod patients had less overall curve correction after final fusion (44% vs. 63%) and significantly more surgical procedures (54 vs. 13) compared their matched spinal fusion cohorts.
Introduction: Scoliosis surgeons face two distinct treatment options for progressive idiopathic scoliosis in skeletally immature patients: spinal fusion (SF) or growth-friendly surgery such as growing rods (GR). Our objective was to compare treatment outcomes of these two techniques using a case-matched series.
Methods: A multicenter EOS database query identified 11 GR patients who met the following criteria: 1) idiopathic etiology; 2) 9-11 years old with open triradiate cartilage (TRC) at initial surgery; 3) major thoracic curve; 4) had "final" spinal fusion. A multicenter AIS database was used to identify SF patient matches. SF patients had pre-op open TRC and minimum 2-year follow-up. A one-to-one patient match was performed based on pre-op age, major curve size and location of major curve apex. X-rays were visually compared to confirm similar curve patterns. Latest follow-up was analyzed after final fusion for GR patients.
Results: Pre-op age was 10.1 years (9.2-11.4) for GR patients and 10.8 years (10.0-11.6) for SF patients. GR had a mean 2.8 lengthenings prior to final fusion. Follow-up time after fusion (3.8 years vs. 4.5 years; $p=0.51$) and age at latest follow-up (16.4 years vs. 15.3 years; $p=0.28$) were similar between GR and SF. Initial curve correction was significantly greater for SF patients compared to GR patients after initial GR surgery (71% vs. 38%; $p<0.001$). SF patients had better overall curve correction at latest follow-up (63% vs. 44%; $p=0.08$). Overall increase in T1-S1 was 23% for GR and 19% for SF ($p=0.42$). Overall increase in T1-T12 was 19% for GR and 17% for SF ($p=0.76$). GR had more levels instrumented than SF at initial surgery (12.1 vs. 10.5) and at latest follow-up (13.0 vs. 11.1). Complications requiring unplanned surgery occurred in one GR patient (9%) and two 2 SF patients (18%). Total number of surgeries was significantly higher in GR (54) compared to SF (13).
Conclusion: In this case-matched series, SF patients had greater curve correction and comparable increases in spinal height and thoracic height compared to GR patients. GR patients underwent significantly more surgical procedures than SF patients. These findings suggest the utility of the GR technique may be ineffectual in older juvenile patients.

	Growing Rods	Spinal Fusion	*p* value
Pre-op major curve	58°	60°	0.52
Latest major curve	32°	22°	0.08
Pre-op T1-S1	350 mm	341 mm	0.42
Latest T1-S1	428 mm	403 mm	0.08
Pre-op T1-T12	228 mm	210 mm	0.08
Latest T1-T12	267 mm	244 mm	0.01*

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

23. SHILLA GROWTH GUIDANCE GRADUATES

Kwan J. Park, MD; Richard E. McCarthy, MD; Frances L. McCullough, MNSc
USA

Summary: The SHILLA growth guidance system does not use distraction but the child's own growth to lengthen the spine. 19 of 71 patients have "graduated" this system undergoing either definitive fusion with instrumentation (15) or implant removal alone (4). Mean spinal height improved from 183mm pretreatment to 232mm after growth rod and to 246mm after final treatment. The SHILLA growth guidance system was able to achieve similar end results compared to distraction growing rods for EOS with fewer returns to surgery.
Introduction: SHILLA growth guidance has been used since 2004 to treat early onset scoliosis. Thus far 71 patients have been treated at our institution. This system does not use distraction but rather the child's own growth to lengthen the spine. This paper analyzes the 19 patients that have reached enough maturity to "graduate" this system.

Methods: Retrospective chart review of the patients who underwent SHILLA for EOS was performed. Clinical, radiographic, and operative data of the 19 graduates were analyzed.
Results: Over the 9 year period, 19 out of 71 patients received final treatment with either spinal arthrodesis and final correction (15) or implant removal alone (4). The arthrodesis group had 5 nonambulators and 10 ambulators; the removal group had 1 nonambulator and 3 ambulators. Diagnoses were neuromuscular (7), syndromic (7), idiopathic (4), and congenital scoliosis (1).
Mean age at index surgery was 8 yrs (range 3-11), the mean age at the time of definitive surgery was 13 yrs (range 9 to 15 yrs). The average growth period was 4+4 yrs (range 8 mo to 8 yrs). Average # of surgeries from index procedure was 1.8. The mean T1-T12 spinal height increased from preindex procedure of 180 mm to 203 mm to avg 232 mm after SHILLA (prior to graduation) and to 246 mm at post final fusion. The 19 graduates experienced a total of 14 returns to surgery (12 for implant related problems including broken rods, screw pullout, implant prominence) and 2 for infection.
By our calculations, if these pts had undergone distraction growing rod procedure,1 pt would have undergone is 8.8 surgeries (assuming planned lengthening 1 6 mo). This would have been 167 returns to surgery for distraction technique.
Conclusion: 15 of these 19 graduates underwent definitive fusion and 4 of the patients underwent implant removal only. Mean spinal height improved from 183 mm pretreatment to 232 mm after growth rod and to 246 mm after final fusion. The SHILLA growth guidance system was able to acheive similar end results compared to distraction growing rods for EOS with fewer returns to the OR (14 vs 167).

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

24. EARLY RESULTS OF GROWTH MODULATION SURGERY FOR THORACIC SCOLIOSIS IN SKELETALLY IMMATURE PATIENTS USING A BRAIDED UHMWPE TETHER IMPLANTED BY A THORACOSCOPIC-ASSISTED TECHNIQUE

John Nathaniel M. Ruiz, MD, MRCS; Gabriel Liu, MSc, FRCSED(Orth); Hee-Kit Wong
Singapore

Summary: Non-fusion scoliosis surgery via a novel tether-device was compared to bracing in skeletally immature girls for progressive thoracic scoliosis. Patients who received a tether applied through a thoracoscopic technique had progressive curve improvement up to 21% whereas those who used the brace has gradual worsening up to 28% and a deterioration of Lenke curve type for which fusion surgery was done in all but 1 patient at a mean of 18 months after bracing. There were no device-related adverse events.
Introduction: The current treatment recommendation for progressive scoliosis in skeletally immature patients with Cobb angle <50° is bracing, despite curve progression in >50%. Tether devices to effect scoliosis correction in growing spine animal models have been shown to be viable. We describe early results of non-fusion surgery in skeletally immature scoliosis using UHMWPE tethers anchored to bone screws.
Methods: 9 girls aged 9-14 (bone age=10-13, amenarchal, Risser 0) with thoracic scoliosis ≥30° participated in an IRB-approved study for non-fusion surgery. 5 girls underwent thoracoscopic insertion of vertebral screws connected by a braided UHMWPE tether on the curve convexity. 4 girls who did not consent to the tether were braced. Xrays and SRS-22 were done pre-op and at regular intervals. Mean follow-up was 24 months in the tether group & 28 months for the brace group.
Results: Mean pre-op age, bone age, & Cobb (39°) were comparable in the tether & brace groups. A mean of 7.4 spinal levels/patient (range 7-8) received vertebral screws in the tether group. Blood loss was 136mls. Op time was 210mins. Cobb angle decreased after tether placement with further sequential improvement to a mean correction rate of 21%. A definite tethering effect manifested as continuing Cobb reduction was seen in 4 patients. Adding-on effect was seen in 2 patients and resulted in deterioration of Lenke lumbar modifier in 1 patient. Brace group had a mean compliance of 15hrs brace wear/day but resulted in 28% mean curve size increase and deterioration of Lenke curve type & lumbar modifier. Three patients eventually underwent fusion surgery 18 months after bracing (range 12-28 months). SRS-22 analysis showed better self-image in both groups but was better in those that had surgery after bracing; pain was worse in the brace group. Both groups had similar satisfaction scores that were lower compared to pre-treatment. There were no serious adverse events.
Conclusion: Our initial results show that a tether-device is superior to bracing in controlling progressive thoracic scoliosis in skeletally immature patients without resorting to fusion surgery. This new procedure is safe but requires more subjects and longer follow-up to determine the durability of the achieved curve control.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

25. IS NEUROMONITORING NECESSARY FOR VEPTR EXPANSION AND IMPLANT EXCHANGES IN EARLY ONSET SCOLIOSIS?

John T. Smith, MD; Man Hung, PhD
USA

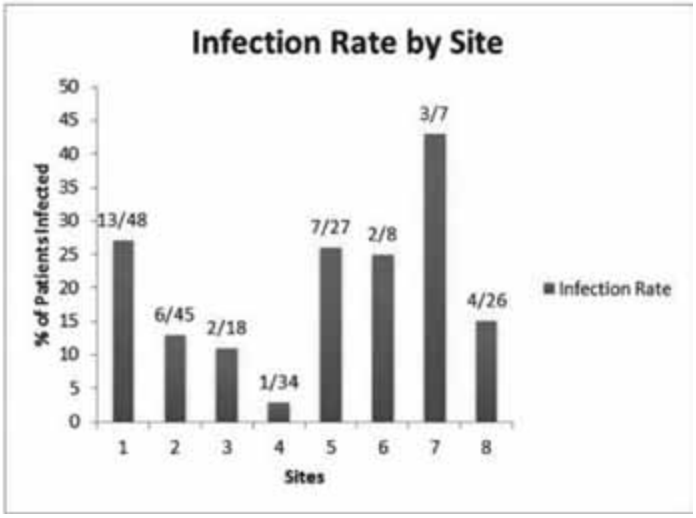
Summary: This study reports the absence of neurologic deficits in a large single surgeon experience with VEPTR lengthening and exchange procedures where neuro-monitoring was not used. This represents a substantial cost savings to the patient. These findings support the conclusion of Skaggs et. al. that neuro-monitoring may not be necessary in routine exchange and lengthening procedures.
Introduction: The Vertical Expandable Prosthetic Titanium Rib (VEPTR) is used to treat a variety of types of early-onset scoliosis associated with thoracic insufficiency syndrome. Previous studies have reported the incidence of neuro-monitoring changes with lengthening procedures between 0.5 - 0.08%, and questioned if neuro-monitoring was necessary. The purpose of this study is to report the absence of neurologic injury related to 823 consecutive VEPTR related surgeries by a single surgeon.

Methods: This is a retrospective review of an IRB approved database of 95 children with EOS treated with the VEPTR device by a single surgeon. Records were reviewed for demographics, diagnosis, procedure type, and complications. Hospital cost data, professional fees and additional OR and Anesthesia time were estimated for neuro-monitoring if it were used.
Results: 95 patients underwent 635 expansions and 90 exchange procedures. The diagnosis was varied. No patient had a documented neurologic event at the time of their initial VEPTR implantation. The average age at initial implantation was 6.05. Patients had an average of 6.68 expansions (range 0-18) and 0.95 exchange procedures (range 0-5). The average rate of complications over time was 20%. However, there were no neurologic deficits in a single patient following these 823 procedures.
Conclusion: The documented incidence of neuro-monitoring changes in VEPTR lengthening surgery is very low (0.08%). In this consecutive series, we did not have a single documented neurologic deficit following 823 lengthening or exchange procedures. While the cost of a true neurologic deficit over a lifetime is very significant, this represents an estimated cost savings of $1500/surgical event, or $1,234,500 over the life of the VEPTR program when the costs of neuro-monitoring are eliminated.

26. DEEP SURGICAL SITE INFECTION RATES FOR VEPTR PATIENTS AT EIGHT MAJOR CENTERS: A SIX-YEAR RETROSPECTIVE COHORT ANALYSIS

Sumeet Garg, MD; Micaela Cyr; Michael Glotzbecker, MD; Patrick M. Carry, BA; John T. Smith, MD; Jeffrey R. Sawyer, MD; Joshua M. Pahys, MD; Scott J. Luhmann, MD; John M. Flynn, MD; Ron El-Hawary, MD, MSc, FRCSC; Michael G. Vitale, MD, MPH; Children's Spine Study Group
USA

Summary: 18% of patients develop infection during VEPTR treatment with significant variability in infection rate among sites of care.
Introduction: Several small series have described high rates of infection with VEPTR surgery.
Methods: A retrospective query was done on a prospectively collected database to identify patients implanted with VEPTR from 2007-2012 at 8 sites. Out of 213 patients, 55 infections requiring operative treatment in 38 patients occurred with average follow up of 4.1 yrs (range 1.7-6.3). Data collected included C-EOS diagnosis, major Cobb angle, construct type, clinical symptoms, and microbiology.
Results: 18% (38/213) of patients implanted with VEPTR developed infection requiring operative debridement. There was significantly different infection rates among the sites, ranging from 2.9% to 42.9% (p=0.029). The average time to infection was 70 days (range 8-236) after infecting procedure. There was a wide range of clinical symptoms in the infection cohort, the most common being wound drainage and dehiscence (41/55, 71%). The majority of infections were due to gram positive bacteria (80%, 44/55), the most prevalent being Methicillin-sensitive Staphylococcus aureus (45%, 25/55). There were 20 patients (53%, 20/38) with either partial or complete implant removal to resolve infection however only 3/38 (8%) of these resulted in abandonment of VEPTR treatment. There was no difference in infection rate across the primary diagnosis categories (p=0.21). After controlling for study site, the odds ratio of an infection following an implant procedure versus an expansion was 2.8 (p=0.002). There was no difference in the odds ratio of an infection between the other procedure types (implant, expansion, exchange/revision).
Conclusion: Since 2007 at the 8 study sites, 18% of patients with VEPTR implanted developed infection. There were significant differences in infection rates between sites. The variability in infection rates from site to site, indicates a need for guided efforts to standardize best practices for infection control in VEPTR surgery.



27. METALLOSIS IS A COMPLICATION OF GROWTH GUIDANCE AND SLIDING DEVICES FOR EARLY ONSET SCOLIOSIS

Elena Lukina; Alaksandr Laka, PhD; Mikhail Kollerov; Mykhamad Sampiev, PhD; Peter Mason, PhD; Paul G. Wagstaff, BSc, MSc(Hon), DSc; Wai Weng Yoon, BSc (Hons), MBBS, MRCS, FRCS (Tr&Orth); Hilali H. Noordeen, FRCS; Gordon W. Blunn, PhD
United Kingdom

Summary: The aim of this study was to investigate metallosis related complications in patients with implanted sliding device LSZ-4D made from Ti6Al4V alloy with unlocked fixtures that allow growth of spine. We found that 20% of patients had seromas or fistulas and all demonstrated elevated Ti and V ion levels in their blood. The data indicates that it is important to exchange sliding instrumentation once the child is fully grown.
Introduction: Growth-guidance and sliding devices such as Shilla (Medtronic, USA) or LSZ-4D (Conmet, Russia) used for early-onset scoliosis have unlocked fixtures allowing rods to slide during growth of the spine and this avoids periodical extensions. This study aimed to estimate the prevalence of metallosis related complications in patients with implanted LSZ-4D devices and to reveal the presence of increased level of metal ions in their blood.
Methods: In the study group LSZ-4D sliding device made from titanium alloy Ti6Al4V consisting of two rectangular section rods and 40±8 fixture elements (20±4 hooks and 20±4 clips) was implanted in 25 patients on 10±2 spine levels for 6±2 years (3 males, 22 females, average age 11.4±1.2). Average age in 10 patients in control group who did not have any implanted devices was 11±1.2 years (1 male, 3

females). Content of Ti, Al and V ions in the whole blood was measured by ICP-MC on quadrupolar Nexion 300D (Perkin Elmer, USA).
Results: 5 patients in the study group had metallosis related complications: 3 patients developed seromas over the implanted device in the lumbar part of the spine, and 2 had fistulas (one with evidence of inflammation). The content of Ti, Al and V in the blood of patients from control group was 32±3.5, 28±6 and 0.08±0.02 ppb for Ti, Al and V respectively. Patients with implanted LSZ-4D device had 89±46, 44±32 and 0.3±0.1 ppb of Ti, Al and V respectively revealing 2.8 to 4 fold increase of Ti and V ($P \leq 0.05$). No statistically significant difference in metal ion content was found in patients who developed seromas or fistulas compared with those with the LSZ-4D device where these did not occur.
Conclusion: 20% of patients had seromas or fistulas and all demonstrated elevated Ti and V ion levels in their blood, indicating the importance of exchanging sliding instrumentation once the child is fully grown.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

28. IS THERE AN OPTIMAL TIME TO DISTRACT DUAL GROWING RODS?

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Summary: Our goal was to determine if there is a significant difference in final T1-S1 height, instrumented height, or decrease in major Cobb angle related to the time interval between distractions of dual growing rods. Data showed growing rod patients with an average ≥9 months between procedures had no significant difference in decrease in correction of primary Cobb angle, increase in T1-S1 length, or increase in instrumented length gain compared with those patients who averaged <9 months.
Introduction: To determine if there is a significant difference in final gain of T1-S1 height, gain of instrumented height, or decrease in primary Cobb angle related to the time interval between surgical distractions of dual growing rods.
Methods: Using data from the Growing Spine Study Group database, 46 patients with early onset scoliosis, treated with dual growing rods, with more than 4 years of surgical treatment, were identified. We divided the patients into 2 groups: those who averaged <9 months and those who averaged ≥9 months between procedures. Standard univariate statistics were calculated. Two-tailed t tests were performed.
Results: 46 patients (23 male, 23 female) met our inclusion criteria. 16 patients averaged <9 months and 30 patients averaged ≥9 months between procedures. The difference in primary Cobb angle, T1-S1 height, and instrumented segment length at the last distraction or final fusion, compared to the post-index procedure values, was not significantly different (p=.52, p=.58, and p=0.60, respectively) between the two groups. The normalized instrumented height gain, in millimeters per year, between both groups was not significantly different (p=0.22).
Conclusion: Patients treated with dual growing rods with an average of ≥9 months between procedures had no significant difference in decrease in correction of primary Cobb angle, increase in T1-S1 length, or increase in instrumented length gain compared with those patients who averaged <9 months between procedures.

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29. THE USE OF ULTRASOUND IN MAGNETIC GROWTH ROD LENGTHENING MEASUREMENT: A PROSPECTIVE STUDY IN PATIENTS WITH A MINIMUM FOLLOW UP OF TWO YEARS

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Summary: This study investigated whether ultrasound (U/S) is an alternative to radiography when measuring magnetic growth rod (MGR) length in order to reduce radiation exposure. U/S was found to be highly agreeable with radiography (interclass correlation coefficient (ICC) = 0.99). U/S reliability was also high (inter- & intra-rater reliability ICC = 0.987 & 0.983 respectively).
Introduction: Distractible spinal growth rods are the gold standard when treating Early Onset Scoliosis (EOS). They allow growth to continue, avoid complications of early fusion & have been shown to have a high success rate. MGRs allow rod distraction via remotely controlled magnets. Unlike traditional systems, MGRs do not require repeated surgery & general anesthetic. This system still requires radiographs to be performed to monitor progress. This results in significant radiation exposure. The aim of this study was to investigate whether U/S is a viable alternative to radiography.
Methods: This was a prospective series. Patients were already undergoing EOS treatment using MGRs with a minimum of 2 years follow-up. 28 data points measured using radiography & U/S were compared. Each U/S data point was measured 3 times by 3 observers to assess intra- & inter-observer reliability. Rod length was measured from the end of the actuator to the shoulder of the tapered rod segment.
Results: The average rods lengths were 1.322 cm with U/S & 1.329 cm with radiography. The ICC (radiography vs. U/S) was 0.992 (95% confidence interval (CI) 0.976, 1.000). The inter- and intra-rater reliability of U/S had a ICC of 0.987 (95% CI 0.966, 1.000) & 0.983 (95% CI 0.956, 1.000) respectively.
Conclusion: U/S is an accurate alternative to radiography when measuring MGRs. It has a high inter- & intra-observer reliability & does not require radiation exposure. Although U/S allows accurate MGR measurement & soft tissue assessment, patients will still need annual radiographs to assess spine bony elements, overall spinal balance & scoliosis correction. Combining radiography & U/S allows patient monitoring & accurate MGR measurement whilst decreasing patients' radiation exposure.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

30. CAN A "FINAL FUSION" PROCEDURE BE AVOIDED IN EARLY ONSET SCOLIOSIS PATIENTS WHO REACH SKELETAL MATURITY AFTER GROWING-ROD TREATMENT?

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Summary: Definitive "final" fusion is the common endpoint to growing rod treatment (GR) for early onset scoliosis (EOS). However, final fusion may not be necessary for a subset of EOS patients who have reached skeletal maturity. The aim of our study was to characterize patients who completed GR treatment but received no final spinal fusion (NSF). We found that patients who did not receive a final fusion had excellent final coronal correction and trunk height, with no fractures in retained rods.

Introduction: Definitive "final" fusion is the common endpoint to growing rod treatment (GR) for early onset scoliosis (EOS). However, final fusion may not be necessary for a subset of EOS patients who have reached skeletal maturity with good alignment, and these patients may end their GR treatment with no definitive fusion. The aim of our study was to characterize patients who completed GR treatment but received no final spinal fusion (NSF).

Methods: A multicenter EOS database was queried to identify 156 patients who received GR treatment and reached skeletal maturity. Radiographs and clinical records of these patients were reviewed. 19 patients were identified as having received GR surgery without a final fusion procedure. Clinical and radiographic characteristics of NSF patients were compared against those treated with GR who did receive final fusion (FF) at skeletal maturity. All patients had a minimum of 2 year followup from final procedure.

Results: NSF group underwent on average 6.6 lengthening procedures (vs 5.6, P=0.28), and 1.7 unplanned revision procedures (vs 1.8, P=0.87). In the NSF group, 16 had rods retained and 3 patients had their growing rods removed at the last surgery. There were no fractures in those with rods retained.

There was no significant difference in the groups in: age at which growing rod treatment was initiated (6.4 vs 6.9 yrs, P=0.44), patient gender (47% vs 58% F, P=0.36), and diagnosis (NSF: 5 idiopathic, 7 neuromuscular, 5 syndromic and 2 congenital; FF: 33 idiopathic, 27 neuromuscular, 52 syndromic and 25 congenital, P=0.32).

There was no significant difference in the preoperative: coronal Cobb (75° vs 74°, P=0.81), coronal balance (2.9 vs 3.9cm, P=0.42) and T1-S1 length (26.4 vs 26.8 cm, P=0.71), or in the postoperative: coronal Cobb (43° vs 46°, P=0.50), coronal balance (2.9 vs 4.2cm, P=0.42) and T1-S1 length (37.4 vs 36.1cm, P=0.38).

Conclusion: Patients who did not receive a final fusion had excellent final coronal correction and trunk height, and had no rod fractures. Due to progressive ankylosis, "No Final Fusion" at maturity is a viable option for patients being treated with GR in all EOS diagnostic subgroups who have satisfactory final alignment.

31. THE TETHERING EFFECT OF A BRAIDED UHMWPE DEVICE IMPLANTED BY A THORACOSCOPIC-ASSISTED TECHNIQUE IN SKELETALLY IMMATURE PATIENTS WITH THORACIC IDIOPATHIC SCOLIOSIS

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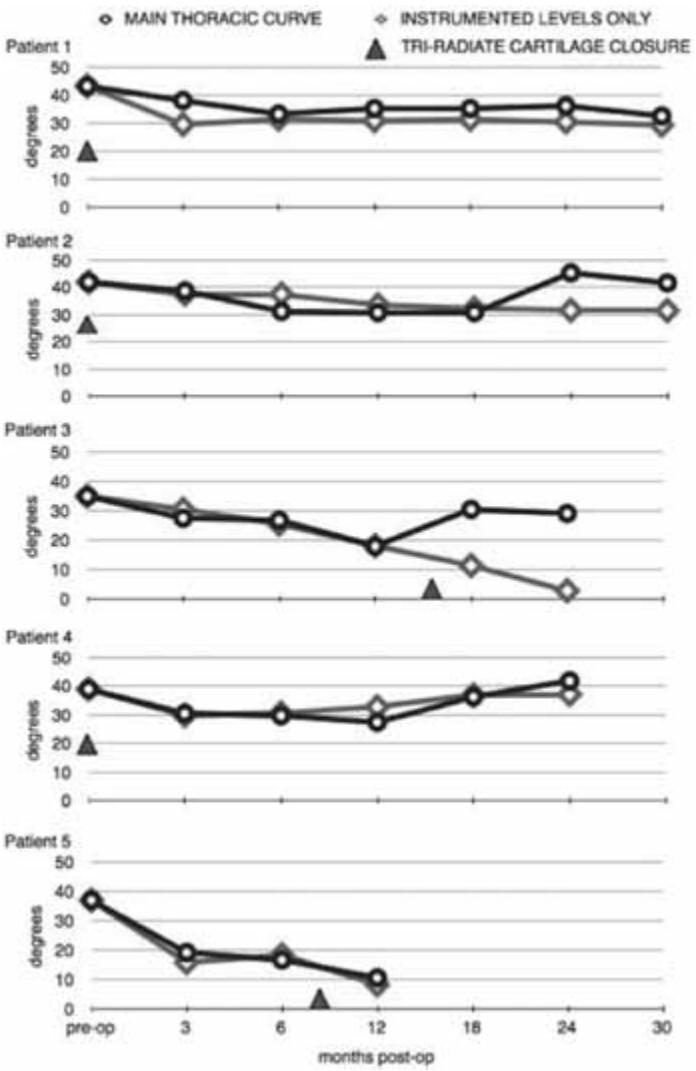
Summary: Non-fusion scoliosis surgery via a novel tether-device was performed in skeletally immature patients for progressive thoracic scoliosis through a thoracoscopic technique. Scoliosis curve improvement occurred immediately after surgery from surgical correction. Further correction from a progressive tethering effect was observed in 4 patients and was most pronounced in those with open triradiate cartilage (TRC) during surgery. Adding-on effect in the adjacent segments occurred in 2 patients by 2 years but did not deteriorate beyond pre-op Cobb angle. There were no device-related adverse events.

Introduction: Tether devices to effect scoliosis correction in a growing spine have been shown to be viable in animal models. We describe early results of non-fusion surgery in skeletally immature scoliosis using UHMWPE tethers anchored to bone screws.

Methods: Five girls aged 9-12 (bone age=10-13, amenarchal, Risser-0, TRC open in 2, closed in 3) with thoracic scoliosis underwent thoracoscopic insertion of vertebral screws that were sequentially connected by a braided UHMWPE tether on the curve convexity. Radiographs, MRIs, and SRS-22 were done pre-operatively and at regular intervals after surgery up to 30 months. Mean follow-up was 2 years.

Results: 37 screws spanning the 2 end vertebrae (range 7-8, most proximal at T5, most distal at T12) were implanted in 5 patients. Mean blood loss was 136mls. Mean op time was 210mins. MRI showed good screw placement and normal discs up to 2 years. The thoracic Cobb angle decreased after tether placement with further sequential curve correction up to 1 year. Better correction was seen in those with open TRC (see figure, patients 3 & 5) vs those with closed TRC (48.6% vs 24.9% correction, respectively). Concave and convex-side disc height and wedging showed time-dependent correction greatest near the apex. The overall Cobb angle returned to baseline by 2 years, but a definite tethering effect of the operated segments manifested as continuing Cobb angle reduction was seen in 4 patients. This was most evident in those with open TRC at surgery. The observed loss of over-all correction despite curve stability of the tethered segments was due to adding-on effect of adjacent levels in 2 patients. SRS-22 analysis showed a trend towards improvement of self-image by 2 years, and a trend to decreasing scores in the other domains but was significant only in the satisfaction domain (p=.006). There were no serious adverse events.

Conclusion: Implanting a tether device in skeletally immature patients with thoracic scoliosis results in progressive curve correction via a tethering effect from sequential improvement of disc wedging. The effect was most pronounced in those with open TRC at surgery. This new procedure is safe but requires more subjects to determine factors to prevent the adding-on effect noted in our series.



Cobb angles of the over-all main thoracic curve and the tethered segments before and after application of the spinal tether with reference to tri-radiate cartilage closure

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32. THE EFFECTIVENESS OF PRE-OPERATIVE HALO-GRAVITY TRACTION (HGT) IN EARLY ONSET SCOLIOSIS (EOS) AND SEVERE KYPHOSCOLIOSIS: CLINICAL AND RADIOGRAPHIC STUDY

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Summary: Treatment of complex spinal deformity in EOS remains a challenge. A rigid spinal deformity, poor pulmonary function, malnourished patients and poor bone stock complicate surgical treatment.
Introduction: HGT is able to restore coronal and sagittal balance, improve pulmonary function and reduce the risk of neurological injury.
Methods: A retrospective review of 21 patients with severe rigid scoliosis and kyphoscoliosis was performed to assess the safety and efficacy of HGT. The use of HGT was preoperative in 15 patients and perioperative in 6. The analysis was focused on the impact of HGT of curve flexibility, thoracic improvement, surgical complications and surgical outcomes in a single spine center between 2005 and 2011 (mean follow-up: 35 months). Space Available for the Lung (SAFL) and T1-S1 distance were used to measure thoracic improvement. HGT traction protocol included 30 to 40% of patient weight (depending on patient condition) during 8 weeks.
Results: 21 patients, 8 males and 13 females. Mean age was 9,33 (range: 3-17 years). Etiologies were 1 idiopathic, 1 congenital, 10 neuromuscular and 9 others (6 arthrogryposis, 2 osteogenesis imperfecta and 1 syndromic).
Mean pre-HGT values were: coronal Cobb :99,3 degrees (range: 62-146), sagittal Cobb: 82 degrees (34-125), SAFL index: 79 (48-127), T1-S1 distance: 235mm (143-345).
With HGT mean values were: coronal Cobb: 70 degrees (27,7% of improvement), sagittal Cobb: 62,8 degrees (21,5% of improvement), SAFL index: 83,2 (5,3% of improvement) and T1-S1 distance: 269,5mm (14,2% of improvement).
At end of follow-up mean values were: coronal Cobb: 57,5 degrees (41% of improvement), sagittal Cobb: 53,7 degrees (24,6% of improvement), SAFL: 86,6 (9,6% of improvement) and T1-S1 distance: 298,1mm (26,9% of improvement).
This results are consistent with others published papers in the literature. Despite 1 pin infection that needed removal and antibiotic treatment, there were no serious complications.
Conclusion: We found that HGT is not only safe and useful as a preoperative treatment in patients with severe rigid scoliosis, but also as an perioperative adjuvant in complicated kyphoscoliosis. Significant deformity correction averaging of 24,6% can be expected during HGT treatment, this correction is maintained or even improved with subsequent surgical correction.

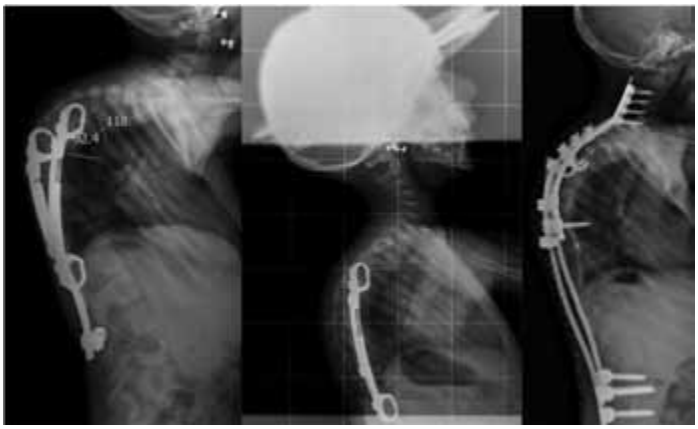

Fig 1: Patient with idiopathic scoliosis treated with Hybrid and Rib-to-rib VEPTR developed PJK at 2° year of treatment. HGT was used for 2 months and treatment was changed to growing rods and cervical extension.

33. SUBLAMINAR WIRES IN GROWING CONSTRUCTS FOR EOS WITH SEVERE CURVES: EFFECTIVE IN DIMINISHING PROXIMAL ANCHOR PULLOUT

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Summary: Use of sublaminar wires as reinforcement or as a proximal anchor in in spine based growing constructs shows promising effectiveness at preventing proximal implant pullout in comparison to hooks and/or pedicle screws alone.

Introduction: A common complication of both spine and rib based growing constructs is proximal implant pullout, particularly with significant kyphosis. The purpose of this study is to compare the incidence of proximal implant pullout in hook and pedicle screw (H&PS) proximal anchors in comparison to the use of sublaminar wires (SW) in patients treated with growing rods.

Methods: SW were utilized as proximal anchors or anchor adjunct in growing rod patients treated at a single institution; these were compared to a multi-center prospective database of growing rod patients with H&PS proximal anchors. Comparisons were made between groups for radiographic and clinical parameters, and incidence of proximal implant pullout.

Results: There were 11 SW patients and 202 H&PS with similar distribution of diagnoses (Congenital: 18.2% SW vs. 11.9% H&PS, IIS: 27.3% vs. 22.3%, NM: 27.3% vs. 26.7%, Syndromic: 27.3% vs. 31.2%, Other: 0% vs. 7.9%, p=0.848). In 6 patients SW was used to re-inforce an implant, and in 5 was the upper implant of a claw construct. In 6 of the 11 (54.5%) patients, SW had been used as salvage due to previous H&PS pullout, the rest were index anchors. Age at index procedure was similar (6.1 SW group vs. 6.4 years H&PS group, p=0.788). Preoperatively the SW group had significantly larger major Cobbs (95.5 vs. 76.7°, p=0.0115) and kyphosis (75.5 vs. 57.0°, p=0.0334); these values were the same when comparing only H&PS patients who had subsequent proximal implant failure to the SW group. Major Cobb correction was less in the SW group (34.5 vs. 42.8%, p=0.0955), but kyphosis was similar (14.8 vs. 13.4 %, p=0932). Average follow-up was similar (5.0 vs. 4.5 years, p=0.385) and number of lengthenings (4.5 vs. 4.8, p=0.768). During this period proximal implant pullout requiring new anchor placement occurred in 1 (9.1%) SW patient and 24 H&PS (11.9%).

Conclusion: Despite their use as salvage implant following previous implant failure and their use in patients with greater spinal deformity, patients treated with sublaminar wires had a similar rate of proximal implant pullout to patients anchored with hooks or pedicle screws alone and lesser deformity. Sublaminar wires should be utilized as part of the proximal construct in patients with significant deformity.

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34. PEAK TIMING AND ASSOCIATED RISK FACTORS FOR SPECIFIC COMPLICATIONS FOLLOWING ADULT SPINAL DEFORMITY (ASD) ARE IDENTIFIABLE: A GUIDE FOR SURGEONS AND PATIENTS

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USA

Summary: Prospective analysis of the timing and risk factors for postoperative complication for 199 consecutive ASD patients at minimum 2 year follow up demonstrated that major complications have a bimodal peak at T=0 (intraoperative) and 12-24 months, neurological complication had bimodal peaks at <3 and 12-24 months and proximal junctional kyphosis (PJK) had bimodal peaks at <3 and 6-12 months. Multivariate adaptive regression splines (MARS) analysis at delineated time points for peak complication incidence identified key risk factors for each complication.

Introduction: ASD surgery complication rates rank the highest of surgical specialties. Total complication rates have been reported, however little data exists for the timing and risk factors associated with specific complications. Purpose: evaluate the peak timing and risk factors for specific complications in a prospective, consecutive ASD cohort at minimum 2 year follow up.

Methods: Prospective analysis of complications following ASD surgery in a consecutively enrolled cohort. Inclusion criteria: ASD, age ≥ 18 years, spinal fusion≥ 4 levels, and minimum 2 years follow up. Complications divided into major and minor, then further divided into operative, implant failure, infectious, neurological, proximal junctional kyphosis (PJK), return to OR, and wound complications. Peak timing of complications identified and rank order best fit modeling for complication risk factors created using multivariate analysis (MARS) at delineated time points (T=0, <3, 3-6, 6-12, 12-24 and >24 months).

Results: 199 patients, mean follow up 44.3 months (range 23.3-60.3) met inclusion criteria. There were 350 total complications (214 minor, 136 major). Minor complications peaked at t<3 months, major complications had bi-modal peaks at T=0 and 12-24 months. Neurological complications had bimodal peaks at <3 and 12-24 months, PJK had bimodal peaks at <3 and 6-12 months and implant failures peaked at >24 months. Rank order best fit MARS variables for major complications at T=0 was rhBMP-2 interbody dose/level, BMI and EBL, and at 12-24 months was SVA. MARS risk factors for minor complications at <3 months were rhBMP-2 posterior dose/level, EBL, total posterior fusion levels, and maximal scoliosis. The only risk factor for neurological complications at <3 months was total osteotomies; no risk factors were identified at 12-24 months. Risk factors for implant failures at >24 months were 3-column osteotomies, SVA and EBL.

Conclusion: Risk factors for the peak timing of specific complications following ASD surgery are identifiable. Surgeons should be aware of complication timing and risk factors to improve patient care.

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35. IS AGE ASSOCIATED WITH INCREASED COMPLICATIONS RATES IN ADULT SCOLIOSIS SURGERY? A REVIEW OF 5,591 CASES FROM THE SCOLIOSIS RESEARCH SOCIETY DATABASE 2004-2007

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Summary: Patients who experienced complications, including mortality, following spinal fusion for adult scoliosis were significantly older than those without complications.
Introduction: Increasing life expectancy and advances in medical sciences have led to more aggressive treatments being offered to the elderly including adult scoliosis surgery. A few studies have identified advanced age as a risk factor to develop complications following long spinal fusion. However, these reports are often limited by relatively small number of study subjects.
Methods: The Scoliosis Research Society Morbidity and Mortality database was queried for all adult scoliosis surgeries from 2004-2007. Patient demographics, diagnoses, and complications were analyzes. Two-tailed t-test and chi-square test were performed.
Results: Of 5,591 patients, 746 (13.3%) had complications. Patients with complications were 4.0 years older (55.3 years vs. 51.3 years, $p<0.001$). Mortality rate was 0.27%. Patients who died were 14.8 years older than those who did not have complications (66.1 vs. 51.3 years, $p<0.001$).There was a trend toward increasing complication rates with advance age for both idiopathic and degenerative adult scoliosis subtypes. Patients > 50 years were 1.5 times more likely to experience complications ($p=0.001$).
Conclusion: Advance age was associated with increased complication rates including mortality following adult scoliosis surgery. Other factors such as medical comorbidities may also influence surgical outcome and merit further investigation.

36. PREDICTORS OF REVISION SURGERY IN ADULT SPINAL DEFORMITY AND IMPACT ON PATIENT-REPORTED OUTCOMES AND SATISFACTION: TWO-YEAR FOLLOW UP

Peter G. Passias, MD; Sun Yang, BA; Alex Soroceanu, MD, CM, MPH, FRCSC; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Oheneba Boachie-Adjei, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Shay Bess, MD; Eric Klineberg, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group
USA

Summary: Two-year, multi-center, prospective analysis of adult spinal deformity (ASD) patients undergoing revisions due to complications following index surgery vs. primary outcomes. This study investigates the incidence, predictors, and impact on health-related quality of life (HRQL) outcomes and patient satisfaction of unplanned return to surgery after ASD correction. Although HRQL improved in all patients at 2-years, revisions improved less. Positive predictors included body weight and C7-S1 SVA while BMP2 use and thicker rods were negative predictors. Patient satisfaction was unaffected.
Introduction: Patients undergoing ASD correction are at risk for an unplanned return to surgery. This study aims to quantify the incidence of revision after ASD surgery, identify predictors of revision, and determine its impact on HRQL outcomes and patient satisfaction.
Methods: 2-year, multi-center, prospective analysis of surgical ASD patients (age ≥18 years and scoliosis ≥20°, SVA ≥5cm, pelvic tilt ≥25°, or thoracic kyphosis >60°). Inclusion criteria for this study were complete demographic, radiographic, HRQL and operative data at 2-year follow-up. Patients were divided into Index Surgery only or Revisions. Primary infections were excluded. Potential predictors and confounders for revision surgery were identified using univariate analysis. Multivariate logistic regression modeling determined predictors of revision and impact on satisfaction. Multivariate repeated measured mixed models measured revision impact on HRQL.
Results: 243 patients met inclusion criteria. 42 (17.3%) of patients underwent revisions (14.3% at 6 weeks, 38% between 6 weeks and 1 year, and 47.7% between 1-2 years). Non-rod implant complications were the most common indication for revision (9) followed by PJK (8) and rod failure (8). Positive predictors of revision surgery included: weight (OR 1.33 per 10kg increase weight, $p=0.021$) and SVA (OR 1.15 per 2cm increase in SVA, $p=0.006$). Negative predictors included use of BMP2 (OR 0.157, $p=0.001$) and thicker rods (OR 0.5, $p=0.018$). HRQL improved in all patients—SF-36 ($p=0.0001$), ODI ($p=0.0001$) and SRS ($p=0.0001$)—but the rate (SF-36 $p=0.02$) and overall improvement (SRS $p=0.016$) compared to baseline were less for revisions. Revision status did not predict 2-year satisfaction ($p=0.726$).
Conclusion: Overweight patients with greater pre-op global sagittal malalignment are at greater risk for revision surgery following ASD correction. Using thicker rods and BMP2 was associated with decreased odds of revision. Revisions did not impact patient satisfaction at 2-years. Patients with revisions saw significant improvements in HRQL albeit less than those without.

37. THREE-COLUMN OSTEOTOMIES IN ELDERLY PATIENTS: IS IT WORTH IT?

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USA

Summary: Three-column osteotomy (3CO) is known to be an effective surgical procedure to correct spinal sagittal deformity (SSD) with clinical improvement in all fields of age, despite relative high rates of complication and revision. We propose to evaluate sagittal alignment and its evolution after three-column osteotomy in a population over 70 years old. Despite higher rates of revision for PJK and infection, radiographic outcomes suggest that three-column osteotomies can be pursued for healthy, elderly patients.
Introduction: As the elderly population grows, there has been a concomitant increase in their functional expectations. Degenerative spine deformity requires surgical techniques of correction such as various types of 3CO, many of which carry risks of complications

and revisions. Despite these risks, 3CO have shown potential benefit across commonly studied age groups. However it remains unclear if these benefits apply to the elderly population. We propose to evaluate sagittal alignment and its evolution after 3CO in a population over 70 years old.
Methods: Radiographic retrospective review of 54 patients over 70 year who underwent 3CO for SSD and were consecutively enrolled from 11 sites across the United States. All patients had full-spine radiographs analyzed at baseline (BL) and post-operatively (2 years). Operative reports and complications were also collected. A comparison was performed with a control group of younger patients (CG) matched by global and spino-pelvic alignment.
Results: Radiographic analysis at BL revealed severe SSD according to SRS-Schwab classification sagittal modifiers showing comparable values with CG. At 2 years, significant improvement was observed in the elderly cohort (EC). Compared with the CG, there was a significant difference in changes in PI-LL. There was no significant difference in OR time, post-operative complications, or total rate of revisions between groups. There were significantly more intra-operative complications such as increased rate of bleeding over 4L (77% of intra-operative complication in the EC), revision for PJK and infection in the EC.
Conclusion: In terms of global and spino-pelvic alignment, advanced age does not appear to be a contra-indication to 3CO; the EC achieved reasonable sagittal alignment, and PI-LL mismatch less than 10 was reached. It is important to recognize that these patients presented with severe SSD at BL and had much to gain from surgery. There were significant differences in intraoperative complications, PJK and infection between groups. Despite these differences, radiographic outcomes suggest that 3CO can be pursued for healthy, elderly patients especially those suffering from severe SSD.

38. CHARACTERIZING COMPLICATIONS OF ANTERIOR COLUMN REALIGNMENT (ACR) FOR ADULT SAGITTAL DEFORMITY

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USA

Summary: Complications of Anterior Column Realignment (ACR), a novel technique to treat adult sagittal deformity, have not been characterized. This study presents the first 30 consecutives ACR patients from 2 institutions and found a 50% and 26.7% incidence of major and minor complications, respectively. There was a 20% incidence of thigh sensory deficit post-operatively, which all resolved by 1 year, suggesting a transient approach related phenomenon. The complications reported are subject to interpretation as there are numerous confounding variables.
Introduction: Anterior Column Realignment (ACR) is a novel technique in the treatment of adult sagittal deformity through a minimally invasive lateral trans-psoas approach (LTA) with anterior longitudinal ligament release. Complications of this technique have not been described. We aim to characterize the complications of ACR.
Methods: Retrospective multicenter review of consecutive patients with min 1-yr f/u who underwent ACR. Complications were classified according to Glassman et al. (Table 1). LTA specific neurologic changes were recorded. Complications clearly related to posterior approach (i.e. posterior wound infection) were not recorded, however complications that were related to both procedures were included (i.e. rod fracture).
Results: 30 pts (mean age 65.2 yrs) with mean follow-up of 2.1 yrs (10m - 7.4yrs) were identified. 20 (66.6%) had at least one (1-4) complication. 15 (50%) had a major and 8 (26.7%) had at least 1 minor complication. 10 (33.3%) had a new neurologic complication. 8 (26.7%) required a reoperation. All pts required open posterior procedures with numerous osteotomies, 23 (76.7%) with ponte, and 2 (6.7%) with pedicle subtraction.
Of the neurologic complications, thigh (L1-3) and leg (L4-S1) sensory and motor deficits (TSD, TMD, LSD, LMD) were collected pre-op, within 30 days of ACR, 1 yr, and latest f/u. 10 (33.3%) pts had a new neurologic complication. 6 (20%) pts had TSD, with all resolving by 1 year. Of 4 (13.3%) TMD, 2 (50%) resolved by I year and one resolved at 2 years. There were no LSD at any time points and 4 (13.3%) had LMD with 1 (25%) resolving by 1 yr.
Conclusion: This study represents the first 30 consecutive ACR pts from 2 institutions. The incidences of major and minor complications were 50% and 26.7% respectively. While new TSD did occur, all resolved by 1 year suggesting a transient approach related phenomenon. The complications reported are subject to interpretation as there are numerous confounding variables (learning curve, 4 different surgeons, open posterior procedures and osteotomies) that could not be accounted for due to the retrospective design.

39. DOES TRANEXAMIC ACID EFFECTIVELY REDUCE BLEEDING AFTER SINGLE-LEVEL SPINAL FUSION SURGERY IN PATIENTS WHO ARE TAKING LOW DOSE ASPIRIN?

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Summary: The objective of this prospective study was to evaluate the efficacy of tranexamic acid in reducing blood loss after spinal fusion surgery in patients who taking low dose aspirin. The first 24 postoperative hours blood loss through drain showed a significant difference between 413.6±115.8ml in the tranexamic acid group and 698.1±158.9ml in the control group (p=0.004). The amount of total blood loss through drain was significantly less in the tranexamic acid versus control group, 631.4±251.6ml vs 986.4±363.8ml (p=0.017).
Introduction: Low dose aspirin is commonly used for preventive purposes in patients who have had myocardial infarction and stroke. However, in spinal surgery, aspirin has been reported to increase the bleeding tendency. The objective of this prospective study was to evaluate the efficacy of tranexamic acid in reducing blood loss after spinal fusion surgery in patients who taking low dose aspirin.
Methods: A total of fifty-one patients who taking low dose aspirin undergoing single level spinal fusion surgery for spinal stenosis were included in this study. Twenty-seven patients who administered tranexamic acid were compared with 24 patients who had not taken tranexamic acid. Blood loss through drain, amount of blood transfusion, and hematological laboratory findings were evaluated.

Results: For a mean period of 29.6 months, 100mg aspirin was administered. It was discontinued at least 7 days before surgery. There were no differences in patient demographics in terms of sex, age, weight, and height. The first 24 postoperative hours blood loss through drain showed a significant difference between 413.6±115.8ml in the tranexamic acid group and 698.1±158.9ml in the control group (p=0.004). The amount of total blood loss through drain was significantly less in the tranexamic acid versus control group, 631.4±251.6ml vs 986.4±363.8ml (p=0.017). The period until the removal of closed suction drain after surgery was 2.6±1.1 days in the tranexamic acid group and 2.7±0.9 days was in the control group with no significant difference (p=0.074). In the tranexamic acid group, the packed red blood cell (pRBC) transfused volumes for the first 24 postoperative hours was significantly lower than in the control group (525.2±251.4ml vs 967.7±430.5ml, p=0.038). There were no differences in the amount of transfused fresh frozen plasma volumes and hematological profiles.
Conclusion: Tranexamic acid had an effect to reduce bleeding after spinal fusion surgery in patients who taking low dose aspirin. Therefore, the pRBC transfusion was less required during the first 24 hours after surgery.

40. RISK FACTORS ASSOCIATED WITH 30-DAY READMISSIONS AFTER INSTRUMENTED SPINE SURGERY IN 14,941 PATIENTS

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Summary: Thirty day hospital re-admission rates are a recent measure of quality of care in spine surgery. Several studies report these rates to range from 3% to 7.9, but little is known about the associated risk factors. A spine surgery registry from an integrated healthcare system was used to identify the study cohort (n=14,94l patients) who had instrumented spine surgery between 1/09-3/13. Our study found 30-day readmission risk factors include surgical complications, malignancy, lengthy operative times, and lengthy initial hospitalizations.
Introduction: A recent measure of quality of care in spine surgery has been the 30-day hospital readmission rate. Several studies report these rates to range from 3% to 7.9%, but little is known about the associated risk factors. In addition, prior studies have been limited by single center designs and Medicare studies which may not generalize to the overall population. The purpose of this study was to investigate the 30-day readmission rate and the associated risk factors after instrumented spine surgery.
Methods: A spine surgery registry from an integrated healthcare system was used to identify the study cohort (n=14,94l patients) who had instrumented spine surgery between 1/09-3/13. The outcome of interest was 30-day hospital readmission. Patient characteristics, admitting diagnosis, surgical and procedure variables, surgical and/or medical complications, and co-morbidities were evaluated as possible risk factors for readmission. Descriptive statistics and multivariate logistic regression analysis were applied to identify readmission rates and associated risk factors.
Results: The average age of the cohort was 59 (SD=13.4) and 52% were females. During the study period the 30-day readmission rate was 5% (821/14,941) with 17%, 31%, 24 %, and 28 % readmitted during 1st, 2nd, 3rd, and 4th week respectively. The top 5 diagnosis for readmissions were infection, sepsis, uncontrolled pain, hematoma, and wound dehiscence. In adjusted models, a higher risk for 30-day readmission was associated with age group 80-89 years (OR 1.82, 95%CI 1.01-3.29), operative time > 200 minutes (OR 1.81, 95% CI 1.25-2.62), hospital stay >6 days (OR 2.23, 95% CI 1.43-3.48), depression (OR 1.49, 95%CI 1.14-1.94), hypothyroidism (OR 1.29, 95%CI 1.01-1.64), deficiency anemia (OR 1.3, 95%CI 1.05-1.61), rheumatoid arthritis (OR 1.45, 95%CI 1.04-2.01), malignancy - lymphoma (OR 2.98, 95%CI 1.55-5.72) and perioperative surgical complications (OR 1.66, 95%CI 1.17-2.35).
Conclusion: Surgical complications, malignancy, lengthy operative times, and lengthy initial hospitalizations are all risk factors for 30-day readmission. These findings support the need for closer post-operative follow-up within the first 1-2 weeks after discharge for patients at elevated risk for readmission.

41. REVISIONS AND JUNCTIONAL FAILURES OF SHORT VERSUS LONG FUSIONS FOR ADULT SPINAL DEFORMITY TREATED BY THREE-COLUMN OSTEOTOMY

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Summary: Proximal junctional kyphosis (PJK) is a concern after spinal fusion, especially in shorter fusions with an upper instrumented vertebrae (UIV) in the thoraco-lumbar junction. A comparison of short fusion (SF) and long fusion (LF) cohorts suggests that while SF leads to radiographic PJK, it does not necessarily lead to an increase in surgical intervention for it, and certain patients with a high sagittal vertical axis (SVA) up to a point can undergo SF with satisfactory sagittal outcomes.
Introduction: There has been much concern about the risk of PJK after spinal fusion, especially with shorter fusions. The only study evaluating rates of PJK in proximal versus distal thoracic fusions, found no significant difference. The purpose of this study was to investigate the rates of PJK and revisions in long fusions (LF) versus shorter fusions (SF).
Methods: Retrospective analysis of a multicenter database of 167 patients who underwent a lumbar three column osteotomy (3CO) and fusion to the pelvis with minimum 1 year follow-up. LF group was defined as UIV at T2-T4 (n=74) and SF group was defined as UIV T10-L3 (n=93). Cohorts were analyzed for differences in baseline and post-operative radiographic parameters, complications, and revisions.
Results: At baseline, patients were similar in age (61+9 years) and BMI (28+6), but LF patients had a significantly greater pelvic tilt, max kyphosis, and SVA (Table 1). Following surgery, LF patients had significant larger lumbar lordosis at 6weeks, max thoracic kyphosis

(TK) at 6months, max kyphosis and PJK at 1 year (Table); there were no significant differences in 1 year SVA. No significant differences existed in total revisions, revisions at 1 year, and total complications. SF patients had a significant larger rate in revisions at 3 months (LF 1.4% vs SF 11.8%, p 0.010), with no difference in etiology. In total, there were 8 revisions for PJK (of 47 revisions in total); 75% of the revisions for PJK (n=6) were SF patients who all had a baseline SVA>10cm.

Conclusion: At baseline, the LF group had significantly more global sagittal malalignment and TK; however post-operatively, sagittal alignment was not significantly different at any time point. There were also no significant differences in total number of revisions, except at 3 months for the SF group. PJK was higher at 1 year for the SF group, without a significant difference in revisions for PJK. These results suggest that while SF leads to radiographic PJK, it does not necessarily lead to an increase in surgical intervention, and certain patients with a high SVA can undergo SF with satisfactory sagittal outcomes.

42. SELECTION OF LOWER INSTRUMENTED VERTEBRA IN TREATING LENKE TYPE 2A ADOLESCENT IDIOPATHIC SCOLIOSIS

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Summary: Significant independent factors associated with postoperative distal adding-on in Lenke type 2A curve were examined in 116 patients who underwent posterior thoracic fusion. Distal adding-on was present in 16 patients (13.8%) at the 2-year follow-up. The identified risk factors include the CA at the 2-year follow-up, the lumbar correction rate immediately after surgery, and the difference between the LIV and LTV levels. Selecting a LIV at or distal to the LTV may prevent postoperative distal adding-on in Lenke type 2A.

Introduction: LIV level may affect the risk of postsurgical adding-on. The choice of the last touching vertebra (LTV)—the most caudal vertebra of the main thoracic curve that touches the central sacral vertical line when standing—as an appropriate LIV has been validated for Lenke type 1A but not type 2A curve. This study is to identify the ideal LIV to prevent distal adding-on after surgical correction of Lenke type 2A curve.

Methods: Radiographs obtained before, immediately after, and 2 years after surgery were evaluated for 116 consecutive patients who underwent posterior thoracic fusion surgery for Lenke type 2A curve. The LIV was proximal to the LTV in 18 patients (PLTV), distal in 43 (DLTV), and at the LTV in 55 (ALTV). Significant independent factors associated with adding-on were analyzed first by univariate analysis, and then by stepwise logistic regression analysis.

Results: Distal adding-on was present in 16 patients (13.8%) at follow-up: 9 PLTV (50.0%), 3 DLTV (7.0%), and 4 ALTV (7.3%). Adding-on was significantly more common in the PLTV group. One PLTV-group patient required revision surgery to treat adding-on. Univariate analysis identified the following significant factors associated with adding-on: the T2-T5 kyphosis angle and shoulder height before, immediately after, and 2 years after surgery; the lumbar Cobb angle at the 2-year follow-up; the 2-year postoperative lumbar curve correction rate; and the difference between the LIV and the end vertebra, neutral vertebra, and LTV levels. Significant independent risk factors identified by stepwise logistic regression analysis included the clavicle angle at follow-up, the correction rate of the lumbar curve immediately after surgery, and the difference between the LIV and LTV levels.

Conclusion: A LIV at or distal to the LTV may prevent postoperative adding-on in Lenke type 2A curve.

43. SCREW PLACEMENT AT THE APEX ALTERS SURGICAL OUTCOMES OF MODERATE LENKE 1 ADOLESCENT IDIOPATHIC SCOLIOSIS

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Summary: As the most rigid, translated and rotated part of the curve in acolescent idiopathic scoliosis (AIS) is the apex, it appeared logical to achieve a strong segmental instrumentation at this level. However, no studies have compared the effect of pedicle screw instrumentation of the apex in thoracic AIS patients. In the present study, sixty nine Lenke 1 type AIS patients were reviewed and it was found that although the insertion of pedicle screws in apical vertebrae won't significantly improve the curve correction, it can improve the derotation of apical vertebrae.

Introduction: Despite the reports of satisfactory correction of scoliosis by pedicle screw instrumentation, no studies have compared the effect of pedicle screw instrumentation of the apex in thoracic AIS patients with exclusive pedicle screw instrumentation. The purpose of this study was to investigate the effect of apical pedicle screw placement on the correction of Lenke 1 AIS.

Methods: Lenke 1 type AIS patients with all pedicle screw instrumentation between June 2009 to January 2010 were reviewed. According to whether pedicle screws were inserted on the apical vertebrae, 35 patients (Group A) were identified without apical screw placement due to the pedicle penetration. Thirty four patients (Group B) instrumented with apical screws were also enrolled according to matched age and Cobb angles to allow the most exact comparison. The fusion levels, the implant density, postoperative Cobb angle, the correction rate in Cobb angle, and derotation degree of the apical vertebra were also compared between the two groups.

Results: The implant density averaged 63.4% in Group A and 65.3% in Group B. The fusion levels was 11.3 in Group A and 11.6 in Group B. The correction rate in Cobb angle was 73.9% in Group A and 72.6% in Group B. There was no statistical difference in terms of implant density, number of fused vertebrae, the Cobb angle correction rate, and the loss of correction between the two groups. However, in terms of the derotation degree of the apical vertebra, it was observed significantly lower in group A (18.4%) than that in group B (34.8%) ($P<0.001$). In the 41 pedicle screws inserted in the apical vertebra in Group B, 5 (12.2%) were identified as misplacement.

Conclusion: For the patients with moderate Lenke 1 adolescent idiopathic scoliosis (Cobb angle 50°-70°), although the insertion of pedicle screws in apical vertebrae won't significantly improve the curve correction, it can improve the derotation of apical vertebrae.

44. CHARACTERIZATION OF SIGNIFICANT NEUROPHYSIOLOGIC INTRAOPERATIVE MONITORING EVENTS IN SEVERE SPINAL DEFORMITY SURGERY

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Summary: Corrective osteotomies are the most common cause of persistent Neurophysiologic Intraoperative Monitoring (NIOM) deterioration in severe spinal deformity. Unlike positioning, traction, or instrument-related correction which can be reversed, NIOM changes associated with performing osteotomies are not always reversible. Caution should be taken when performing Smith-Peterson (SPO)/ Ponte osteotomies during correction of severe spinal deformity.
Introduction: NIOM is a standard tool for avoiding or mitigating neurological injury during spinal deformity surgery in the developed world. Despite the severity of deformities, NIOM is used infrequently in the developing world. This is the first comprehensive study characterizing NIOM changes in this setting.
Methods: A prospectively collected database was reviewed for all spinal deformity surgery performed at a single site in a West African hospital over a 12-month period. Operative reports and monitoring data were reviewed. The surgical and systemic triggers of NIOM events and neurological status upon surgical completion were compiled. A significant NIOM event was defined as a 50% or greater decrease from baseline in the amplitude of tibial nerve SSEP, or 75% decrease in the MEP amplitude recorded from the lower extremity muscle with the largest baseline response.
Results: 88 patients met inclusion criteria. The average age was 14 years (3-28), and male:female ratio was 43:45. Diagnoses included idiopathic scoliosis (20), congenital scoliosis (9), congenital kyphosis (7), congenital kyphoscoliosis (11), idiopathic kyphoscoliosis (5), early-onset scoliosis (6), post-infectious kyphosis (15), and other (15). The average kyphosis was 108° (54-176°); the average scoliosis was 100° (48-177°). There were 44 separate NIOM events in 34 patients (39%).The most common triggers were traction or positioning (16), SPO/Ponte/VCR osteotomies (10), and intraoperative corrective maneuvers or implant placement (9). Upon surgery completion, 100% (9/9) events triggered by corrective maneuvers and implant placement resolved, 75% (12/16) of events resulting from traction or positioning resolved; 0% (0/10) of events associated with corrective osteotomies resolved completely.
Conclusion: NIOM events are encountered commonly during severe spinal deformity surgery. The most frequent event trigger was intraoperative traction or positioning. However, the most common cause of persistent NIOM deterioration was the performance of osteotomies. Unlike traction- or instrument-related correction, osteotomies produced irreversible events, possibly from canal intrusion by instruments or sudden localized deformity change. Caution should be taken when performing SPO/Ponte osteotomies.

45. SAGITTAL CERVICAL ALIGNMENT IN PATIENT WITH ADOLESCENT IDIOPATHIC SCOLIOSIS

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Summary: We have analyzed the sagittal cervical alignment of surgically treatemt patient with AIS. Despite the significant increase of cervical lordosis, 85% of patients still have a kyphotic or less lordotic spine. The strong positive association between cervical lordosis and T2 sagittal tilt suggests that the sagittal cervical alignment of adolescent idiopathic scoliosis patients is closely related to the global sagittal spine balance rather than thoracic kyphosis.
Introduction: Cervical kyphosis is a well recognized phenomenon in patient with adolescent idiopathic scoliosis. Despite recent reports, the prevalence, radiographic changes and the possible factors affecting post-op sagittal cervical kyphosis are still controversial. The purposes of this study are to assess the radiographic changes of cervical kyphosis and to identify the possible factors affecting post-op sagittal cervical kyphosis in a surgically treatment patients with adolescent idiopathic scoliosis.
Methods: A retrospective review of a single center database was performed on 133 consecutive patients with adolescent idiopathic scoliosis treated with long instrumented (>5 levels) spine fusion. (minimum 2yrs. mean 3.3 years, range from 2 years to 5.5 years). 89 patients met all the inclusion criteria. The pre-op and post-op radiographic measurement and patient demographics were investigated.
Results: Post-op cervical kyphosis was observed in 46 patients. Cobb angle decreased from 48.1+/-13.1 ° to 15.4+/-11.1 ° at the final follow-up. Cervical kyphosis significantly decreased from 5.5+/-8.9° pre-op to -1.5+/-8.9 degrees at the final follow-up. No difference was observed for T2-T5, T5-T12, LL, SS, PI, PT and SVA during the follow-up. Notably, T2 sagittal tilt was significantly increased from pre-op to the final follow-up. Pearson's correlation coefficient test showed strong correlation between post-op cervical lordosis and T2 sagittal tilt ($r=0.73$, $p<0.001$).
Conclusion: Despite the significant increase of cervical lordosis, 85% of patients still have a kyphotic or less lordotic spine. The strong positive association between cervical lordosis and T2 sagittal tilt suggests that the sagittal cervical alignment of adolescent idiopathic scoliosis patients is closely related to the global sagittal spine balance rather than thoracic kyphosis.

46. COMPLICATIONS AFTER 10 YEARS EXPERIENCE IN LUMBAR LATERAL ACCESS SURGERY

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Summary: The retroperitoneal approach preserves great vessels and bowel from iatrogenic injuries, but psoas traverse brings out a new set of complications. Reported complications include infection, vascular and bowel injuries, neurological deficit, cage subsidence and necessity of direct decompression. This work presents the

complications inherent to the lateral surgical procedure after 10 years experience.

Introduction: Lateral lumbar transpsoas approach aims to offer minor surgical morbidity due to the less invasive nature of the procedure, offering reduced overall complication rate in comparison to traditional surgery. However, it brings a new set of complications. This work presents the complications inherent to the lateral surgical procedure after 10 years experience.

Methods: This is a retrospective single center analysis that included 612 patients that underwent a lateral retroperitoneal transpsoas approach for lumbar interbody fusion between 2003 and 2014. The mean age was 63.3 years, being 355 female and 257 males. 131 were supplemented with pedicle screws, being the others standalone constructions.

Results: From all surgeries, only one deep infection was seen, while 22 cases of superficial infections occurred. Two cases of bowel injury happened, being one sutured during surgery and other required reintervention. No cases of great vessels injury were reported, while 5 patients showed incisional hernia. Cage subsidence was seen in 13 patients with supplemented pedicle screws, while 82 standalone constructions have shown some cage sinking. The overall rate of subsidence was 15.5%, being most of them resolved without the necessity of reoperation. A reintervention for direct decompression was needed in 31 patients (5.1%). 39% of all patients complained about some access related symptom at immediately postop visit that included hypoesthesia or paresthesia in the anterior thigh (29%), anterior thigh pain (10%) or quadriceps deficit (12%), all resolved before 6 months after surgery.

Conclusion: The lateral approach offers a minimally invasive alternative to access the lumbar spine. The retroperitoneal approach preserves great vessels and bowel from iatrogenic injuries, but psoas traverse brings out a new set of complication that includes plexopathies related to lumbar plexus. Fortunately, these findings have been shown to be transient. For that reason, EMG use is imperative in transpsoas access and larger casuistic studies are required to completly understand all expected effects, collateral damages and complications related to this technique.

47. PERIOPERATIVE STROKE IN PATIENTS UNDERGOING ELECTIVE SPINAL SURGERY: A RETROSPECTIVE ANALYSIS USING THE JAPANESE DIAGNOSIS PROCEDURE COMBINATION DATABASE

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Summary: This retrospective cohort study investigated the incidence of perioperative stroke in patients undergoing elective spinal surgery and to compared the risk of perioperative stroke among different surgical procedures using nationwide administrative impatient database. Perioperative stroke occurred in 0.22% of patients undergoing spinal surgery. Resection of a spinal cord tumor was associated with increased risk of perioperative stroke compared with other surgical procedures.

Introduction: Although a few large-scale study have been reported regarding perioperative stroke following spinal surgery, it remains unclear the relationship between the incidence of perioperative stroke and surgical procedures. The purpose of this study was to investigate the incidence of perioperative stroke in patients undergoing elective spinal surgery and to compare the risk of perioperative stroke among different surgical procedures.

Methods: A retrospective analysis of data from the Diagnosis Procedure Combination database, a nationwide administrative impatient database in Japan, identified 167,230 patients who underwent elective spinal surgery during 2007 to 2012. Patient clinical information was extracted, including age, sex, preoperative comorbidity, administration of blood transfusion, length of hospitalization, and type of hospital. Clinical outcomes included perioperative stroke during hospitalization and in-hospital death. We further classified stroke into hemorrhagic and ischemic stroke.

Results: The overall incidence of perioperative stroke was 0.22% (371 of 167,230) during hospitalization. Of these, ischemic strokes occurred in 318 patients and hemorrhagic strokes in 53 patients. Eighteen patients died of stroke. A logistic regression model fitted with a generalized estimating equation showed that perioperative stroke was associated with advanced age, history of cardiac disease, an academic institution, and resection of a spinal tumor. Compared with resection of a spinal cord tumor, the incidence of perioperative stroke was lower after discectomy (odds ratio (OR), 0.29; 95% confidence interval (CI), 0.14-0.58; $p = 0.001$), decompression surgery (OR, 0.52; 95%CI, 0.32-0.84; $p = 0.007$), and arthrodesis surgery (OR, 0.60; 95%CI, 0.36-0.99; $p = 0.045$). Also, resection of a spinal tumor was associated with a higher risk of hemorrhagic stroke compared with the other surgical procedures.

Conclusion: Perioperative stroke occurred in 0.22% of patients undergoing spinal surgery. Resection of a spinal cord tumor was associated with increased risk of perioperative stroke compared with other surgical procedures.

48. ADULT SPINAL DEFORMITY SURGEONS ARE UNABLE TO ACCURATELY PREDICT POST-OPERATIVE SPINAL ALIGNMENT: INITIAL ANALYSIS OF A THREE-PHASE STUDY

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Summary: Failure to achieve adequate correction in adult spinal deformity (ASD) is common. It is unknown how well surgeons predict postoperative alignment change without the use of surgical planning software. 17 thoracolumbar ASD cases were presented and surgeons predicted the postop alignment correction. Although there was fair inter-rater agreement, correct prediction occurred only 42% of the time.

Introduction: Adult spinal deformity (ASD) surgery rates are increasing and failure to achieve adequate correction is common. It is currently unknown how well surgeons are able to predict postoperative alignment change without the use of surgical planning software (SPS) and if software aids in the prediction. The current

study is phase 1 of a 3 phase study to assess surgeons' abilities to accurately predict postop spinal alignment.
Methods: 17 thoracolumbar ASD cases were presented that included a full-length standing radiograph with standard preop radiographic measurements and the surgical plan. Surgeon demographics collected included: # yrs in practice, % practice of ASD, # 3-column osteotomies (3CO)/yr, % usage and importance of SPS. Questions included: 1) if the surgical strategy provided adequate correction of SVA, PT, PI-LL, 2) predict postop SVA, PT, PI-LL, and change in TK based on 3 listed ranges for each. Means of % correct and inter-rater reliability measures based on Fleiss' Kappa values were used.
Results: 17 surgeons participated, 71% were within 0-10yrs of practice. 71% perform 10-50 3CO/yr. 53% do not use SPS but 88% feel it is important. On average, surgeons felt the listed surgical plan would provide adequate correction of SVA 63±13%, PT 67±15% and PI-LL 66±14% of the time ($p>0.05$ for all). Overall, correct prediction of postop changes occurred 42±6% of the time. Correct PT prediction (60±10%) was significantly higher than SVA (44±8%), PI-LL (27±11%), and TK (35±21%, $p<0.0002$ for all) and SVA over PI-LL ($p<0.0001$). Inter-rater Kappa values were generally fair: overall (0.34), SVA (0.32), PT (0.46), PI-LL (0.32) and TK (0.05).
Conclusion: It is unknown how well surgeons predict postoperative alignment change without the use of surgical planning software. The majority of surgeons in this study do not use planning software. Although there was fair inter-rater agreement, correct prediction occurred only 42% of the time.

49. FACTORS CAUSING FAILURE IN NAVIGATION-ASSISTED PEDICLE SCREW PLACEMENT IN SCOLIOSIS: WHY IS SCREW DEVIATION RATE NOT ZERO PERCENT EVEN WITH O-ARM-BASED NAVIGATION?

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Summary: The success rate of pedicle screw placement is not 100% even with O-arm-based navigation. This study aimed to analyze the factors causing failure in pedicle screw placement in scoliosis. The study minimized the technical factors by the use of O-arm-based navigation. The narrowness of pedicle channel was a factor causing failure in screw placement despite the use of O-arm-based navigation. The odds ratio of the failure rate increased 4-fold when the pedicle channel grade increased by one grade (became narrower).
Introduction: The success rate of pedicle screw placement is not 100% even with O-arm-based navigation. This study aimed to analyze the factors causing failure in pedicle screw placement in scoliosis. The study minimized the technical factors by the use of O-arm-based navigation for screw placement.
Methods: The subjects were 810 pedicles (55 AIS patients) probed for screw placement using O-arm-based navigation. In the evaluation, pedicles were considered to have failed screw placement if probing was performed but screws could not be placed because of perforation, if screws were placed but were subsequently removed intraoperatively because imaging confirmed their malposition, or if postoperative CT showed a deviation of screw of at least 2 mm. In the analysis, the independent variable was failure and dependent variables were curve laterality (convex side, concave side, or neutral), right side or left side, degree of scoliosis (less than 60°, or 60° or more), and pedicle channel grade. The pedicle channel grade was determined by measuring the inner diameter of the pedicle on the preoperative CT scan and divided into 4 group: grade 1; at least 4 mm, grade 2; at least 2 mm but less than 4 mm, grade 3; at least 1 mm but less than 2 mm, grade 4; less than 1 mm.
Results: The failure rate of screw placement was 0.5% for pedicle channel grade 1, 2.9% for grade 2, 12.0% for grade 3, and 31.5% for grade 4, indicating significant differences ($p<0.001$). The failure rate by curve laterality was 5.9% for convex side, 8.0% for neutral, and 9.0% for concave side, indicating no significant difference. The failure rate was 7.9% for left side and 7.1% for right side, indicating no significant difference. The failure rate was 8.2% for scoliosis of less than 60° and 5.6% for scoliosis of 60° or more, indicating no significant difference. Logistic analysis showed that pedicle channel grade was a significant risk factor (odds ratio: 4.0, 95% confidence interval: 2.9-5.6, $p<0.001$).
Conclusion: The narrowness of the pedicle channel was a factor causing failure in screw placement despite the use of O-arm-based navigation. The odds ratio of the screw placement failure rate increased 4-fold when the pedicle channel grade increased by one grade (became narrower).

50. SAGITTAL ALIGNMENT FOLLOWING LUMBAR THREE-COLUMN OSTEOTOMY: DOES THE LEVEL OF RESECTION MATTER?

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USA

Summary: 3-Column osteotomy (3CO) is an effective technique to correct sagittal malalignment, but is associated with high complication rates. Whether the angle of wedge resection and spinal level of the osteotomy are well correlated to the correction of spino-pelvic parameters remains unclear. This study sought to investigate the impact of the osteotomy site on sagittal correction. Post-operative apex of lumbar lordosis has a significant impact on pelvic tilt with more caudal 3CO levels associated with higher post-operative motor deficits and revision.
Introduction: 3CO is a technique to correct sagittal malalignment. However the distribution of correction of global truncal alignment versus pelvic retroversion remains unclear, with a belief that more caudal osteotomy leads to larger correction. We hypothesize that the level of 3CO or post-op apex of lumbar lordosis correlates with sagittal spino-pelvic correction.
Methods: Radiographic retrospective study of a multi-center database. Inclusion criteria were 2year follow-up (demographics, OR data, revisions and complications), UIV>L1, and lumbar 3CO. Radiographic data were analyzed at baseline, 6m, 1Y, 2Y FU to quantify spino-pelvic alignment, apex of lordosis and resection angle. Multivariate analysis was performed and correlations were tested using pearson for

continuous variables and spearman for apex or osteotomy level.
Results: 347 (56%) patients were included (mean age 60 yrs, BMI 28kg/m2, 69% female). Average resection angle was 25.3° without significant difference across 3CO levels. There were no significant correlations between 3CO level and amount of sagittal vertical axis (SVA) or pelvic tilt (PT) correction. Post-op apex location, which was more caudal than 3CO level (Figure), significantly correlated with a greater correction of PT (2° per more caudal level, r=-0.2, p=0.006) but not with SVA or "pelvic incidence minus lordosis" (PI-LL). A significant correlation existed between lower 3CO level and revision for pseudarthrosis (OR=4.4 3M-1Y; OR=2.8 1Y-2Y, p=0.01) and a higher rate of motor deficits (p=0.015). The overall risk of peri-op complications was related to the amount of wedge resection (p=0.03)
Conclusion: In this study, caudal lumbar 3CO does not lead to greater SVA correction. The location of post-op apex of lordosis has a significant impact on PT. While much attention is paid to the degree of resection during surgery, restoration of lordotic apex appears to have a greater impact on spino-pelvic alignment, which is not identical to osteotomy level. However, caudal levels are associated with a higher rate of motor deficits. This could be due to the anatomical consideration of roots and lumbar plexus.

51. CLINICAL MANIFESTATION AND SURGICAL TREATMENT IN SPINAL LESION ASSOCIATED WITH MUCOPOLYSACCHARIDOSIS

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Summary: Mucopolysaccharidosis are a group of inherited metabolic disorder of childhood, characterised by abnormal storage of glycosaminoglican and multisystem involvement.
Introduction: Spinal cord compression at the craniovertebral junction and multilevel cervical stenosis are common and life threatening manifestation.
Progressive thoracolumbar gibbus associated to kyphoscoliosis, leading to poor trunk balance and possible neurologic deterioration. Our purpose was evaluated the clinical presentation, management, surgical indications and results
Methods: Retrospective database of 52 patients with mucopolysaccharidosis was evaluated between 1992-2011, 11+8 year of follow up. Clinical presentation were: spinal stenosis n:18, kyphoscoliosis n:15, odontoid dysplasia n:13, atlantoaxial instability n:11, myelomalacia n:8, spondylolistesis n:2. Neurologic involvement was presented in 21 patients: paraparetic n:7, quadriparetic n:13, paraplegic n:1, bladder dysfunction n:18
Results: 20 female and 32 males, mean age 8+4 yrs, 38 patients underwent surgery, 14 had no indications for surgery. The most common indication was neurologic compromise n:21, followed by progressive spinal deformity n:17.
We performed 19 cervical decompression and fusion (C0-C2 n:13, C1-C2 n:6), laminectomy and fusion n:4, laminoplasty n:2; 13 thoracolumbar fusion (posterior n:6, circunferential n:7). 28 instrumented and 10 single fusion.
The total incidence of complications was 55%, neurologic deterioration n:6, pseudoarthrosis n:5, junctional kyphosis n:6 and deep wound infection n:4. 12 patients had revision surgery
Conclusion: To the authors knowledge it is the large series in published literature. The extradura soft tissues thickening develops spinal cord compression; spinal deformity and hypermovility segment exacerbate stenotic channel
Early descompresión avert or reverse neurologic deterioration. Fusion is always recommended
Surgical fixation on dysplastic spinal elements was possible without major complication.
Multidisciplinary managment and early cervical spine evaluation are mandatory.
The mid term results were good for fusión, neurologic preservation and mantein quality of life.

52. THE "3D SAGITTAL PROFILE" IN ADOLESCENT IDIOPATHIC SCOLIOSIS: LOSS OF THORACIC KYPHOSIS REVEALED

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USA

Summary: The 3D sagittal profile of patients with adolescent idiopathic scoliosis (AIS) was compared to a normal cohort. We found a substantial average loss of thoracic kyphosis in both primary thoracic and primary lumbar AIS curves as compared to normal adolescents. The 3D assessment of sagittal alignment corrects for error due to out of plane measurement associated with 2D measurements.
Introduction: The 3D assessment of scoliosis allows the "true" deformity to be measured. This is particularly relevant for the sagittal plane in which a substantial loss of thoracic kyphosis is typical. A proper understanding of the sagittal profile will allow for surgical strategies to correct deformity and appropriate outcome measures of the results. The purpose of this study was to compare the 3D sagittal profile of patients with adolescent idiopathic scoliosis (AIS) to a normal cohort.
Methods: Biplanar upright radiographs were obtained on 132 primary thoracic (T: Lenke 1-4), 42 primary lumbar (L: Lenke 5-6) curves and 75 normal (N) spines using an EOS scanner. 3D spinal reconstructions were created using sterEOS software. Multiple virtual Stagnara lateral views (each rotated to a direct lateral projection) were created to measure the true segmental kyphosis/lordosis for each pair of vertebrae from T1- S1. The segmental measures were summed for the regions of T1-5, T5-12, T12-S1. Comparisons were made between the 3 groups for each sagittal region as well as for the pelvic incidence (PI).
Results: Mean Cobb of T curves was 56.2o (range 37-115o) and L curves 51.0o (range 36-75o). Significant differences in the sagittal measures for each region and for PI between the 3 groups were found. Post-hoc tests revealed significant ($p<0.005$) differences at T1-5, T < N and L < N. All 3 groups (T, L, N) were different from each other at T5-T12 with the lowest kyphosis in the T curves (Table). At T12-S1, lordosis was significantly greater in T and L curves compared to N (Table). Lumbar lordosis extends proximally an average of two

segments in AIS than normal spines (T8 vs. T10/T11). Pelvic incidence was significantly greater for T curves compared to N.
Conclusion: The 3D assessment of the sagittal alignment in AIS corrects for the errors due to out of plane measurement associated with conventional 2D measurements. There is a substantial average loss of thoracic kyphosis (~15-25 degrees) for both primary thoracic and primary lumbar AIS curves compared to normal adolescents.

53. SEXUAL FUNCTION IN WOMEN WITH A HISTORY OF BRACING OR SURGICAL CORRECTION OF ADOLESCENT IDIOPATHIC SCOLIOSIS

Leon Kaplan; Tal Falick-Michaeli, MD; Yair Barzilay, MD; Amir Hashroni, MD, PhD; Eyal Itshayek, MD; Joshua E. Schroeder, MD
Israel

Summary: Female patients who have undergone uncomplicated care of scoliosis- bracing or surgical correction due to AIS have decreased sexual function many years after surgery compared to the general population due to decreased arousal, less frequent orgasm, and decreased sexual satisfaction.
Introduction: Adolescent idiopathic scoliosis (AIS) affects young women with long-term consequences for body image and sexual function.
Methods: Women 18-35 with a history of AIS treated with bracing or uncomplicated surgical correction with a time from surgery of 2 years or more were included. A group of healthy volunteers was used as control. Rates of sexual dysfunction and depression were compared using the Female Sexual Distress Scale-Revised (FSDS). Depression rates were assessed with the Beck depression Inventory. In the AIS cohort, manifestations of sexual dysfunction were assessed using the Female Sexual Function Index (FSFI) when dysfunction was detected.
Results: 115 women responded to the questionnaire. Thirty five were braced, 40 underwent surgical treatment and 40 were healthy controls. Mean age was 23.3 in the braced group, 25.1 years in the surgical group and 26.65 in the control group. Patients were braced for an average of 3.6 years (range 3-5 years), average Cobb angle at latest imaging was 34.5°. Among participants who underwent surgical fixation, the mean time from surgery was 8.2 years (range 3-12 years). The mean Cobb angle was 24° The average FSDS score was 6.3 in the scoliosis patients and 4.6 in the healthy group ($P<0.001$). 25% of the women in the scoliosis group scored pathologically vs. 12% in the healthy population ($P=0.02$). Rates of sexual dysfunction were identical in the braced and surgically treated groups. There was no correlation between type of bracing and sexual dysfunction rates. The women in the AIS group with a pathological score on the FSDS questioner answered a FSFI questioner as well. The average score was 24.2. When assessing the subgroups of the questioner a decreased score was noted in sexual arousal, orgasms and satisfaction. There was no correlation sexual dysfunction and depression in this study.
Conclusion: Women with a history AIS suffer from an increased rate of sexual dysfunction many years after they have completed treatment to correct their scoliosis. this leads to decreased arousal, less frequent orgasm, and decreased sexual satisfaction.

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54. MODELING THORACIC VOLUME FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

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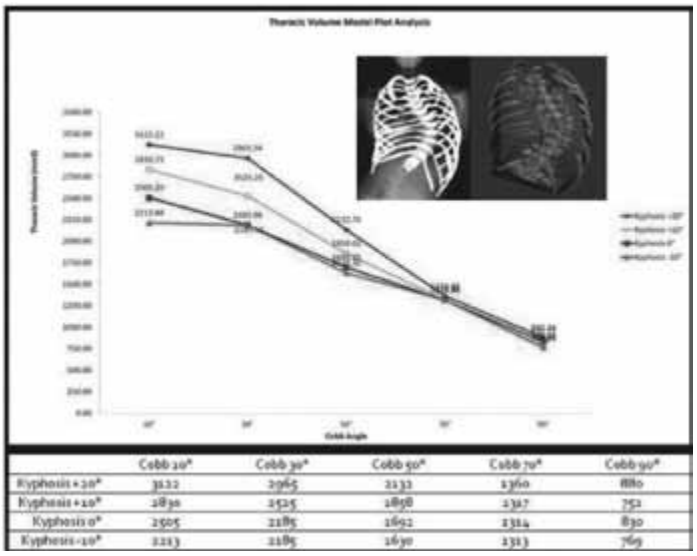
USA

Summary: Thoracic volumes in a virtual scoliosis model correlated positively with thoracic kyphosis and inversely with coronal Cobb angle.
Introduction: While moderate scoliosis is present in 1 in 300 children, its effects on respiratory function is not well understood. Severe skeletal malformations have been shown to result in decreased pulmonary function, lung development, pulmonary hypertension, right-sided heart failure, and premature mortality. Unfortunately, the degree and combination of deformity have not been studied for their specific effects on the space available for the lungs and the resulting pulmonary deficiency. Using a validated thoracic model, we calculated the thoracic volumes associated with different coronal and sagittal curve magnitudes of scoliosis.
Methods: Utilizing Blender software, a computational model of the spine and thorax was constructed to be 'computationally deformed' to match chest X-rays and compute the resulting thoracic volume (Figure 1). The size and orientation of the individual bones of the spine and thorax were altered to fit curves with sagittal (kyphosis) angles of (negative) -10, 0, +10 and +20 degrees and Cobb angles of 10, 30, 50, 70, and 90 degrees. The thoracic volume was then computed by meshing the space within the thoracic cavity. The validation of this model was performed by comparing the model predicted thoracic volume (from chest X-rays) with the thoracic volume measured from total thorax CT scans reconstructed into 3-D models using Mimics software (Materialise).
Results: Thoracic volume was largest with a 10 degree coronal deformity and 20 degrees of kyphosis. Volumes were lowest with 90 degrees of coronal deformity and -10 degrees of kyphosis. Cobb angle and decreased kyphosis resulted in decreased thoracic volume.
Conclusion: We were able to apply this modeling method to predict thoracic volume in scoliosis. This may be used to develop a predictive model to determine expected thoracic volumes and functional outcomes may based upon the type and severity of deformity and expected progression.



	Cobb 10°	Cobb 30°	Cobb 50°	Cobb 70°	Cobb 90°
Kyphosis +20°	3122	2965	2133	1360	880
Kyphosis +10°	2830	2525	2058	1317	752
Kyphosis 0°	2505	2185	1692	1314	830
Kyphosis -10°	2223	2185	1630	1313	769

55. RETROSPECTIVE ANALYSIS OF FEASIBILITY AND PERFORMANCE OF ROBOTIC GUIDANCE FOR PLACEMENT OF PEDICLE SCREWS IN 223 ADOLESCENTS WITH IDIOPATHIC SCOLIOSIS (AIS)

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USA

Summary: Retrospective chart review to assess feasibility and performance of robotic-guided instrumentation in 223 AIS patients in five centers. Of 3,768 pedicle screws planned (16.9/patient), 3,270 (86.8%) were placed with robotic guidance. As 216 screws were aborted due to surgeon decision, actual success rate was 92.2%. Instrumentation time of 4.5±1.5 minutes/screw demonstrates that robotic-guidance is consistent and may shorten surgeries.
Introduction: Anatomic constraints in AIS frequently confound placement of pedicle screws especially when instrumenting the most deformed regions of the curve. This report documents the technical and performance parameters of robotic guided pedicle screws in 233 cases of AIS in 5 centers.
Methods: Retrospective review of medical records of robotic-guided AIS surgeries from 2007 to 2013 for technical performance parameters including number of screws planned, placed and execution time.
Results: 223 (76% female) records were reviewed. 3,768 pedicle screws were planned (16.9/patient) and 3,270 (14.7/patient) were successfully executed using robotic-guidance. Screws were performed freehand when the robot's software failed to register a vertebra (181 screws, 4.9%) or due to trajectories beyond the robot's working envelope (94 screws, 2.5%). 216 screws (5.7%) were not placed due to surgeon's intra-operative decision. When accounting for these, the execution is 92.2%.
Average instrumentation time was 4.5±1.5 minutes per screw, ranging from 3.5-7.5 minutes, depending on surgical technique: drilling all pilot holes first and placing the screws after the robot is removed from the surgical field, or immediate placement of screws after each drilling, respectively. Standard deviations were low in both techniques (1.1-2.7 minutes).
Conclusion: Robotic-guided instrumentation in 223 AIS patients demonstrated high feasibility and performance in executing surgical plans. Instrumentation times demonstrate that robotic-guidance may shorten surgeries, and low standard deviations represent consistency regardless of anatomy or technical complexity.
Evidence level: 4

56. HOW DO IMPLANT COSTS IMPACT ACCESS TO PEDIATRIC SPINAL DEFORMITY SURGERY? AN INTERNATIONAL SURVEY OF SPINE SURGEONS

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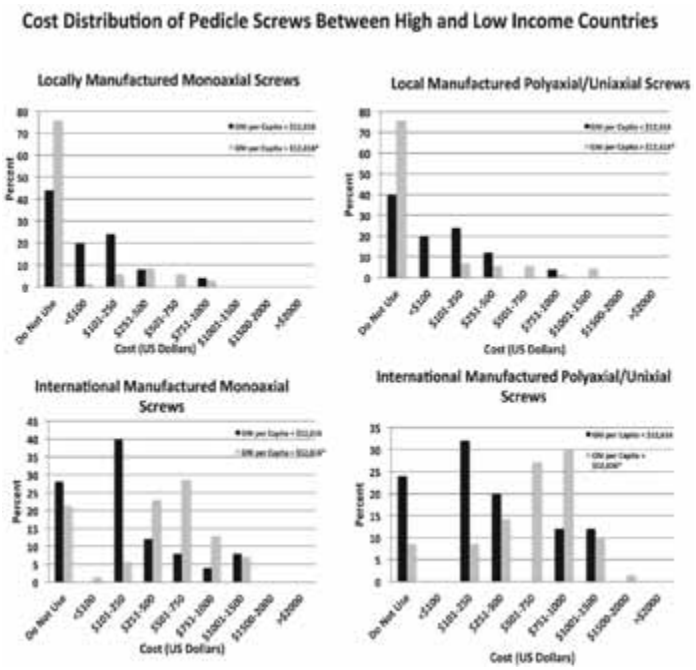
USA

Summary: In this survey of 95 international spinal deformity surgeons, pedicle screw costs and unsafe surgical facilities were the principle barriers for access to pediatric spinal deformity surgery (PSDS) in low income countries. Locally made implants & other cost reduction strategies were alternatives to using expensive international made pedicle screws
Introduction: In countries with limited resources, the burden of expensive pedicle screws may restrict access to surgical care. This study investigated how implant costs impact access to PSDS globally
Methods: A 28-item survey was developed on RedCap that queried society member or published international spine surgeons regarding the costs of pedicle screws, patient characteristics, cost reduction strategies, & barriers to PSDS in their countries. Implant costs were stratified between local & international manufactures. Local manufactures included either physician owned or start-up entities that only market implants locally or regionally. Surgeons, by their nationality, were grouped into two cohorts based upon the World Bank classification of "high income country" (HIC) (gross national income per capita (GNIPC) >$12,616) vs "low income country" (LIC). Statistical analysis used t-tests for continuous variables, chi-square for categorical data (alpha level <0.05) and multivariate regression analysis to correlate implant costs as a function of GNIPC
Results: Surveys were electronically sent to 441 pediatric spine surgeons in 58 countries. 95 surgeons (21.5%) from 36 countries responded, with 70 (73.7%) surgeons from HICs & 25 (26.3%) from LICs. Surgeons from LICs performed a greater annual number of pediatric deformity cases than the HIC cohort (83 vs 56, p=0.05). Patients from LICs more frequently pre-purchased implants from the vendor (45% vs 3% p<0.001) or the surgeon (30% vs 2% p<0.001) and were more likely to utilize charity funds (72% vs 40% p=0.009), compared to patients from HICs. Surgeries in HICs were associated with greater pedicle screw costs, regardless of manufacturing location (p<0.05). To reduce costs, a greater proportion of the LIC cohort utilized locally manufactured, older, refurbished, or donated implants (p<0.05); whereas the HIC cohort favored volume based or price negotiations with the vendor (p<0.05). High implant costs (43% vs 8%, p<0.001) & unsafe surgical facilities (16% vs 1%, p=0.005) were the most common barriers to access in LICs compared to HICs
Conclusion: Implant costs and unsafe surgical facilities, not surgeon experience or skill, were the chief barrier to access to PSDS in low income countries



57. ASSESSMENT OF BREAST ASYMMETRY IN ADOLESCENT IDIOPATHIC SCOLIOSIS USING AN AUTOMATED 3D BODY SURFACE MEASUREMENT TECHNIQUE

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

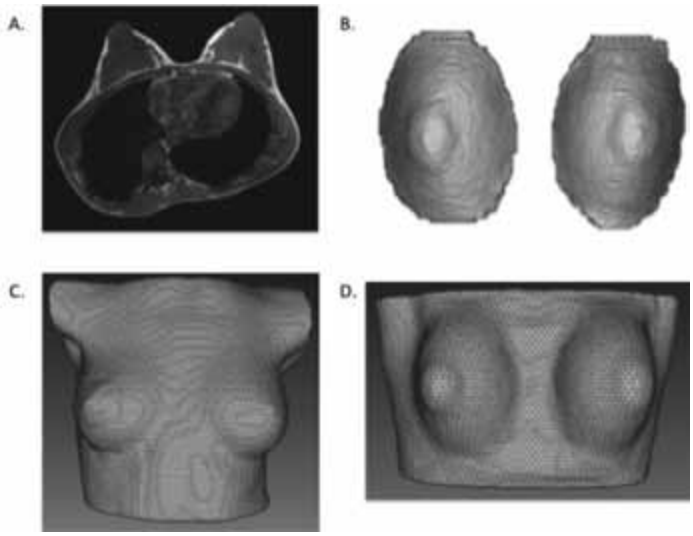
Summary: Breast asymmetry (BA), a common concern in female presenting with AIS, was measured using MRI and found to be prevalent and independent of chest wall deformity in a cohort of 30 patients with significant AIS. An automated 3D body surface measurement technique is proposed to evaluate BA in the clinical setting. Strong correlations are obtained when comparing the measured breast volumes (BV) to the MRI values. Additionally, BVs remain comparable despite being measured in different body positions (standing and prone) in our cohort.

Introduction: Breast asymmetry (BA) is a common concern in young female patients with adolescent idiopathic scoliosis (AIS). In a previous study using MRI, we found that the majority of patients with significant AIS presented BA (defined as a difference in breast volume (BV)) of up to 21% in addition to their chest wall deformity. MRI is costly and not always readily available. 3D surface topography, which offers fast and reliable breast acquisitions in a natural standing posture without radiation, is an alternative method in the clinical setting. The objective of this study was to assess BA directly with 3D surface imaging and to validate it using MRI values from a cohort of 30 patients with significant AIS. Also, to study the influence of posture (prone vs standing) on measured BA using the automated method on both modalities.

Methods: Thirty patients with AIS were enrolled in the study on the basis of their thoracic curvature, skeletal and breast maturity, without regard to their perception of their BA. Each patient underwent two imaging studies of their torso: a 3D trunk surface topography (patient standing) and a breast MRI (patient prone). BVs were first measured using a semi-automatic segmentation of the MRI cuts. Then, an automated BV measuring method was proposed using a program developed by our team and applied to the torso meshes from both imaging studies.

Results: Strong correlations were obtained when comparing the proposed method to the segmented MRI on the left breast volumes (LBV) (r=0.747), the right breast volumes (RBV) (r=0.805) and the BA (r=0.614). Using the same method on the torso surfaces from both modalities also yielded strong correlations on the LBV (r=0.896), the RBV (r=0.939) and the BA (r=0.709).

Conclusion: The proposed 3D body surface automated measurement technique is feasible clinically and correlates very well with BVs measured using MRI. Additionally, BVs remain comparable despite being measured in different body positions (standing and prone) in a young cohort of AIS patients. This measurement technique could be used in different centers to evaluate BA in patients with AIS.



Figures depicting the same patient A. MRI axial cut at the nipple level B.MRI segmented breasts C.3D surface topography mesh D. 3D MRI mesh

58. FAILURE AND SUCCESS IN VERTEBRAL BODY STAPLING

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USA

Summary: Vertebral body stapling (VBS) has been shown to be an effective treatment alternative for scoliosis in the growing spine. We report factors predictive of successful outcomes.

Introduction: The standard of care for moderate scoliosis (20-45°) consists of observation and bracing with the goal of halting curve progression. Recent studies have demonstrated that VBS is a safe and viable treatment option for idiopathic scoliosis. The objective of this study is to identify factors associated with successful outcomes in patients treated with VBS for idiopathic scoliosis.

Methods: We retrospectively reviewed all patients with idiopathic scoliosis treated with VBS who met the inclusion criteria: 1) idiopathic scoliosis; 2) age 7-16 years old at time of surgery; 3) preoperative

coronal curve magnitude of 20-35° for thoracic curves and 20 45° for lumbar curves; 4) preoperative Risser sign of 0 or 1; and 5) minimum of 2-year follow-up. Success of treatment was defined as avoidance of a fusion surgery and a final Cobb angle < 10° than the pre-treatment Cobb angle.
Results: We identified 63 patients who underwent VBS at a mean age of 10.78 years old and had a mean follow-up of 3.62 years. The mean pre-op Cobb angle for stapled thoracic curves was 29.1°. 74% of the patients who had VBS of the thoracic curve have avoided progression and/or fusion, and the mean Cobb angle at most recent follow-up was 21.8°. The mean pre-op Cobb angle for lumbar curves was 30.5°. 82% of the patients who had VBS of the lumbar curve have avoided progression and/or fusion, and their mean Cobb angle was 21.6°. For thoracic curves, the first erect and 1 year follow-up worst Cobb were associated with long-term success. In the lumbar curves, the preoperative bending Cobb, preoperative percent bend, and 1 year follow-up worst Cobb were associated with long-term success.
Conclusion: VBS is an effective means of preventing progression and fusion for moderate idiopathic scoliosis in skeletally immature patients. Several parameters correlated with successful outcomes for both stapled thoracic and lumbar curves.

59. RISK FACTORS OF PROXIMAL JUNCTIONAL KYPHOSIS IN ADOLESCENT IDIOPATHIC SCOLIOSIS: THE PELVIS AND OTHER CONSIDERATIONS

Baron S. Lonner, MD; Peter O. Newton, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Harry L. Shufflebarger, MD; Jahangir Asghar, MD; Paul D. Sponseller, MD; Randal R. Betz, MD; Burt Yaszay, MD; Yuan Ren, PhD
USA

Summary: The incidence of PJK following AIS surgery was 7%. Independent risk factors for PJK development for all curve types included loss of kyphosis, post-operative lordosis-PI mismatch, UIV caudal to CEV (except for Lenke 5), and increased rod contour angle.
Introduction: An incidence of radiographic proximal junctional kyphosis (PJK) as high as 27% has been reported in patients after Adolescent Idiopathic Scoliosis (AIS) surgery. Factors associated with PJK have been incompletely explored. The purpose of this study was to assess the incidence of PJK in operative AIS and to evaluate the impact of sagittal spinopelvic and other parameters on this phenomenon.
Methods: 864 operative AIS patients (years 2000- 2011, 78.2% female, age at surgery 14.4 yrs) were enrolled prospectively in a multicenter study and evaluated 2 years post-operatively. PJK was defined as an increase of the PJK angle ≥10° and postoperative (PO) PJK ≥10°. Factors studied included T5-12 kyphosis, lordosis/pelvic incidence (PI) ratio, lordosis-PI difference, kyphosis/(lordosis-PI) ratio, Rod Contour Angle (RCA), a new measure that reflects the proximal contouring of the rod, level of upper (UIV) and lower (LIV) instrumented vertebra, and were independently evaluated for association with PJK based on Lenke type. Lenke 2 & 4 curves and 3 & 6 curves were grouped together to increase numbers for purposes of statistical analysis. Multivariate logistic regression with backward elimination was performed to identify risk factors for PJK.
Results: Overall PJK incidence was 7%. Among patients with Lenke 1 curves, risk factors (see table) for PJK were: loss of kyphosis, large difference between PO lordosis and PI, and stopping caudal to the CEV. The risk of developing PJK increases by 8.4% with each lost degree of kyphosis. For Lenke 2 & 4 curves, loss of kyphosis and greater RCA were risk factors for PJK. For Lenke 3 and 6 curves, loss of kyphosis, PO (lordosis-PI) difference and PO lordosis/PI ratio were associated with PJK. UIV cephalad to the CEV was associated with increased risk of PJK in Lenke 5 curves, which was contrary to the finding for Lenke 1 curves.
Conclusion: The incidence of PJK in patients after surgery for AIS is 7% and varies based on Lenke type. Loss of kyphosis, lordosis-PI mismatch-shown in adult spinal deformity fusion to the sacrum to result in global sagittal malalignment, UIV caudal to the proximal CEV (except for Lenke 5), and increased RCA for Lenke 2 and 4 curves were the major risk factors for PJK in AIS.

60. IMPROVING THE PREDICTION OF SPONTANEOUS LUMBAR CURVE CORRECTION (SLCC) WITH SELECTIVE THORACIC FUSIONS: A STUDY ON 306 AIS PATIENTS

Heiko Koller, MD; Oliver Meier, MD
Germany

Summary: 306 patients were analyzed to study the best predictors of spontaneous lumbar curve correction (SLCC) with selective thoracic fusion (STF). To establish prediction models, a target outcome was defined by a lumbar curve (LC) ≤20°. A statistical model with high accuracy identified the information provided by preop LC *and* LC on bendings as best predictors for SLCC. Definition of target outcomes and modelling processes akin the current can support the decision making process in selective vs. non-selective thoracic fusion.
Introduction: The prediction of SLCC with STF remains difficult. Usually, recommendations base on the analyses of failures, LC-progression, adding-on, and trunk imbalance.Defining a target SLCC (LC≤20°) based on established criteria for favorable long-term outcomes, we tested the performance of an unique model to determine those parameters predicting the target SLCC best.
Methods: Retrospective analysis of 306 STF. 87% had Lenke 1 curves. LC modifier was Type A in 66%, B in 21% and C in 13%. Fusion length averaged 7 levels. Lowest instrumented vertebra was T12 in 54% and L1 in 29%. LC were stratified in Type-L (independent left-sided LC, 52%) and Type-R (single right thoracic curve (TC), 48%). Step-wise regression analyses were performed to identify criteria predicting a target LC≤20°. A multivariate logistic regression model was built with preop TC, preop LC, TC-bending and LC-bending as predictors. A prediction model was developed, the output variable was the target LC≤20°. For the model 273 patients were allocated in a learning sample, 33 additional patients in an independent test sample to test generalizability of the model. Two thresholds were applied in the learning sample to end up with high pos. and neg. predictive values.
Results: Scoliosis measures are summarized in table 1. F/U was 33months. Notably, mean SLCC was 13° in Lenke modifier Type A curves, 16° in Type B, and 14° in Type C w/o significant differences. Stepwise regression analysis showed that after selection algorithms,

preop LC (p<.02) and LC-bending (p<.009) remained in the model: Patients with preop LC≥51° had ≥90% risk for LC>20° at F/U, patients with preop LC≤18° had ≤10% risk for LC>20° at F/U. The model was applied to the independent test sample: Differences between the observed and predicted values was 1±4.5° only. To increase clinical significance of the model, the lower threshold for risk calculation was set to 25%, the upper to 75%. Model tests revealed that 100% of pts were correctly classified to achieve a target LC≤20° (86% correct for a LC>20°).

Conclusion: Significant predictors for optimum SLCC could be established. Accuracy was validated in an independent learning sample. Stratification of outcomes by target criteria will improve comparison of treatment effects in STF.

61. A LOGISTIC REGRESSION MODEL TO PREDICT COMPLICATIONS IN COMPLEX DEFORMITY SPINE SURGERY

Ferran Pellise, MD; Alba Vila-Casademunt; Lidia Mora; Maria J. Colomina; Montse Domingo-Sàbat; Ibrahim Obeid; Francisco J. S. Pérez-Grueso, MD; Ahmet Alanay, MD; Emre Acaroglu, MD; European Spine Study Group (ESSG)
Spain

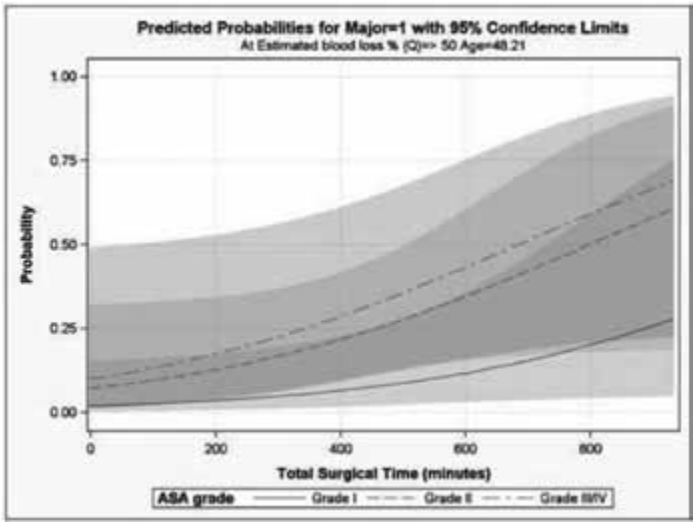
Summary: Adult spinal deformity surgery is associated with a high perioperative complication rate. The development of a predictive model would be extremely useful for preoperative patient selection and counseling. A retrospective analysis of prospectively collected data from a multicenter adult spinal deformity database was performed. Our data shows that the likelihood of perioperative major complications can be reliably predicted by the ASA grade, Estimated Blood Loss EBL and duration of surgery.

Introduction: Adult spinal deformity (ASD) surgery is associated with a high complication rate. The development of a predictive model would be useful for patient selection and counseling. The purpose of this study was to evaluate the degree to which the patient's physical condition and the magnitude of surgery were associated with the occurrence of complications after major reconstructive ASD surgery.

Methods: A retrospective analysis of prospectively collected data from a multicenter ASD database was performed. The patient's preoperative physical condition, intraoperative data, and postoperative major complications were used to build a predictive model. A logistic regression analysis was carried out with the dependent variable major complication and 4 independent (predictor) variables: ASA comorbidity grade, age, duration of surgery and estimated blood loss (EBL, given as % of an estimated blood volume of 75ml/kg for men, 65ml/kg for women) as continuous values or quartiles. The sample was stratified in four quartiles of EBL defined as: <15%, 15-30%, 30-50%, >50%. The Area Under the Curve (AUC) was determined to define the discriminatory power of the model.

Results: 260 operated patients (205 females), mean age of 48.2 (SD 19.7) years, were included in the database; 59 (23%) were excluded due to missing data. Average blood loss was 1546 (SD1102) ml, which represented a mean of 35.6 % (SD 25.5) EBL. The mean duration of surgery was 297.7 (SD 141.7) minutes. There were 60 (29.8%) complications, of which 18 (8.9%) were considered major. For a given ASA grade, the risk of major complications increased with longer surgeries (see Figure) and greater EBL. For the worst situation (EBL>50%), the risk of major complications was four-fold higher in patients with ASA grade II than in those with ASA grade I (Odds Ratio 3.99) and six-fold higher in ASA grade III/IV than in ASA grade I (Odds Ratio 5.77). AUC was 0.78.

Conclusion: ASD surgery is associated with a high probability of major complications. The likelihood of their occurrence can be predicted by the ASA grade, EBL and duration of surgery. Future analyses should include a more detailed description of comorbidities and the long-term clinical outcome to evaluate the patient's overall benefit from surgery.



62. PREDICTORS OF INFECTIONS AND MEDICAL COMPLICATIONS IN THE SETTING OF ADULT SPINAL DEFORMITY SURGERY

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USA

Summary: This study looks at wound infections and medical complications in the setting of adult spinal deformity (ASD) surgery. Predictors of medical complications include smoking, hypertension, and duration of symptoms. Despite the occurrence of medical complications, patients improved on HRQOL outcomes following ASD surgery.

Introduction: ASD surgery is known for its high complication rate. This study examines baseline patient characteristics for predictors of postoperative medical complications in ASD patients.

Methods: Retrospective review of a prospective multi-center database looking at surgical ASD patients. Intra and perioperative infections and medical complications were included. Medical complications were: pneumonia, UTI, c-difficile, sepsis, stroke, delirium, DVT, PE, MI, arrhythmia, CHF, pneumothorax, atelectasis, ARDS, bowel obstruction, ileus, and renal failure. Potential predictors were identified using univariate testing (p<0.2). Multivariate poisson regression was used to determine independent predictors of medical

complications. HRQL were measured using the ODI and SF-36. Multivariate repeated measures mixed models were used to examine HRQL, accounting for confounders.
Results: 448 patients were included. The incidence of patients with at least one medical complication was 26.8%. Potential predictors included: age, BMI, anemia, arthritis, depression, cardiac history, hypertension, lung disease, history of PVD, Charlson Comorbidity Index, ASA, smoking, gender, and the number of years with spine problems. Independent predictors identified on multivariate logistic regression modeling included hypertension (IRR 2.43 p=0.0001), smoking (IRR 2.49 p=0.0001) and number of years with spine problems (IRR 1.23 p=0.03). Despite medical complications, patients experienced significant improvements in HRQL, as measured by the SF-36 (p=0.0001) and ODI (p=0.0001). The rate of improvement and overall improvement compared to baseline was not statistically different than that of patients who did not experience medical complications.
Conclusion: Risk factors for the development of postoperative medical complications and infections following correction of ASD include smoking, hypertension and duration of symptoms. Patients who have one or more of these risk factors should be identified and informed during informed consent of their increased risks. They should be optimized pre-operatively, and followed closely during the post-operative period.

63. THE EFFECT OF COMPLICATIONS AND RE-OPERATION ON RECOVERY KINETICS IN 149 ADULT SPINAL DEFORMITY PATIENTS WITH TWO-YEAR FOLLOW UP: AN AREA UNDER THE CURVE ANALYSIS

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USA

Summary: Complication rates in ASD are high and the effect on overall outcome metrics are not well understood. Current methods of reporting outcomes are limited to static time points. A retrospective review of a multicenter, prospective ASD database was conducted. Area under the curve (AUC) analysis suggests there is a significantly protracted mental recovery phase associated with patients that have at least one complication and the addition of reop does not affect the recovery kinetics.
Introduction: Complication rates in adult spinal deformity (ASD) surgery are high and the effects on overall recovery are not well understood. Current methods of reporting outcomes are limited to static outcome time points perhaps diminishing the health impact of the entire recovery experience. This study aims to identify the effect of complications on the kinetics of the recovery process (recovery kinetics) by examining the effect of HRQOL over time via an area under the curve analysis (AUC).
Methods: A retrospective review of a multicenter, prospective ASD database. Inclusion criteria, ≥18yrs, ASD. Complication number, type, and need for reoperation (reop) were recorded. Pts were stratified as having no complication (NOCOMP) and any complication (COMP). HRQOL collected included Oswestry Disability Index (ODI), Short Form-36(SF-36), and Scoliosis Research Society-22 (SRS22) at baseline, 6wks, 1 and 2yrs postop. All HRQOL was normalized to each pts' baseline scores as a comparison relative to where the pts started. An AUC was then calculated across the entire 2yrs. Standard HRQOL, normalized HRQOL, and AUC means were compared between groups.
Results: 149 pts were included (COMP:84, NOCOMP:45). There were no significant HRQOL differences at any time point between the groups (p>0.05 for all). However, after normalizing the HRQOL, COMP had significantly lower SRS mental scores at 1yr (1.1±0.2vs1.2±0.3,p=0.0002) and 2yrs (1.1±0.3vs1.3±0.4,p=0.0003, Figure1). COMP had significantly lower SRS Mental AUC than NOCOMP (3.2±0.5vs3.5±0.6,p=0.0023). 28 (19%) pts had a reop. There were no significant differences between any HRQOL 2yr AUC values between pts with complications requiring reop and those with no reop (p>0.05 for all).
Conclusion: Static HRQOL analysis would suggest there is no difference between complication groups. Area under the curve (AUC) analysis suggests there is a significantly protracted mental recovery phase associated with patients that have at least one complication and the addition of reop does not affect the recovery kinetics.

64. DOES CHRONIC KIDNEY DISEASE AFFECT THE MORTALITY RATE IN PATIENTS UNDERGOING INSTRUMENTED SPINE FUSION? LONG-TERM FOLLOW UP OF A MULTICENTER SPINAL REGISTRY

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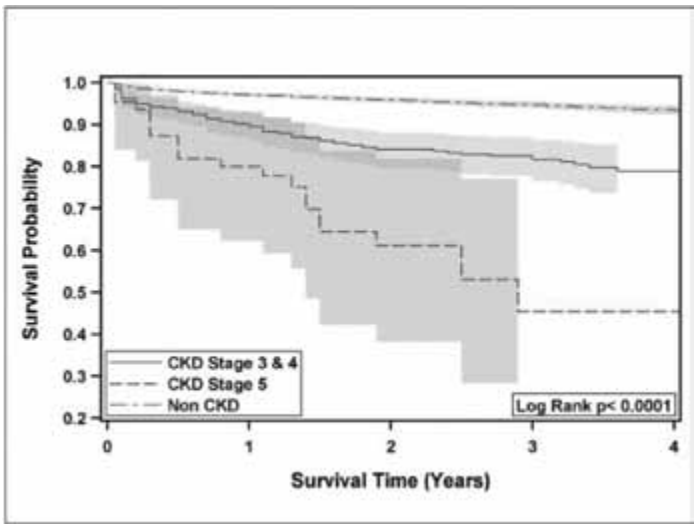
Summary: Chronic kidney disease (CKD) patients have a significantly higher rate of mortality following spine surgery, as compared to non-CKD patients.
Introduction: The number of patients with CKD requiring spine surgery is increasing. Data on the effect of CKD on overall clinical outcomes following spinal surgery is sparse, limited to small clinical series from single institutions reporting variable outcomes with limited follow-up. The purpose of this study was to investigate the long-term mortality rate in CKD patients who underwent instrumented spine fusion using a large, multi-center spine registry.
Methods: An integrated health system's spine registry was used to identify 12,276 consecutive patients who underwent instrumented spine fusion procedures performed between 1/09 and 12/12. Data on CKD status and mortality were obtained using an integrated electronic medical records system. Patient characteristics, surgical factors, comorbidities, and complications were evaluated. Logistic regression and Kaplan-Meier analysis were used to evaluate risk of mortality following spine surgery.
Results: The average age of the cohort was 59 (SD=13.4) and 53% were female. Patients who had stage 3, 4 or 5 CKD were older than the non-CKD patients, 71 (SD=9.2) vs. 59 (SD=13.3). After adjusting for age, gender, BMI, admitting diagnosis, use of BMP, smoking, diabetes, other comorbidities and complications, higher mortality rates were observed for patients who had stage 3 or 4 CKD (OR 1.78, 95% CI 1.3-2.45). Even higher mortality rates were noted for hemodialysis-dependent patients (stage 5 CKD), (OR 4.18, 95% CI 1.87-9.34).

Conclusion: Spine surgery is associated with significantly higher mortality rates in patients with chronic kidney disease compared to patients with normal kidney function. Understanding the additional morbidity and mortality of spine surgery in this medically complicated group of patients is imperative for accurate preoperative risk assessment. Our findings from a large, multi-center spinal registry provide a starting point for future studies aimed at understanding the perioperative risk factors and clinical outcomes of spine surgery in the CKD patient population.



Kaplan-Meier survival plot (with 95% confidence limits) for CKD and non-CKD patients following spine surgery.

65. THE EFFECT OF ESOPHAGEAL CONTENTS ON POST-OPERATIVE DYSPHAGIA FOLLOWING PRIMARY ANTERIOR CERVICAL DISCECTOMY AND FUSION SURGERY: A RANDOMIZED PROSPECTIVE STUDY

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Summary: Placement of an esophageal temperature probe at the time of primary ACDF resulted in improved dysphagia scores up to 1 year post operatively. In those undergoing two level ACDF, significantly improved dysphagia scores were seen at 2 weeks and 6 months post-operatively with a probe in place at surgery.
Introduction: Following anterior cervical discectomy and fusion (ACDF), dysphagia is a well-documented and common complaint that may persist for several months to years. The goal of this study is to determine whether contents in the esophagus at the time of surgery, specifically an esophageal temperature probe, play a role in worsening or alleviating the severity of dysphagia post-operatively.
Methods: A prospective randomized controlled trial of patients undergoing primary ACDF surgery was performed at our institution. These patients were randomly assigned into two groups. The first group of patients was assigned to placement of an esophageal temperature probe in the esophagus during surgery. The second group was assigned to no esophageal probe and therefore no contents in the esophagus at the time of surgery. Patients enrolled in the study were asked to fill out a Swallowing- Quality of Life (SWAL-QOL) dysphagia questionnaire at their pre-operative visit and again at 2 weeks, 6 weeks, 3 months, 6 months and 1-year post operatively. The scores were analyzed for differences with respect to time within groups and for differences between groups at all time points. A further subgroup analysis was performed for differences based on sex and the number of cervical levels involved in surgery (1, 2 or 3).
Results: There were no differences with regards to age, sex, and pre-operative dysphagia scores between the two groups. A statistically significant improvement in scores at 2 weeks and 6 months post-operatively was found favoring the probe group in those undergoing 2 level ACDF. Overall, a trend towards improved scores was seen at all time points post-operatively and improved rates of dysphagia at 1 year post-operatively was found favoring the probe group.
Conclusion: The overal results from this study show a trend toward improved dysphagia outcomes up to a year post-operatively when an esophageal probe is placed during surgery. More specifically, patients undergoing 2 level surgery were shown to have a significantly better score in the post-operative period when a probe was placed. The results are applicable to patients undergoing primary ACDF surgery to improve the morbidity of dysphagia post-operatively.

Statistic	No Probe	Probe	P Value Between probe and no probe group	No Probe P Value Compared to Pre Op	Probe P Value Compared to Pre Op
Average Age	49	52	0.28		
Male:Female	6:12	15:6	0.51		
Average Pre Op Score	63.67	63.67	1		
2 Weeks Post op	53.17	58.29	0.069	**0.0001**	**0.002**
6 weeks Post Op	60.17	62.1	0.44	0.092	0.212
3 Months Post op	61.33	64.14	0.22	0.292	0.667
6 Months Post op	63.11	66.33	0.15	0.815	0.008
1 year Post op	65.94	67.05	0.48	0.217	0.003
Male 2 Weeks Post Op	54.33	57.83	0.443	**0.0084**	0.55
Female 2 Weeks Post Op	52.58	58.47	0.11	**0.0035**	**0.0004**
Female 1 year Post Op	66.83	67.8	0.523	**0.025**	**0.027**
2 Levels 2 Weeks Post Op	48.5	57.89	**0.043**	**0.0021**	**0.045**
2 Levels 6 Months Post Op	62	67.78	**0.039**	1	**0.039**
2 Levels 1 Year Post Op	65.5	68.22	0.134	0.173	**0.003**

66. READMISSION, RE-OPERATION AND INDEX LENGTH OF STAY RESULTING FROM SPECIFIC COMPLICATIONS FOLLOWING ADULT DEFORMITY SURGERY

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Summary: Complications after adult deformity surgery result in increased readmissions, reoperations and hospital length of stay. This retrospective cohort study reviewed the effect of various classes of medical and surgical complications on healthcare utilization. Radiographic complications showed the highest rates of readmission and reoperation, while major infection, cardiac, operative and renal complications showed significant increases in length of stay. These results may help in the development of objective measures of clinical and economic impact of adverse events among adult deformity patients.

Introduction: Medical and surgical complications are common after adult deformity surgery, resulting in increased healthcare utilization. We assessed rates of reoperation, readmission and length of stay (LOS) resulting from specific complications after adult deformity surgery.
Methods: A prospective multicenter cohort of 256 adult patients undergoing thoracolumbar fusion for adult deformity was retrospectively analyzed. LOS at index surgery, readmissions and reoperations were recorded for patients experiencing complications in the first two years postoperatively. LOS was used as a surrogate of healthcare utilization related to early postoperative complications, while readmission/reoperation was used to capture utilization related to complications after discharge.
Results: There were 173 patients with any complication, 99 with major and 118 with minor, resulting in 55 reoperations and 54 readmissions. Major radiographic complications (junctional failure/pseudarthrosis) had the highest rate of both readmission and reoperation (9.8% for both) followed by major implant complications (6.3%, 5.9%). Major infection (2.7%, 3.1%), neurologic (2.3%, 3.1%), cardiac (0.4%, 0.8%), operative (0.8%, 0%), and wound (1.2%, 0.4%) complications were less likely to result in reoperation or readmission. Median LOS for patients without complication was 8 days, while major infection, cardiac, operative and renal complications led to increased LOS (Table 1). Minor complications did not result in significantly increased LOS.
Conclusion: Patients experiencing perioperative complications consume greater medical resources than patients without complications. Radiographic and implant related complications led to the highest risk of hospital readmission and reoperation, while renal complications resulted in the greatest increase in hospital length of stay. These results may help in the development of objective measures of clinical and economic impact of adverse events among adult deformity patients.

67. PROSPECTIVE ANALYSIS OF LOCATION OF RHBMP-2 USE IN ADULT SPINAL DEFORMITY (ASD) SURGERY DOES NOT CORRELATE WITH SITE SPECIFIC COMPLICATIONS AND GENERATES GREATER FUSION RATES AT MINIMUM TWO-YEAR FOLLOW UP

Shay Bess, MD; Breton Line, BSME; Virginie Lafage, PhD; Christopher P. Ames, MD; Oheneba Boachie-Adjei, MD; Douglas C. Burton, MD; Robert A. Hart, MD; Behrooz A. Akbarnia, MD; Eric Klineberg, MD; Gregory M. Mundis, MD; Richard Hostin, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; International Spine Study Group
USA

Summary: Minimum two year follow up of 199 consecutive, prospectively enrolled ASD patients demonstrated the location of rhBMP-2 use (interbody, posterior or interbody+posterior) for multi-level fusion in ASD does not correlate with site specific complications. Major complications correlated with EBL, BMI and total levels fused. Patients receiving interbody+posterior rhBMP-2 demonstrated higher fusion grades and rates than patients not receiving rhBMP-2. Final and postoperative improvement in health related quality of life (HRQOL) was similar for all groups.

Introduction: Location of rhBMP-2 use may correspond to specific complications. Little data exists for complication and fusion rates based upon location of rhBMP-2 use in ASD. Purpose: compare complications, fusion rates and clinical outcomes for ASD patients based upon location of rhBMP-2 use.
Methods: Multicenter, prospective analysis of 199 consecutive ASD patients. Inclusion criteria: ASD, age ≥ 18 years, spinal fusion≥ 4 levels, minimum 2 year follow up. Patients divided into those receiving rhBMP-2 (BMP; n=130) or no BMP (NOBMP; n=69), and location of BMP use: posterior only (PBMP; n=79), interbody only (IBMP; n=6), and interbody + posterior (I+PBMP; n=45). Types and timing of complications were evaluated, spine fusion assessed using Lenke grade, HRQOL recorded (SRS-22r, ODI, SF-36), and multivariate analysis (MARS) performed.
Results: 199 patients, mean follow up 44.3 months (range 23.3-60.3) met inclusion criteria. Posterolateral rhBMP-2 dose/level was similar for I+PBMP (3.2mg) and PBMP (3.3mg). I+PBMP was older, had more comorbidities and greater EBL than NOBMP ($p<0.05$). Total spinal levels fused were similar for all groups (range 10.3-10.6). Early minor complications (Time=0, 0-3 months) were greater for I+PBMP and PBMP vs. NOBMP. Major complications, infections and radiculopathy were similar for all groups at all time points. Implant failures and revision surgery at 6-12 months were greater for NOBMP than PBMP; PSO procedures were greater for NOBMP however pre and postop sagittal alignment and correction was similar for NOBMP vs. PBMP. MARS demonstrated major complications correlated with EBL, BMI and total fusion levels. I+PBMP had greater posterior fusion grade and rate than NOBMP, and PBMP had greater anterior fusion grade and rate than NOBMP. HRQOL improvement was similar for all groups.
Conclusion: RhBMP-2 at referenced doses improves fusion rates and does not correlate with site specific complications. Longer follow up is needed to assess if fusion rates correlate with revision surgery and HRQOL.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

68. PRE-WARMING TO PREVENT INTRA-OPERATIVE HYPOTHERMIA: A POSITIVE IMPACT ON PERI-OPERATIVE OUTCOMES IN SPINAL DEFORMITY SURGERY

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Summary: Intraoperative hypothermia (IH) can lead to significant adverse perioperative outcomes and efforts at minimizing hypothermia during surgery have been previously described. We report on the utility of pre-warming (PW) of patients prior to spinal deformity surgery as an effective strategy to decrease intraoperative hypothermia, resulting in less blood loss, fewer blood transfusions, and decreased surgical site infections and hospital stay. Reducing the incidence and severity of intraoperative hypothermia may have the potential for drastically reducing complication-related costs.

Introduction: Unless active measures are taken to maintain normothermia, IH can be common in patients undergoing spinal deformity surgery due to its length, complexity, and prone positioning of the patient. IH is a known cause of significant morbidity in surgical patients and its negative effect on coagulation and infection rates have been previously described. PW of patients prior to surgery is a simple, non-invasive measure which has shown to significantly decrease IH. The purpose of this study was to evaluate the effect of PW of patients undergoing deformity surgery on surgical site infection (SSI), blood loss, risk of transfusion and length of hospital stay (LOS).
Methods: A retrospective comparative study of cases (pre-warmed between 2011-2012) to controls (not pre-warmed between 2009-2010) was undertaken after institutional IRB approval. All consecutive patients undergoing spinal deformity surgery with complete temperature and surgical data were included in the analysis. MATLAB (The Mathworks Inc., Natick MA USA) was used to plot temperature trends, and identify episodes of hypothermia and their level of severity. The percentage of case spent hypothermic was the summed durations of all hypothermic episodes divided by the duration of temperature monitoring. Patient demographics and surgical data were obtained from retrospective chart review.
Results: A total of 414 patients were identified of which 254 were PW (61%). The median age (PW:15.3, non-PW:15.2), surgical time (PW:343.5min, non-PW:415min), weight (PW:50.9kg, non-PW:46.7kg) and number of levels instrumented(PW:11,non-PW:12) was similar between the groups. The percent case hypothermic was significantly different in the PW group (15.5%) compared to non-PW (25%; p=0.009). The odds of SSI (OR=0.43, CI:0.19-0.99), cell saver (OR=0.58,CI:0.38-0.87) and allogenic blood transfusion rates(OR=0.24, CI:0.14-0.41), as well as LOS > 6 days (OR=0.67, CI:0.45-0.99) were all significantly less in the cohort that was PW compared to non-PW.
Conclusion: PW is an effective, safe, and non-invasive strategy to prevent IH. The odds of adverse peri-operative outcomes, namely SSI, blood transfusion rates, and prolonged LOS were all significantly less in patients who underwent PW prior to spinal deformity surgery.

69. EVALUATION OF THE ALARM CRITERIA OF TRANSCRANIAL ELECTRICAL STIMULATION MUSCLE EVOKED POTENTIAL IN SPINAL CORRECTIVE SURGERY FOR DIFFERENT CLINICAL DIAGNOSIS OF SCOLIOSIS: MULTI-INSTITUTION SURVEY BY THE MONITORING COMMITTEE OF THE JAPANESE SOCIETY FOR SPINE SURGERY AND RELATED RESEARCH

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Japan

Summary: 409 patients received spinal corrective surgery for scoliosis were prospectively enrolled in this study. The alarm criteria (AC) were set at a 70% amplitude loss in TES-MEP. 39 patients showed wave changes. Among them, 4 patients with adult degenerative scoliosis and one with symptomatic scoliosis sustained postoperative motor loss. The 70% decrease in amplitude of TES-MEP was acceptable to prevent iatrogenic neurological deficit for idiopathic scoliosis, not for adult kyphoscoliosis and symptomatic scoliosis.
Introduction: The AC of transcranial electrical stimulation motor evoked potentials (TES-MEP) has not yet been established. We proposed a 70% amplitude loss in TES-MEP can be accepted in spinal scoliosis surgery based on the results of nationwide prospective study. The aim of the present study is to evaluate the AC of TES-MEP during spinal corrective surgery for different clinical diagnosis of scoliosis.
Methods: 409 patients (male / female=81/328) received spinal corrective surgery for scoliosis in fourteen medical institutions, and were prospectively enrolled in this study. The clinical diagnosis was idiopathic scoliosis in 197 patients, symptomatic scoliosis in 56, congenital in 16, and adult degenerative kyphoscoliosis in the other 140 patients. The AC were set at a 70% amplitude loss in TES-MEP. We investigated (1) the correlation if any between wave change, clinical diagnosis of scoliosis, and any postoperative neurological deficit, (2) the sensitivity and specificity of the AC.
Results: 21 patients with idiopathic scoliosis showed wave changes. None of 21 patients sustained postoperative motor loss. 9 patients with symptomatic scoliosis showed wave changes, one of whom sustained postoperative motor loss. 9 patients with adult kyphoscoliosis showed wave changes, four of whom had postoperative motor loss. Three of them had partial recovery of motor function at the final follow up. The sensitivity and specificity of the alarm criteria were 0%, 89.3% for idiopathic scoliosis, 100%, 85.5% for symptomatic scoliosis and 100%, 96.3% for adult kyphoscoliosis
Conclusion: The 70% decrease in amplitude of TES-MEP was acceptable to prevent iatrogenic neurological deficit for idiopathic scoliosis. However, another criteria should be discussed in the case with adult degenerative kyphoscoliosis and symptomatic scoliosis.

70. EFFECT OF ROTEM-GUIDED HEMOSTATIC THERAPY IN ADULT DEFORMITY SURGERY (ADS)

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USA

Summary: To maintain a normal coagulation profile for ADS, goal-directed hemostatic algorithms derived from trauma resuscitation guidelines are traditionally used. This can result in inappropriate use of blood products. Rotational thromboelastometry (ROTEM) facilitates treatment of specific hemostatic abnormalities. Less crystalloid, PRBCs and FFP are used with a measurable cost saving. Furthermore, there is no difference in the postop coagulation profile with the reduced product use. ROTEM can play an integral part in hemostatic management during complex reconstructive spine surgery.
Introduction: To maintain a normal coagulation profile for ADS, goal-directed hemostatic algorithms derived from trauma resuscitation guidelines are traditionally used. This can result in inappropriate use of blood products. Rotational thromboelastometry (ROTEM) is a visco-elastometric method for hemostasis testing in whole blood. Abnormalities of different coagulation pathways are identified and

treated with factor-specific therapy. Our aim was to investigate how ROTEM-guided therapy changes product utilization and costs in ADS.
Methods: We identified subjects who had undergone ASD with ROTEM-guided therapy and matched them 1:1 or 1:2 on Surgery Invasiveness Index (SII) with historical cohorts who had ASD without ROTEM. The SII includes number of levels decompressed, instrumented and fused.
Results: 51 ROTEM subjects were matched with 90 controls. The two groups were well matched by the SII (R: 7.4+ 3 vs. C: 7.2+ 3). Mean and median values for blood loss, cell saver volume, crystalloid, colloid, blood products between the ROTEM and control groups are listed in Table 1. Significantly less packed red blood cells were administered in the ROTEM group (R: 2 vs C: 3; $p<0.03$). Fresh frozen plasma use was reduced 20%; cryoprecipitate use was increased 37%. With the exception of a slight increase in the INR on postop day (POD) 2 (R: 1.3 vs C: 1.2; $p<0.005$), which normalized by POD 3, there was no difference in the postop coagulation profile. No differences were observed in postop transfusion requirements or drain outputs between the two groups. Median dollar cost per case for allogeneic blood and product use was $487 ($0-$2,927) and $626 ($0-$4,119) in the ROTEM and control group, respectively. There would have been a cost savings of $12,510 if ROTEM were applied to the control group.
Conclusion: ROTEM facilitates treatment of specific hemostatic abnormalities. Less crystalloid, PRBCs and FFP are used with a measurable cost saving. Furthermore, there is no difference in the postop coagulation profile with the reduced product use. ROTEM can play an integral part in hemostatic management during complex reconstructive spine surgery.

71. BIOMECHANICAL PERFORMANCE OF VARIOUS CEMENT AUGMENTED CANNULLATED PEDICLE SCREW DESIGNS FOR OSTEOPOROTIC BONES

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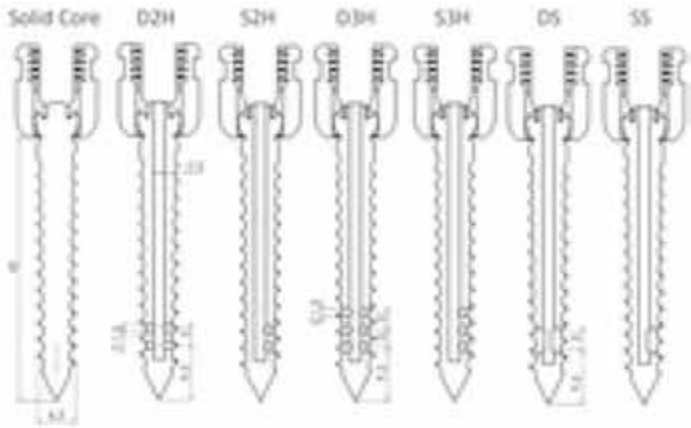
Summary: In this study, six different cannule types were designed and manufactured. Position, numbers and orientation of holes/slots normal to the main axis of screw shaft were investigated biomechanically. Torsion and pull-out tests were carried out according to ASTM F 543. Grade 40 polyurethane (PU) foam was used to mimic the healthy bone structure and grade 10 PU to mimic the osteoporotic bones in pull-out tests. The design named S3H exhibited the best performance towards investigated design types.
Introduction: Early stage pullout is very common problem for surgeons on the fixation of osteoporotic bones. Poor bone quality limits the use of pedicle screws for those suffering from osteoporosis. In this study, effect of hole/gap position and type on the pullout strength of cannullated screws were investigated.
Methods: Seven different designs were tested including control group. Hole and gape types are given in Figure 1. All cannule diameters were 2 mm and holes were drilled with a diameter of 1,5 mm. Gap was milled with a 2 mm diameter tool with a 2 mm displacement through proximal. All holes and gapes were drilled/opened unilaterally and bilaterally. Grade 40 and 10 polyurethane (PU) foam were used to simulate healthy and osteoporotic bones, respectively.
Pullout Tests: Insertion depth was 30 mm and 2 mm diameter pilot holes were drilled to blocks before the insertion of screws. Cross head speed was 2mm/min. Load versus displacement values were recorded until the pullout occurred.
Torsion Test: One side of screw was fixed and other was twisted clockwise. Torque versus angle values were recorded until the screw breakage.
Results: On the results of torsion tests, maximum torque values exhibited by control group (non-cannullated) with a 14,94 Nm torque value. The highest torsional strength was 13,54 Nm ($P<0,0001$) among the tested cannullated screws, namely S2H. Minimum torsional strength was 9,45 Nm with a breaking angle of 39 degrees ($P<0,005$).
When comparing the pullout test results for the samples that were pulled out from Grade 40 polyurethane foams, SS samples exhibited the highest pull out strength with a maximum force of 3104 N.
Conclusion: Unilateral three sequential radial holes drilled cannullated screw (S3H) was found as the optimum alternative when considering the pullout and torsional strength as comparison criteria. To the knowledge of investigators this is the first study comparing both pullout properties and torsional strength for several cannullated screw designs.



72. KINETICS OF INFLAMMATORY MARKERS AND CORRELATION WITH VARIOUS FACTORS AFTER UNEVENTFUL SPINAL SURGERIES: A PROSPECTIVE OBSERVATIONAL STUDY

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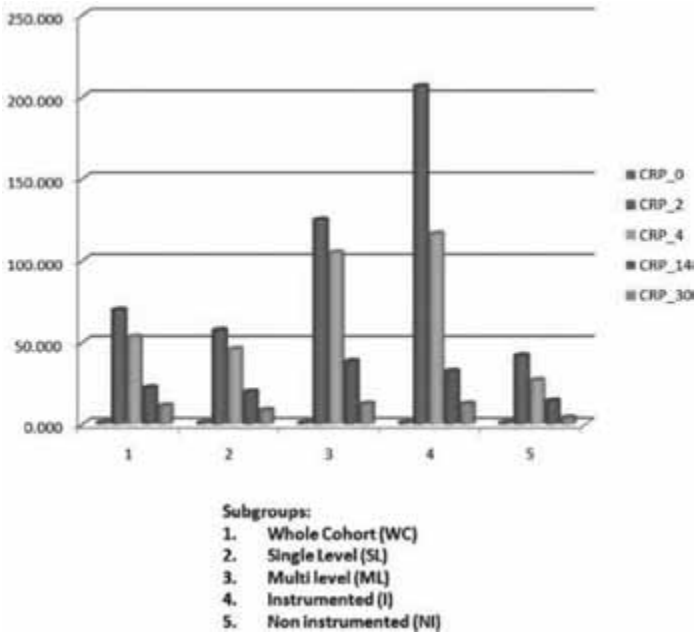
Summary: Inflammatory markers like C-reactive protein(CRP), erythrocyte sedimentation rate(ESR), total leukocyte count (TLC) tend to increase after an uneventful surgery as well as in an infective squeal to the surgical procedure. We studied these markers in uneventful spinal surgeries at Day 2, 4, 14 and 30 and tried to correlate them with patient and surgery related variables.
Introduction: Existing literature regarding how CRP, ESR and TLC behaves after uneventful spinal surgeries is sparse though present. However there correlation with patient and surgery related variables is not present. The objective of this study is to predict the kinematics of these inflammatory markers against these variables.

Methods: 90 consecutive patients who underwent spinal surgery between July and December 2012 were prospectively enrolled. CRP, ESR and TLC was recorded preoperatively and on postoperative Days 2, 4, 14 and 30. Patient related variables tested included age, body weight (Kg) and height (mt). Surgery related variables were operative time, estimated blood loss(EBL), single level(SL) vs multilevel surgery(ML), and non-instrumented (NI) vs instrumented surgery(I). Subgroup analysis was done using Stat Soft v6.
Results: Whole cohort analysis revealed CRP,ESR,TLC changes by 70,1.43,1.19 times on D2;53.5,1.87,1.31 times on D4;22.5,1.35,1.15 times on D14 and 11.5, 1.0, 1.0 times on D30. Peak rise of CRP is on D2, with gradual fall from D4 and baseline reached by D30. Peak CRP value on D2 is much higher in ML and I as compared to SL and NI. ESR and TLC peak on D4, start falling from D14 and come near baseline levels by D30 with no difference in the subgroups.. Age, body weight, height, EBL and operative time have a positive correlation to peak CRP(D2) but not with peak ESR/TLC values(D4).
Conclusion: CRP is more applicable, predictable, and responsive in the early postoperative period compared with ESR or TLC. Multilevel and instrumented surgeries have much higher peak values of CRP on day 2 but there is not much difference between the peak values for ESR and TLC on day 4. Single level and instrumented surgeries are the ones most predictable as far as the kinetics of the inflammatory markers are concerned. The deviation from this kinetic profile, too is an indication for further clinical assessment to rule out post operative infectious squeal.



Peak values of CRP on post-op days 0,2,4,14 and 30

73. CURRENT EVIDENCE REGARDING DIAGNOSTIC METHODS FOR PEDIATRIC LUMBAR SPONDYLOLYSIS: A REPORT FROM THE SCOLIOSIS RESEARCH SOCIETY EVIDENCE-BASED MEDICINE COMMITTEE

Charles Gerald T. Ledonio, MD; Charles H. Crawford, MD; Shay Bess, MD; Jacob M. Buchowski, MD, MS; Douglas C. Burton, MD; Serena Hu; Baron S. Lonner, MD; David W. Polly, MD; Justin S. Smith, MD, PhD; James O. Sanders, MD
USA

Summary: The SRS Evidence Based Medicine Committee conducted a structured literature review on diagnostic methods for pediatric spondylolysis to assess the current evidence both to make diagnostic recommendations and identify areas requiring further research.
Introduction: The SRS requested an assessment of the current state of peer reviewed evidence regarding pediatric spondylolysis with the goal of identifying both what is really known and what research remains essential to further understanding. Spondylolysis is common among children and adolescents and no formal synthesis of the published literature regarding diagnostic imaging has been previously performed.
Methods: A comprehensive literature search was performed with the assistance of a medical librarian. Citations and abstracts were retrieved. Abstracts were reviewed for exclusions and data from included studies were analyzed by committee. Consistent Level I studies were considered to provide Good Evidence, Level II or III studies Fair Evidence and Level IV studies Poor Evidence.
Results: From 947 initial citations with abstract, 383 articles underwent full text review. The best available evidence for the questions of diagnostic methods was provided by 26 included studies. There were no randomized validation or sensitivity/specificity studies. Five studies were graded as Level II and two as Level III evidence. Nineteen of the studies were graded as Level IV evidence. No Level V (expert opinion) studies were included in the final list.
Conclusion: Plain radiography is still considered a good screening tool for pars defect,but the evidence is unclear as to its validity and accuracy. The evidence is fair when Multi-slice CT with multi-planar reformats is considered as the gold standard and most accurate modality for detecting the bony defect and assessment of osseous healing; however, it exposes the pediatric patient to high ionizing radiation. There is poor to fair evidence that Magnetic resonance imaging has been reported to be as accurate as CT imaging and useful in detecting early edematous stress reactions of the lumbar pars interarticularis without a fracture line. Optimal MR sequences (and interpretation) should be the focus of future investigations. The evidence is unclear as to the diagnostic accuracy of Single-photon emission computed tomography (SPECT) and scintigraphy. There are conflicting reports on the rate of false-positive and false-negative results. However it is clear that the radiation dose is high compared to MRI and plain radiographs.

74. CERVICAL EXTENSION MAGNETIC RESONANCE IMAGING IN EVALUATING CERVICAL SPONDYLOTIC MYELOPATHY

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Summary: Cervical spondylotic myelopathy (CSM) may be caused by static and dynamic spinal cord compression, particularly during neck extension. Correlation with clinical myelopathic symptoms was better in extension magnetic resonance (MR) images rather than static images. Clinician's agreement in patient evaluation and decision making was improved with extension MR images. Thus, the evaluation of CSM may be improved with dynamic MR images and could be considered in patient evaluation of CSM.
Introduction: Cervical spondylotic myelopathy (CSM) may be caused by static and dynamic spinal cord compression, particularly during neck extension. Dynamic compression may be better evaluated with dynamic magnetic resonance (MR) images. We performed a retrospective study to determine the clinical indication for dynamic MR imaging and conducted a survey regarding image interpretation by clinicians.
Methods: A total of 32 patients (M:F=20:12, 60.1±10.7 years) who had taken neutral/extension cervical MR images were included. The study population consisted of 22 patients with signs of cervical myelopathy (M-group) and 10 patients without signs of myelopathy (NM-group). The number of compression level (complete obliteration of the anterior and posterior subarachnoid space) was assessed at each level in mid-sagittal T2-weighted neutral and extension MR images. Reproduced images from 22 patients in the M-group were randomly arranged and 4 experienced spine surgeons at 4 different institutes interpreted to determine clinicians' agreement. The agreement was assessed with inter-rater correlation coefficient (ICC).
Results: With extension MR images, the number of compression levels was increased in 23/32 (72%) of patients; 20/22 in the M-group and 3/10 in the NM-group ($p < 0.01$, Chi-square test) compared to neutral MR images. Clinical factors for increased compression levels in extension MR images were age ($p < 0.01$, 63.3 ± 10.0 years vs. 51.9 ± 8.1) and signs of myelopathy ($p < 0.01$, odds ratio, 23.33). Clinicians' agreement was improved with extension MR images; ICC was 0.67 with neutral and 0.81 with extension MR images.
Conclusion: The evaluation of CSM may be improved with dynamic MR images. Dynamic MR scanning may be considered for elderly patients with signs of myelopathy, but a precautious interpretation for asymptomatic spinal compression, exclusively on extension MR image, is required.

75. PREOPERATIVE ANALYSIS OF PARASPINAL MUSCLE ATROPHY: INSIGHT INTO CORRELATIONS WITH STENOSIS SEVERITY AND HEALTH-RELATED QUALITY OF LIFE

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USA

Summary: This study was designed to evaluate the relationship between degenerative conditions of the lumbar spine and paraspinal fat infiltration. Preoperative patients with lumbar spondylosis demonstrated severe levels of disability and poor HRQL measures. Patients with lumbar spondylosis demonstrated increased paraspinal fat infiltration in both the multifidi and erector spinae. Patients with severe canal stenosis yielded the greatest paraspinal fat infiltration and the most significant loss of the normal muscular architecture in the lumbar spine.
Introduction: No previous study has examined the relationship among lumbar spinal stenosis, spondylosis, and the infiltration of fat within the paraspinal musculature. Purpose is to evaluate this relationship and determine if the presence of paraspinal fat is associated with higher levels of disability and lower HRQL measures
Methods: Retrospective review of chart and MRI data for 81 preoperative patients with lumbar spondylosis and varying severity of neurogenic claudication. Body Mass Index, SF-12, Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) were recorded. Patients were divided into: Mild(MI) (<1/3 canal stenosis, 33 patients), Moderate(MO) (1/3-2/3 stenosis, 27 patients), or severe(S) (>2/3 stenosis, 21 patients). The volume of the erector spinae (ES) and multifidi were calculated on axial T2 image at facet joint and fat infiltration was recorded as a percent of total volume of the bilateral muscle group
Results: Patient population exhibited severe disability (Mean VAS 6.4, ODI 46.5) and poor physical HQRL (SF-12 PCS 28.2, SF-12 MCS 45.0). Mean age (MI 51.4, MO 59.2, S 61.0) and BMI (MI 31.9, MO 30.2, S 32.1) were similar. Mean SF-12 PCS (MI 28.9, MO 27.0, S 27.0), SF-12 MCS (MI 43.8, MO 50.1, S 45.6), VAS (MI 7.0, MO 6.3, S 5.9) , and ODI (MI 45.6, MO 45.7 , S 45.8) were consistent among groups. Increase in fat infiltration occurred to a greater degree in the multifidi (Δ13.8%) compared to ES (Δ6.8%). Increase in fat infiltration of the multifidi (MI Δ8.9%, MO Δ13.3%, S Δ18.0) and erector spinae correlated to severity of stenosis ((MI Δ3.9%, MO Δ4.9%, S Δ9.5 %)
Conclusion: Preoperative patients with lumbar spondylosis with myelopathy demonstrate severe levels of disability and poor HRQL measures. Due to severe disability in the patient population, the HRQL measures did not vary among groups. Paraspinal fat infiltration was independent of BMI. Patients with lumbar spondylosis demonstrate paraspinal fat infiltration in both multifidi and erector spinae. Patients with severe canal stenosis demonstrate the greatest paraspinal fat infiltration and the most significant loss of the normal muscular architecture

76. USE OF MAGNETIC RESONANCE NEUROGRAPHY FOR IMAGING THE LUMBAR PLEXUS, A PREOPERATIVE TOOL FOR THE LATERAL TRANSPSOAS APPROACH

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USA

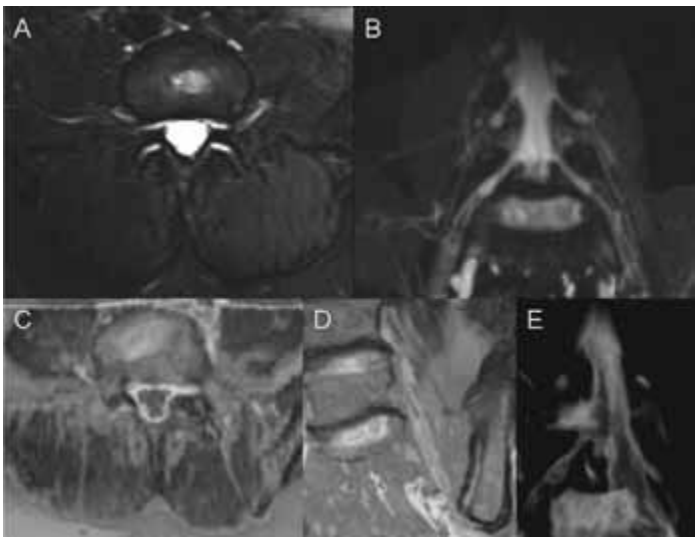
Summary: Magnetic Resonance Neurography is a non-invasive means of imaging the lumbar plexus at the L4-5 disc space. The ability to visualize the anatomic relationship of the lumbar plexus overlying the disc space is a useful preoperative surgical planning tool for lateral transpsoas interbody fusion and may decrease the incidence of neurological deficits.
Introduction: The lateral retroperitoneal tranpsoas approach for lumbar interbody fusion is a minimally invasive surgical technique

that is now frequently used to treat common spinal disorders. One limitation of this approach is the close proximity of the lumbar plexus to the surgical corridor and the risk of iatrogenic neurological injury. Current techniques of assessing the proximity of neural tissue to the L4-5 disc space have limited capabilities. Magnetic resonance neurography has been used as a non-invasive tool for the evaluation of lumbosacral plexopathy, and as a surgical planning tool for patients with peripheral nerve entrapments or peripheral nerve tumors. The ability to visualize the position of the lumbar plexus overlying the disc space from a surgical corridor view could be useful in the preoperative planning for patients undergoing lateral transpsoas interbody fusion. By providing the surgeon with a preoperative anatomic map of the lumbar plexus overlying the disc space, MR neurography may improve the safety profile of lateral access procedures.

Methods: A total of 10 consecutive lumbar plexus (20 sides) MR neurograms were reviewed. All scans were performed on a Siemens 3-Tesla Skyra MRI The imaging protocol included multiplanar T1-weighted and T2 weighted spectral abiabatic inversion recovery (SPAIR; Siemans Healthcare). Following image acquisistion image fusion and modeling was preformed using TeraRecon Aquarius iNtuition v4.4. 3D models of the lumbar plexus overlying the L4-5 disc space were created using the General Electric AW Suite v2.

Results: In all patients 3D reconstructions of MR neurograms were created and the course of the lumbar plexus overlying the disc space was visualized. The disc space in a sagittal view was divided into 5 zones, and the relationship of the lumbar plexus to the overlying disc space was recorded.

Conclusion: Lumbar plexus neurography is a non-invasive imaging technique for visualizing the lumbosacral plexus and its relationship to the disc space.



Coronal (A) and axial (B) SPAIR source images with reconstructions (C-E)

77. FINITE ELEMENT ANALYSIS OF LORDOSIS RESTORATION WITH ANTERIOR LONGITUDINAL LIGAMENT RELEASE AND LATERAL HYPERLORDOTIC CAGE PLACEMENT

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USA

Summary: Finite element analysis was used to evaluate the changes in segmental lordosis when using lateral hyperlordotic interbody cages and release of the anterior longitudinal ligament (ALL). Each cage increased lordosis, however resection of the facets or spinous processes were required to maximize the lordotic angle.

Introduction: Restoring sagittal alignment is an important factor in the treatment of spinal deformities. Recent investigations have determined that releasing the ALL and placing hyperlordotic cages can increase lordosis while minimizing need for 3 column osteotomies. The influences of parameters such as cage height and angle have not been determined. FEA was employed to assess the extent of lordosis achievable after placement of different sized lordotic cages.

Methods: A 3-dimensional model of a L3-L4 segment was used. The vertebrae were represented by quadratic tetrahedrons and the ligaments by tension-only nonlinear springs. Distraction of the disc space was simulated by inserting interbody cages mid-body with lordosis of 20° and 30°, posterior cage heights of 6, 8, and 10 mm, and cage width of 22 mm. Analyses were performed in the following conditions: 1) ALL release, 2) ALL release + facetectomy, and 3) ALL release + SPO. Changes in disc angle and disc heights were measured. Each condition was compared to a baseline model of a 10° cage with the ALL intact

Results: After ALL resection and insertion of the 20° and 30° cages, lordosis was increased in all cases with respect to the baseline. For the 20° cages, the 10 mm cage achieved 19° of lordosis. The lordosis for shorter cages was less due to posterior disc height maintained by the facet joints. Of the 30° cages, the 10 mm cage provided the most lordosis, but was limited to 22°. A facetectomy was required to increase segmental lordosis for the 20° and 30° cages, which resulted in all cages achieving segmental lordosis ranging from 21° to 26°. However this condition led to contact between the spinous processes. The 30° cages required a SPO if the end goal was to match the segmental lordosis. With 30° cages and SPO the 6 mm posterior cage height resulted in significant narrowing (33% of baseline) of the posterior disc space.

Conclusion: Increased segmental lumbar lordosis is achievable with hyperlordotic cages after ALL resection. Increased cage height tended to increase the amount of lordosis achieved, although with the 30° cage in this model, additional posterior bone resection was required to maximize lordosis. Further studies are needed to evaluate the impact on regional lumbar lordosis.

Paper Abstracts

78. CUMULATIVE RADIATION EXPOSURE WITH EOS® IMAGING COMPARED TO STANDARD SPINE RADIOGRAPHS

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USA

Summary: If PA EOS® technique rather than standard computed radiography were used during the entire scoliosis treatment course, estimated cumulative effective radiation dose would be reduced from 5.38 mSv to 2.66 mSv. An AP vs. PA EOS® radiograph results in an 8X higher radiation dose to the breasts and 4X higher dose to the thyroid. When possible, consider obtaining PA rather than AP EOS® films.
Introduction: EOS® is a slot-scanning x-ray system designed to reduce radiation exposure in orthopaedic imaging. There are few independent studies comparing EOS® PA, AP, and lateral films vs. standard films for children with spinal deformity. We sought to estimate the total radiation exposure to scoliosis patients during the course of treatment using standard imaging techniques vs. EOS® PA and AP views.
Methods: Forty-two skeletally immature patients presented with idiopathic scoliosis and were followed to skeletal maturity. Treatment included bracing only (21) and spinal fusion (21). The number of scoliosis x-rays (PA and lateral) for each patient was recorded. A computerized dosing model assuming a 15-year-old patient (weight 56 kg, height 168 cm, trunk thickness 19.6 cm, width 29.7 cm) was used to calculate estimated patient and organ doses for PA and lateral scoliosis x-rays taken with EOS®, computed radiography with and without filter (CR and CRF respectively), and intraoperative x-rays. Assuming that each x-ray taken delivered the same radiation as the phantom calculation, we estimated the total effective and organ dose that each child would have received using either EOS®, CR, or our institution's standard CRF technique (Table). For reference, annual background radiation is 3 mSv.
Results: Mean number of radiographs per patient was 20.9 (range 8-43). Patients who underwent surgical treatment had a significantly greater number of x-rays than patients who were braced (27.3 vs. 14.5, $p<0.001$). Assuming CR technique for all films, mean effective dose is estimated to be 5.38 mSv. Assuming EOS® PA and lateral films were used during the treatment course, the mean cumulative estimated dose is 2.66 mSv, a decrease of 50.6%.
Conclusion: The EOS® imaging system moderately reduced the total radiation exposure to skeletally immature patients with idiopathic scoliosis during their treatment course. Over the entire course of treatment, this represents 2.72 mSv mean reduction or 0.91 years of background radiation. Surgical patients had more exposure than bracing patients. PA films significantly reduced breast and thyroid dose. Consider using PA radiographs to reduce breast and thyroid radiation exposure.

79. UTILIZING THE ACCELEROMETER OF YOUR MOBILE PHONE FOR QUANTITATIVE MEASUREMENT OF SPINAL RANGE OF MOVEMENT: A RELIABILITY AND VALIDITY STUDY

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China

Summary: This study indicated excellent validity and reliability of a program called MSKROM to be installed in mobile phones which can be readily available for use at bedside for quantitative measurement of range of movement at both the thoracic and lumbar spine.
Introduction: A readily available method for routine use to quantitatively measure the range of movement at both the thoracic and lumbar spine for patients with back problems has been a long existing quest. MSKROM is a software developed in the Android 4.x.x. OS of a mobile phone for quantitative measurement of spinal movement. The objectives of this study were to evaluate the validity and reliability of MSKROM. The validity of the fingertip-to-floor method was also studied and compared with MSKROM.
Methods: Bench validity was checked by measuring the angles from a reference angle plate which was a flat surface the inclination of which could be adjusted. 32 healthy female subjects (16.3±1.7 years old) were then recruited and asked to perform spinal movements of (i) full flexion and extension, and (ii) full right and left lateral bending according to standard instruction. T1, T12, L1 and L5 were registered with the mobile device at various postures and ROM at the thoracic (T1-T12) and lumbar (L1-L5) segment was automatically calculated. Electronic Inclinometer was used as the gold standard. Fingertip-to-floor method was carried out according to the standard protocol and the distance of finger-tip from the floor was measured.
Results: Bench validity of the MSKROM was high ($r=1.00$, $p<0.001$). There was excellent concurrent validity of MSKROM when compared with the Electronic Inclinometer with Pearson correlation coefficient ranging from 0.925 to 991 except 0.757 for thoracic extension (all with $p<0.001$). The intra and inter-rater reliability of MSKROM was also excellent with ICC ranging from 0.873 to 0.997. In contrast, concurrent validity of the fingertip-to-floor method was poor with Pearson correlation coefficient ranging from -0.048 to 0.237 and none of the correlation reached statistical significance.
Conclusion: The results provided strong evidences that MSKROM installed in a mobile phone could give valid and reliable quantitative measurement of spinal movement in both the frontal and sagittal planes. The measurement was simple and fast. Given the inadequacy with the fingertip-to-floor method which is actually measuring combined movement at both the hip and the spine, MSKROM can be disseminated for use both at bedside and for clinical researches.

80. ADULT SPINAL DEFORMITY TREATED WITH MINIMALLY INVASIVE TECHNIQUES: TWO-YEAR MULTICENTER CLINICAL AND RADIOGRAPHIC OUTCOMES STUDY COMPARING CIRCUMFERENTIAL MIS AND HYBRID SURGERY

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USA

Summary: Traditional techniques to treat ASD are accompanied with significant morbidity. Minimally invasive techniques are used in an attempt to decrease the associated morbidity. This study reviews a multicenter experience of prospectively collected data with 2 year follow up. At 2 year follow up patients can expect to have improved HRQOL and radiographic parameters and an associated complication rate that is favorable compared to historic norms.
Introduction: Adult spinal deformity (ASD) surgery has been shown to lead to improved clinical and radiographic outcomes. Despite historic good results, there is significant morbidity associated with the open approaches. The aim of this study is to demonstrate 2 year outcomes of ASD patients treated with minimally invasive surgery (MIS) techniques.
Methods: Multicenter, retrospective review of prospectively collected data was performed. Radiographic, clinical and health related quality of life (HRQOL) measures were collected and analyzed for significance. Patients were categorized by approach: complete MIS (cMIS- posterior MIS screw placement and MIS lateral or MIS posterior with MIS TLIF), and Hybrid (MIS lateral with open posterior). All unpaired comparative analyses were done using the Mann Whitney U, and Wilcoxon Signed Rank for paired tests. Correlations were determined by Chi-squared test.
Results: 118 pts identified with 2 year follow up. 53 were MIS and 65 HYB. Baseline and 2 year radiographic parameters were similar between groups and only the change in Cobb was greater among HYB (11.9° vs 18.8°; p=0.013) Table 1. Improvements in HRQoL were significant though equal , in both groups at 2 years after surgery. 53 (44.9%) patients had a total of 79 complications. 40 (33.9%) had a major complication and 18 (15.3%) had a minor. HYB had statistically higher minor complications (14/65) than MIS (4/53), (p=0.04). Reoperation was 23.7% (28/118) at 2 years [9/53 MIS (17%), 19/65 HYB (29.2%); p>0.05]. Neither the occurrence of a complication or reoperation had negative effect on HRQOL .
Conclusion: Minimally invasive surgery can be applied effectively to augment an open operation (HYB) or be utilized circumferentially to treat ASD. We have demonstrated the sustainability of these results at 2 year follow up with satisfactory improvement in HRQOL and radiographic parameters. Complications and reoperation rates are comparable with traditional techniques with no significant impact on HRQOL.

81. COMPARISON OF BEST VERSUS WORST CLINICAL OUTCOMES FOR ADULT SPINAL DEFORMITY (ASD) SURGERY: A PROSPECTIVE, MULTICENTER ASSESSMENT WITH MINIMUM TWO-YEAR FOLLOW UP

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USA

Summary: Although recent studies suggest that average clinical outcomes are improved following surgery for selected ASD patients, these outcomes span a broad range. In this study, baseline (BL) and perioperative factors distinguishing between the best and worst outcomes for ASD surgery included several patient factors (BL depression, BMI, comorbidities and disability), as well as residual deformity (SVA), and occurrence of complications. These findings suggest factors that may warrant greater awareness in order to achieve optimal surgical outcomes for ASD patients.
Introduction: Studies suggest that average clinical outcomes are improved with surgery for selected ASD patients, but these outcomes span a broad range. Our objective was to compare ASD patients with best vs worst clinical outcomes to identify distinguishing factors.
Methods: This is a multicenter, prospective study of consecutive ASD patients treated operatively. Inclusion criteria included: age>18yr, ASD and min 2yr follow-up. Best vs worst outcomes patients were compared separately based on SRS-22 and ODI. Only those with BL SRS-22<3.5 or ODI>30 were included to minimize floor effect. Best and worst outcomes were defined for SRS-22 (>4.5 and <2.5) and ODI (<15 and >50).
Results: Of 227 patients, 187 had SRS-22<3.5 (25 best and 27 worst outcomes) and 162 had ODI>30 (43 best and 51 worst outcomes). Based on SRS-22, compared with best outcomes patients, those with worst outcomes had greater BL SRS-22 (p<0.0001), higher prevalence of BL depression (p<0.001), greater comorbidities (p=0.012), greater prevalence of prior surgery (p=0.007), higher complication rate (p=0.012) and worse BL deformity (SVA [p=0.045], PI-LL mismatch [p=0.034]). The best-fit multivariate model for SRS-22 included BL SRS-22 (p=0.033), BL depression (p=0.012) and complications (p=0.030). Based on ODI, compared with best outcomes patients, those with worst outcomes had greater BL ODI (p<0.001), greater BL BMI (p=0.002), higher prevalence of BL depression (p<0.028), greater BL SVA (p=0.016), higher complication rate (p=0.02) and greater 2yr SVA (p<0.001) and PI-LL mismatch (p=0.042). The best-fit multivariate model for ODI included BL ODI (p<0.001), 2yr SVA (p=0.014) and BL BMI (p=0.037). Age did not distinguish best vs worst outcomes for SRS-22 or ODI (p>0.1).
Conclusion: Factors distinguishing best vs worst outcomes for ASD surgery included several patient factors (BL depression, BMI, comorbidities and disability), as well as residual deformity (2yr SVA) and complications. These findings suggest factors that may warrant further attention in order to achieve optimal surgical outcomes for ASD.

82. ARE ESTABLISHED TARGETS FOR SPINAL DEFORMITY CORRECTION VALID? PRE- TO POST-OPERATIVE ANALYSIS USING THE T1 PELVIC ANGLE (TPA), A NOVEL RADIOGRAPHIC PARAMETER OF SAGITTAL DEFORMITY

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USA

Summary: Targets for deformity correction are based on preoperative alignment parameters and baseline HRQOL. The T1 Pelvic angle (TPA), a novel measure of global spinopelvic alignment, correlates with HRQOL and a postoperative target of less than 15 degrees has been proposed (Figure 1). This study determines whether postoperative and preoperative alignment match in determining thresholds for mild and severe disability. Reasonable alignment targets for ASD correction include TPA less than 15, SVA less than 2cm and PI-LL of less than 4.2.

Introduction: Targets for deformity correction have been proposed including SVA<5cm, PT<20deg, PI-LL<9. A novel radiographic parameter of sagittal alignment, the TPA, has been proposed with a postoperative target of less than 15 degrees. While targets for spinal deformity correction are based on preoperative analysis of HRQOL and baseline alignment measures, this study investigates postoperative alignment parameters and HRQOL to determine the validity of these targets of correction.

Methods: Multicenter, prospective, analysis of consecutive ASD patients. Inclusion criteria: ASD, age>18, and any of the following: scoliosis Cobb angle >20 deg, SVA>5 cm, thoracic kyphosis>60 deg, and PT greater than 25 deg. Clinical measures of disability included ODI, SRS and SF36. Baseline and 2-yr follow-up radiographic and HRQL outcomes evaluated.

Results: 520 ASD patients were enrolled (mean age 53.7). 407 patients underwent deformity correction with 2 year follow up. Baseline and 2 year TPA correlated with PT (r=0.92/0.91), PI-LL (r=0.89/0.86) and SVA (r=0.83/0.75). Baseline TPA, PI-LL, PT and SVA correlated with ODI (r=0.45/0.42/0.35/0.47), SF36 PCS and SRS with all p<0.001. At 2 year follow up, TPA, PI-LL, PT and SVA correlated more weakly with ODI (r=0.28/0.25/0.20/0.32), SF36 PCS and SRS with all p<0.001. Utilizing a linear regression analysis, the thresholds for pre and postop severe disability were 20.6 and 18.2 for TPA, 5.1 and 3.8cm for SVA and 12.6 and 4.9 for PI-LL. Thresholds for mild disability (ODI=20) pre and postop were 14.7 and 16.4 for TPA, 1.9 and 2.4cm for SVA and 4.2 and 3.0 for PI-LL.

Conclusion: Targets for adult spinal deformity correction were similar using baseline and postoperative alignment and HRQOL data particularly for the TPA (14.7 baseline vs 16.4 postop). The correlations between HRQOL and all the alignment parameters were stronger for the baseline data. Reasonable alignment targets for ASD correction include TPA less than 15, SVA less than 2cm and PI-LL of less than 4.2.

83. THE EFFECT OF PATIENT AGE ON RECOVERY KINETICS IN 149 ADULT SPINAL DEFORMITY PATIENTS WITH TWO-YEAR FOLLOW UP: A NOVEL AREA UNDER THE CURVE ANALYSIS

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USA

Summary: Elderly adult spinal deformity (ASD) patients (pts) generally have worse baseline health-related quality of life (HRQOL) measures than younger patients. Current reporting of HRQOL is limited to static time-points perhaps diminishing the entire postoperative recovery experience. A retrospective review of a multicenter, prospective ASD database was conducted. AUC analysis suggests that the recovery kinetics is significantly worse for younger pts than the older pts. Older pts have a shorter and improved recovery period than younger pts.

Introduction: Among adult spinal deformity (ASD), elderly patients (pts) generally have worse baseline disability and health-related quality of life (HRQOL) than younger patients. Current methods of reporting outcomes are limited to static time points perhaps diminishing the health impact of the entire postoperative recovery experience. This study aims to identify the effect of age on the kinetics of the recovery process by examining the effect of HRQOL over time via an area under the curve analysis (AUC).

Methods: A retrospective review of a multicenter, prospective ASD database. Inclusion criteria, ≥18yrs, ASD. Pts were stratified by age groups: ≤45yrs, 46-64, 65-74, ≥75. HRQOL collected included Oswestry Disability Index (ODI), Short Form-36(PCS/MCS), and Scoliosis Research Society-22 (SRS22) at baseline, 6wks, 1 and 2yrs postop. All HRQOL was normalized to each patients' baseline scores as a comparison relative to where the patients started. An AUC was then calculated across the entire 2yrs. Standard HRQOL and AUC means were compared between groups.

Results: 149 pts met inclusion criteria (≤45:32, 46-64:67, 65-74:38, ≥75:12). Older pts had significantly worse preop ODI, PCS, SRS activity, pain and total compared with their respective younger age groups (p<0.05 for all) with the exception of 65-74 vs ≥75 and 46-64 vs 65-74 (p>0.05 for all). All age groups significantly improved all HRQOL at 2yrs compared with preop (p<0.05 for all) except SRS mental and MCS for all age groups and ODI and SRS Activity for ≤45 (p>0.05). However, normalized AUC HRQOL for the younger pts was worse than the respective older age groups for ODI, PCS, SRS Activity, pain and total over the 2 year recovery period from index surgery.

Conclusion: Based on static HRQOL analysis, all age groups improved HRQOL at 2yrs following surgery with older pts having worse preop HRQOL than younger pts. AUC analysis, however, suggests that the recovery kinetics is significantly worse for younger pts than the older pts. Older pts have a shorter and improved recovery period compared to younger patients when normalized to their own preop baselines.

84. SURGICAL SITE INFECTION IN ADULT DEGENERATIVE SCOLIOSIS: RISK FACTORS AND COUNTERMEASURES

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China

Summary: To identify independent risk factors for surgical site infection (SSI) and to evaluate the positive effect of Aquae hydrogenii dioxidi (AHD) to decrease the risk of SSI in patients with Adult degenerative scoliosis. A retrospective review (phase 1) and prospective clinical study (phase 2).
Introduction: Surgery for Adult degenerative scoliosis is associated with an increased risk of SSI. Although previous reports have evaluated risk factors of SSI for Adult degenerative scoliosis, most of the studies lack multivariate analysis. A recent study demonstrated the utility of AHD in decreasing wound complications in patients with prior hormone therapy. The role of AHD in surgery for Adult degenerative scoliosis has not been previously evaluated.
Methods: 7107 patients with Adult degenerative scoliosis were retrospectively reviewed (phase 1). Risk factors for SSI were analyzed using logistic regression. Phase 2 was a prospective clinical trial investigating the utility of AHD at reducing the rate of SSI. 1072 patients with Adult degenerative scoliosis were treated at our institute. The infection rate and risk factors identified in phase 1 and 2 were compared.
Results: The rate of SSI during phase 1 was 7.7%. Independent risk factors identified by multivariate logistic regression were diabetes, and preoperative hormone therapy. The rate of SSI for patients who had hormone therapy before surgery was 32%, whereas the rate for patients without hormone therapy was 1.7%. This difference was statistically significant. The rate of SSI in phase 2 was 4.7%. In phase 2 patients who received preoperative hormone therapy, the rate of SSI was 4.9%. The difference between phase 1 and phase 2 was statistically significant.
Conclusion: This study identified diabetes and preoperative hormone therapy to be independent risk factors for SSI in patients with Adult degenerative scoliosis. AHD administration was found to significantly decrease the incidence of SSI in patients with Adult degenerative scoliosis who underwent preoperative hormone therapy.

85. BIOMECHANICAL DEMANDS ON S2AI SACRAL AND PELVIC INSTRUMENTATION IN LONG FUSION CONSTRUCTS WITH AND WITHOUT INTERBODY SUPPLEMENTATION

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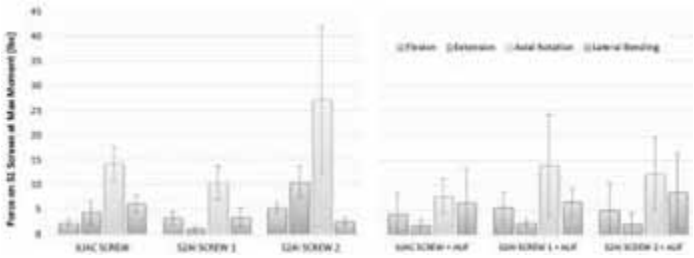
USA

Summary: The goal of this study is to evaluate iliac and S2AI instrumentation in long fusion. The addition of a common interbody supplementation was also investigated. Outcome measures included loading at the S1 screws and range of motion during biomechanical testing. Both S2AI groups reduced the L1-L5 and L5-S1 ranges of motion similarly to iliac screws. The addition of an ALIF cage showed similar trends to non-ALIF testing but decreased the largest loads seen during non-ALIF testing seen during axial rotation.
Introduction: Long fusions (above L2) to the sacrum generate high stresses on the sacral screws that may lead to loosening or screw breakage. Surgical techniques reducing strain on caudal screws such as S2-alar-iliac (S2AI) or iliac screws are intended to improve rigidity of the L5-S1 motion segment and bear a majority of the load. The goal of our study is to investigate the demands on iliac and S2AI screws during range of motion (ROM). We hypothesize that both S2AI and iliac screw fixation increase construct rigidity but do not differ significantly in ROM or reduction in screw strain at S1.
Methods: Five specimens (T12-full pelvis) were used for this study. Bilateral pedicle screws were deployed from L1-S1 for all specimens. S1, S2AI and iliac screws specially instrumented with strain gauges to measure loading were deployed into all specimens. Specimens were first tested in three treatment groups: S2AI with a standard screws (S2AI 1), S2AI with lag screws of the same diameter but larger tulip and neck (S2AI 2), and iliac screws. An ALIF cage was added to the L5-S1 disc space of each construct and testing was repeated.
Results: ROM for all treatment groups was significantly less ($p<0.05$) than the intact ROM in all loading directions for L1-L5 as well as L5-S1. For L5-S1 flexion-extension ROM, the iliac screws, S2AI 1, S2AI 2, iliac screw+ALIF, S2AI 1+ALIF, S2AI 2+ALIF groups decreased by 96, 95, 95, 94, 97 and 97% compared to intact. None of the treatments groups were significantly different in terms of ROM. Both iliac screw and S2AI groups showed similar trends in loading of the S1 pedicle screw (Figure 1). The peak load occurred during axial rotation for the S2AI 2 group and was 27.2 +/- 14.8 lbs. The different treatments groups did not show significant differences in loading of the S1 screw.
Conclusion: Both S2AI groups were able to reduce the L1-L5 and L5-S1 ROM similarly to the iliac screw group. The addition of the ALIF cage showed similar trends to non-ALIF testing but did decrease the largest loads seen during non-ALIF testing seen during axial rotation. Given these results, S2AI instrumentation showed similar characteristics to iliac screws for reduction of motion and decreasing loads at the caudal screws in the long fusion construct.



86. SEGMENTAL PELVIC CORRELATION (SPEC): ANALYSIS OF THE RELATIONSHIP BETWEEN LUMBAR SEGMENTAL LORDOSIS AND PELVIC MORPHOLOGY

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United Kingdom

Summary: Pelvic incidence (PI) is known to influence the apex of lumbar lordosis (LL) and inflection point between thoracic kyphosis (TK) and LL. By analysing the relationship between lordosis at each segment and PI in 40 individuals, it is shown that the bulk of LL is contributed by L4 and L5 motion segments while L1 and L2 motion segments fine tune the LL to the corresponding PI. This paves the way

for anatomical segmental reconstruction of the lumbar spine.
Introduction: The relationship between thoracic kyphosis (TK), lumbar lordosis (LL) and pelvic incidence (PI) is established. Restoring this relationship has been shown to improve the outcome of degenerative spinal deformity correction. Due to the wide range of normal PI in the normal human pelvis, the sagittal anatomy of the lumbar spine is also variable and normal LL is within 9 degrees of PI. Current techniques in deformity correction aim to correct total lumbar lordosis but sagittal plane segmental abnormalities cannot be accurately analysed.
Aim: To define the relationship between PI and segmental lordosis in the normal lumbar spine.
Methods: 40 lateral whole spine radiographs with normal sagittal profiles were reviewed. PI, LL, TK and segmental angulation at each level from L1 to the sacrum were measured (from endplate to endplate) distinguishing the vertebral body and intervertebral disc contribution. Pearson correlation coefficients were used to analyse any relationship between pelvic parameters and segmental lordosis.
Results: A strong correlation was found between pelvic incidence and total lumbar lordosis and angulation at cephalad lumbar segments (L1 and L2 motion segments) with the increased lordosis from L1 to L5 found at the intervertebral disc. At the L5/S1 motion segment, the shape of the L5 vertebral body contributed significantly to lordosis at that level. The proportion of total lumbar lordosis contributed at L4/5 and L5/S1 reduced as pelvic incidence increased ($P<0.0001$, $P=0.05$ respectively). The proportion of total lumbar lordosis contributed at L1/2 and L2/3 increased as pelvic incidence increased ($P<0.0001$, $P<0.001$ respectively).
Conclusion: PI can predict segmental angulation at cranial lumbar segments. PI predicts the proportion of lordosis arising from cephalad and caudal segments. Although the majority of lumbar lordosis is produced at L4/5 and L5/S1, cephalad-lumbar segments sequentially become increasingly important as PI increases. This describes a continuum that allows segmental abnormalities to be identified. This paves the way for anatomical reconstruction in degenerative adult deformity based on pelvic morphology.

87. INSTRUMENTATION STRATEGIES TO REDUCE THE RISKS OF PROXIMAL JUNCTIONAL KYPHOSIS IN ADULT SCOLIOSIS: A DETAILED BIOMECHANICAL ANALYSIS

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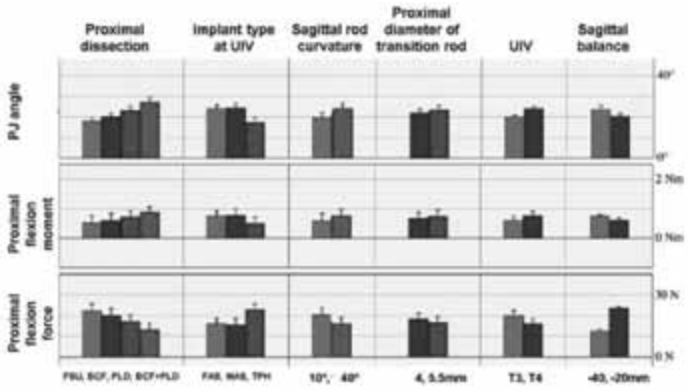
Canada

Summary: The individual effects of the sagittal balance, proximal instrumentation level and four surgical variables on the proximal junctional (PJ) kyphotic angle and flexion loads were evaluated through biomechanical analyses using computer simulations. Avoiding posterior shift of the sagittal balance, reasonably extending instrumentation proximally, preserving PJ intervertebral elements, using a more flexible proximal anchorage, reducing the sagittal rod curvature, each helps reduce the biomechanical risks of proximal junctional kyphosis (PJK).
Introduction: Despite numerous retrospective clinical studies, biomechanical analysis of individual parameters associated to PJK is still lacking to biomechanically support recommendations to adapt instrumentation strategies to reduce the risks of PJK. The objective was to computationally assess the effect of sagittal balance, the proximal instrumentation level and four other surgical variables on biomechanical indices related to the risks of PJK.
Methods: A validated biomechanical model was used to simulate posterior spinal instrumentations of six adult scoliosis cases with different operative strategies (1152 simulations). PJ angle and flexion loads were evaluated against the simulated sagittal balance, the proximal instrumentation level, the extent of PJ dissection, the proximal implant type, the sagittal rod curvature, and the diameter of the proximal transition rods.
Results: A posterior shift of the sagittal balance by 20mm resulted in an increase of the PJ angle, flexion force and moment of 16%, 37% and 22%. Extending the instrumentation proximally by one level resulted in a decrease of the three indices by 18%, 16%, and 25%. Bilateral complete facetectomy, posterior ligaments resection, and the combination of the two resulted in an increase of the PJ angle (by 10%, 28% and 53%, respectively), flexion forces (4%, 12% and 22%) and moments (16%, 44% and 83%) above the upper instrumented vertebra (UIV). Transverse process hooks at UIV, compared to pedicle screws allowed 26% lower PJ angle and flexion loads. The use of proximal transition rods with reduced proximal diameter from 5.5 mm to 4 mm slightly reduced PJ angle, flexion force and moment (<8%). The increase of the sagittal rod curvature from 10° to 40° increased the PJ angle (by 6% to 19%), flexion force (3%, 10%) and moment (9%, 27%).
Conclusion: Avoiding posterior shift of the sagittal balance, reasonably extending instrumentation proximally, preserving PJ intervertebral elements, using a more flexible anchorage (transition rods with reduced diameter and transverse process hooks at UIV), reducing the sagittal rod curvature, each helps reduce the biomechanical risks of PJK.



Typical results for one case (#2): FSU: intact functional spinal unit; BCF: bilateral complete facetectomy; PLD: posterior ligaments dissection; FAS: fixed angle screw; MAS: multiaxial screw; TPH: transverse process hook; PJ: proximal junctional; UIV: upper instrumented vertebra.

88. A NEW EVIDENCE-BASED PROTOCOL FOR PREVENTION OF POST-OPERATIVE SURGICAL SITE INFECTIONS SUBSTANTIALLY REDUCES INFECTION RATE IN LONG POSTERIOR INSTRUMENTED SPINE PROCEDURES FOR DEFORMITY

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Summary: Surgical site infection (SSI) is a major concern following orthopaedic spine surgery, particularly in patients undergoing posterior instrumented procedures for deformity. Implementation of our new infection control protocol decreased the rate of infection in these procedures from 5.7% to 1.35%.

Introduction: Surgical site infection (SSI) is a major concern following orthopaedic spine surgery, particularly in both adolescent and adult patients undergoing posterior instrumented procedures for deformity. The sequelae of SSI in spine can be severe, including fusion failure, vertebral osteomyelitis, persistent instrumentation infection, sepsis, and neurologic damage. Return to the operating room for irrigation and debridement and the added length of hospital stay impose significant financial costs. Historically, the rate of infection following long posterior spine fusion (>7 levels) at our institution has been 5.7%, comparable to the published rates at other centers.

Methods: We sought to identify and address the factors contributing to postoperative infections in adolescent and adult patients. Risk factors were categorized as preoperative, intraoperative, or postoperative, and a protocol was developed to address the identified risks. This included adding preoperative back cleansing with chlorhexidine, intraoperative timed irrigation with antibiotic saline, cleaning and control of Bair hugger device, limiting traffic in the operating room, vancomycin powder before closing, and covering the wound with loban adhesive. Postoperatively, the drains and foley are removed by 48 hours while the dressing is not changed until discharge. For our analysis, only those patients who developed a postoperative infection requiring surgical irrigation and debridement (return to operating room) were considered.

Results: In 2012, 6 of 105 long instrumented fusions (5.7%; age range 16-85) developed a postoperative infection. Bacteriology included: 4 methicillin-resistant Staphylococcus aureus and 2 coagulase-negative staphylococci. In 2013 after the implementation of the new infection control protocol, there was only 1 patient of 74 (1.35%; age 16) who developed a postoperative infection (E. coli).

Conclusion: The substantial morbidity suffered by patients and cost incurred by a SSI following posterior spine surgery warrants comprehensive action to mitigate risk factors. Our institution developed an evidence-based protocol to systematically reduce the risk of this serious postoperative complication.

89. CURRENT SURGICAL PRACTICE FOR TRAUMATIC SPINAL CORD INJURY IN CENTRAL CORD SYNDROME PATIENTS IN CANADA

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Canada

Summary: Traumatic spinal cord injury (tSCI) is often treated surgically, however there is no consensus on indications and timing. Central cord syndrome (CCS) is a clinical diagnosis based on the ASIA Injury Scale (AIS) being C or D, and an upper extremity motor score (UEMS) being ≥5 points lower than the lower extremity motor score (LEMS). There is little consensus among clinicians on how best to treat patients with CCS. We aimed to determine any surgical practice or outcome differences in treatment of CCS patients with AIS C vs D.

Introduction: Traumatic spinal cord injury (tSCI) is often treated surgically, however there is no consensus on indications and timing. Central cord syndrome (CCS) is a clinical diagnosis based on the ASIA Injury Scale (AIS) being C or D, and an upper extremity motor score (UEMS) being ≥5 points lower than the lower extremity motor score (LEMS). There is little consensus among clinicians on how best to treat patients with CCS. We aimed to determine any surgical practice or outcome differences in treatment of CCS patients with AIS C vs D.

Methods: tSCI patients with complete records from the Rick Hansen Spinal Cord Injury Registry (RHSCIR), prospectively recruited from 2004-2013 from 18 acute care participating centres across Canada were studied. Those with AIS C/D and UEMS<LEMS of 5 or more points were classified as CCS. Data on the patient (e.g. age, ethnicity, neurology), treatment (surgery yes/no, time to surgery), and outcome (change in motor score and Functional Independence Measure (FIM)) were compared using chi-squared tests.

Results: 525 participants had complete data and CCS; in those with surgery data available (n=471), 75.9% had surgery (entire sample surgery rate was 86.8%). In participants with CCS, there was no difference between rates of surgery between those with AIS C vs D, but AIS C patients had a shorter mean time from injury to surgery (81.4h vs 109.0h, p=0.0051), a significantly larger change in motor score (38.3 vs 9.6 points, p<0.0001), and a significantly larger change in FIM (30.1 vs 14.9 points, p<0.0001) than AIS D patients.

Conclusion: There is no difference in surgical rates for CCS patients with AIS C/D at admission, however there is an association that favours a role for early surgical intervention. Surgeons should consider surgical intervention for AIS C patients presenting with CCS.

90. CURRENT TREATMENT OF INDIVIDUALS WITH TRAUMATIC SPINAL CORD INJURY: DO WE NEED AGE-SPECIFIC GUIDELINES?

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Canada

Summary: The elderly are increasingly at risk for tSCI from falls compared to younger patients. However, it is unknown if this translates into different management and outcomes. Our objective was to determine if age affected management decisions and outcomes.

Introduction: The elderly are increasingly at risk for tSCI from falls compared to younger patients. However, it is unknown if this translates into different management and outcomes. Our objective was to determine if age affected management decisions and outcomes.

Methods: tSCI patients with complete records prospectively recruited from 2004-2013 for the Rick Hansen Spinal Cord Injury Registry (RHSCIR) were included. Demographic/injury differences between age groups (<70/≥70y) were assessed. Age (<70/≥70y), gender, injury etiology (falls vs other), energy of injury (high/low), injury level (cervical vs thoracolumbar), admission AIS (A&B vs C&D), and Injury Severity Score (ISS; </≥ 25) were examined with chi-square bivariate analysis and multivariate analysis for associations with operative treatment.

Results: Of 1440 participants with operative data, 167(11.6%) were >70y at time of injury. Older patients were more likely to have been injured by falling compared to higher-energy mechanisms (83.1% v 37.4%, p<0.0001), to have cervical (75.9% vs 60.1%, p<0.0001), to have admission AIS of C/D (67.9% vs 45.4%, p<0.0001), and a higher number of medical co-morbidities (mean 1.1 vs 0.31, p<0.0001). Older patients were less likely to have received operative treatment (80.2% vs 87.7%, p=0.0077) and to have a high ISS (41.8% vs 60.9%, p=0.0011). Age >70 did not affect odds of having operative treatment with multivariate analysis; high energy of injury and AIS of A/B increased the odds of having surgery (2.3 and 5.0 respectively). Older patients had longer time from injury to surgery, and longer acute (but not rehabilitation) length of stay. Age over 70 was associated with higher in-hospital mortality (25.5% v 5.6%).

Conclusion: Practice patterns in Canada demonstrate that age in of itself, does not impact the odds of having surgery. However, older patients wait longer for surgery and have substantially higher in-hospital mortality rates despite less severe injuries. Surgical guidelines for older patients could reverse these trends!

91. THE RELIABILITY AND VALIDITY OF THE THORACOLUMBAR INJURY CLASSIFICATION SYSTEM IN PEDIATRIC SPINE TRAUMA

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USA

Summary: The thoracolumbar injury classification system (TLICS) was developed to improve the categorization and management of thoracolumbar trauma in the adult population. This study shows that TLICS has good reliability and validity when used in pediatric spine trauma. Therefore, TLICS can be used to reliably categorize thoracolumbar injuries in pediatric patients; however, modifications may be needed to better guide treatment in this specific patient population.

Introduction: The thoracolumbar injury classification system (TLICS) was developed to improve the categorization and management of thoracolumbar trauma in the adult population. The purpose of this study was to determine the clinical applicability of the TLICS in pediatric spine trauma.

Methods: The clinical and radiographic findings of 20 pediatric thoracolumbar fractures were prospectively presented to 20 surgeons with varying levels of training and experience with spinal trauma. These injuries were consecutively scored using the TLICS. Cohen's unweighted kappa coefficients and Spearman's rank order correlation values were calculated for the key parameters (injury morphology, status of PLC, neurological status, and proposed management) to assess the inter-rater reliabilities. 5 surgeons scored the same cases 2 months later to assess the intra-rater reliability. The actual management of each case was then compared with the treatment recommended by the TLICS algorithm to assess validity.

Results: The inter-rater kappa statistics of all subgroups (injury morphology, status of the posterior ligamentous complex, neurological status, and proposed treatment) were within the range of moderate to substantial reproducibility (0.449-0.958) (Table 1). Proposed treatment had the lowest inter-rater agreement (0.449). All subgroups had excellent intra-rater reliability (0.748-1.000). The various indices for validity were calculated (80.3 percent correct, 0.836 sensitivity, 0.785 specificity, 0.676 positive predictive value, 0.899 negative predictive value).

Conclusion: The thoracolumbar injury classification system has good reliability and validity when used in the pediatric population. The inter-rater reliability of predicting management and indices for validity are lower than in adults with thoracolumbar fractures, which is likely due to differences in the way children are treated for certain types of injuries. TLICS can be used to reliably categorize thoracolumbar injuries in the pediatric population; however, modifications may be needed to better guide treatment in this specific patient population.

92. SPINAL FRACTURES IN PATIENTS WITH DIFFUSE IDIOPATHIC SKELETAL HYPEROSTOSIS: POSTERIOR ELEMENT INJURY CAUSES LATE NEUROLOGICAL DETERIORATION

Eijiro Okada, MD; Kota Watanabe; Mitsuru Yagi, MD, PhD; Shinjiro Kaneko, MD, PhD; Yoshiaki Toyama; Morio Matsumoto, MD
Japan

Summary: Spinal fractures in patients with DISH occurred by trivial trauma in elderly population. The fractures mostly occurred in the thoracolumbar junction. Fracture of ankylosings posterior element leads to 3-column injury and causes late neurological deterioration.
Introduction: Diffuse idiopathic skeletal hyperostosis (DISH) makes the spine prone to unstable fractures resulting in neurological deterioration. However, pathomechanism of neurological injury remains unclear. The purpose of this study was to clarify pathogenesis of spinal fractures in patients with DISH using multi-slice computed tomography (CT)
Methods: Multicenter-retrospective study over a 5-year period was conducted. Thirty-nine patients with 41 fractures (30 male; 9 female) were included in this study. Mean age at the time of injury was 77±10 years. Cause of injury, delay in diagnosis, location of fracture and neurological status were recorded. Fracture of anterior and posterior elements, dislocation >3mm and ankylosis of posterior element were assessed by multi-slice CT.
Results: Cause of the injury was trivial trauma, such as fall at home, in the majority of the patients (77% n=30). Delay in diagnosis was observed in 49% of the patients. The thoraco-lumbar junction (T11-L2) was the most frequently involved level (54% n=21). At the time of injury, 20% were neurologically intact, however, 59% were developed late onset paralysis by inadequate conservative treatment. All patients had fracture of anterior element. Fracture of posterior element (p=0.017) and ankyloing posterior element (p=0.046) were significantly associated with neurological deterioration.
Conclusion: Spinal fractures in patients with DISH occurred by trivial trauma in elderly population. The fractures mostly occurred in the thoracolumbar junction. Fracture of ankylosings posterior element leads to 3-column injury and causes late neurological deterioration.

93. THE IMPACT OF EARLY SURGICAL TIMING FOR COMPLETE SPINAL CORD INJURY

Étienne Bourassa-Moreau, MD; Stefan Parent, MD, PhD; Jean-Marc Mac-Thiong, MD, PhD
Canada

Summary: We studied the impact of surgical timing for complete traumatic spinal cord injury. We performed a prospective cohort study of cases of 53 cases of complete SCI. In the patients operated <24h, the rate of improvement in ASIA grade was of 34% compared to 13% in patients operated ≥24h. Cervical complete SCI showed better neurological improvement when compared to thoracic SCI, especially for patients operated <24h.
Introduction: The impact of surgical timing for complete traumatic spinal cord injury (SCI) is unknown. Animal and clinical studies suggested that the severe SCI may poorly respond to surgical decompression even if perform within hours of the trauma. Significant difference exist between thoracic and cervical SCI with regards to neurological recovery. The aim of this study was to compare the impact of early surgical decompression on neurological improvement in thoracic and cervical complete SCI.
Methods: We performed a prospective cohort study of all consecutive SCI from 2010 to 2013 in a single institution. All cases of complete SCI were retrieved for analysis and further divided in two groups of cervical and thoracic SCI. Time elapsed between trauma and surgical decompression was the independent variable. Dependent variable was the change in ASIA grade between initial evaluation after trauma and the end of rehabilitation. Confounding variables such as severity of injury, Age, comorbidities, and Glasgow Coma Scale (GCS) were recorded.
Results: Fifty-three consecutive ASIA A SCI were included in our study. Seventy-two percent of patients were operated <24h whereas 28% were operated ≥24h. Patients operated <24h tended to be younger, more often males. In the patients operated <24h, the rate of improvement in ASIA grade was of 34% compared to 13% in patients operated ≥24h (p=0,0182). In the 33 thoracic SCI improvement in ASIA grade was similar between patients operated <24h (17%) and ≥24h (22%). In the 20 Cervical SCI 9 of 14 patients (64%) had improvement in their ASIA grade whereas none of the 6 patients operated after 24h improved (p=0.008).
Conclusion: Cervical complete SCI showed better neurological improvement when compared to thoracic SCI especially for patients operated <24h. Complete SCI carries a poor neurological prognosis particularly at the thoracic level. Surgical decompression <24h in thoracic complete SCI did not result in better neurological outcome than ≥24h for the current cohort. Further study with a larger number of patients is required to confirm this results. We recommend early neurological decompression to promote neurological improvement for complete SCI, especially for those with cervical lesions.

94. SURVIVAL AFTER SPINAL METASTASIS FROM BREAST CANCER DEPENDS ON TUMOR SUBTYPE

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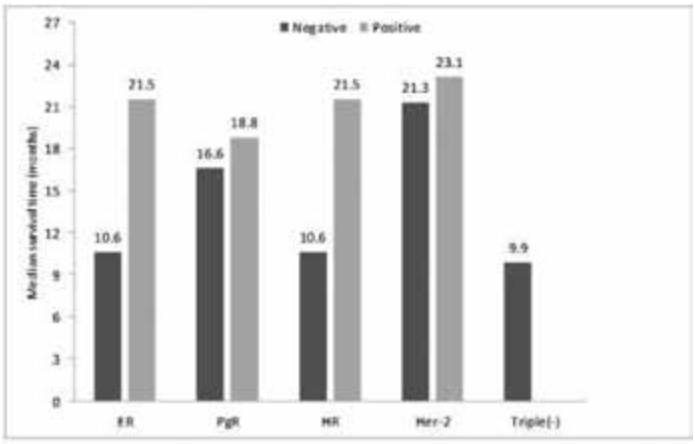
Denmark

Summary: Breast cancer spinal metastases patients with triple negative receptor status or negative estrogen receptor/ hormone receptor had a less than 12 months postoperative median survival. Surgeon should scale down the life expectancy of these patients and avoid high-risk extensive surgery on them.
Introduction: The current prognostic scoring systems for patients with acute symptoms of spinal metastases patients are the Tokuhashi- and Tomita scoring systems and a key element in both systems is the primary tumor. Breast cancer is one of the most common primary tumors that metastasize to the spine. There is a lack of knowledge about specific prognosis of spinal metastases patients in various breast cancer subtypes. Estrogen receptor (ER), progesterone receptor (PgR) and human epidermal growth factor receptor 2 (Her-2) status are the key factors in determining subtypes and predicting patients' response to adjuvant treatment.

Methods: From November 1st, 1997 to August 31st, 2011 we included 151 surgically treated breast cancer patients with spinal metastases from Aarhus University Hospital and Copenhagen University Hospital, Rigshospitalet. We followed all patients for at least two years. All data regarding primary oncologic diagnosis were retrieved from Danish Breast Cancer Group. Survival analysis and Cox's proportional regression analysis unadjusted and adjusted by age were used. P< 0.05 was consider significant
Results: Patients with ER(-) breast cancer had 11 months shorter survival (10.6 vs. 21.5 months) and 48% higher mortality risk (p=0.03) compared with ER (+) patients. PgR (-) patients had 59% higher mortality risk than PgR (+) patients (p=0.02). After combining ER and PgR results, 126 patients had? recorded hormone receptor (HR) status. HR (-) patients had an 11-month shorter median survival (10.6 vs. 21.5 months) and 52% higher mortality risk (p=0.01) compared with HR (+) patients. Her-2 subtypes had similar median survival and mortality rate ratio. Triple negative breast cancer patients had a median survival of 9.9 months.
Conclusion: Spinal metastases patients with ER/HR (-) or triple negative breast cancer could be downgraded to score "3" in Tokuhashi scoring system and to the "moderate growth" group in Tomita scoring system based on the finding that their median survival was between 9 to 12 months. Spine surgeons could refer to patients' ER, PgR, HR and Her-2 biomarkers prior to surgery and thus avoiding high-risk extensive surgery in triple negative patients, and probably, in ER/HR (-) patients.



Median survival time of each subtypes (months).

95. THE ROLE OF PRE-OPERATIVE VASCULAR EMBOLIZATION IN SURGERY FOR SPINAL METASTASES

Naresh S. Kumar, MBBS, FRCS (Orth&Tr), DM; Barry W. Tan, MBBS (Singapore); Aye Sandar Zaw, MBBS, MPH; Gopinathan Anil
Singapore

Summary: Retrospective analysis of embolized versus non-embolized surgical cases for spinal metastases stratified by primary tumor and type of surgery comparing blood loss (hemoglobin concentration drop, estimated intraoperative loss), length of stay (LOS, days) and duration of surgery (DOS, minutes). Certain embolized groups showed better outcome in LOS and DOS but significant reduction in blood loss was only seen in the myeloma/lymphoma group.

Introduction: Preoperative embolization of metastatic tumors aims at reducing perioperative blood loss and improving surgical outcome. This study aims to compare the perioperative degree of blood loss and surgical outcome in surgical cases of spinal metastases, comparing embolized and non-embolized cases.
Methods: We retrospectively analyzed the patients operated on in a tertiary hospital for spinal metastases over a 5-year period. The population was stratified to cases who underwent pre-operative embolization and those who did not. Cases were also stratified into primary tumor type (Renal, Pulmonary, Colorectal, Lymphoma/Myeloma, Breast and Others), type of surgery (I:Cervical Corpectomy & Stabilization, II:Thoracolumbar Laminectomy Decompression & Instrumentation, III:Thoracolumbar Corpectomy & Stabilization) and both. Peri and intraoperative blood loss was quantified by: hemoglobin concentration drop with consideration of blood units transfused and estimated blood loss intra-operatively. In addition, LOS and DOS were assessed. Age & Race were also analyzed for influence on outcome.
Results: Of 98 cases enrolled, 36 were embolized and 62 were non-embolized. Analysis revealed that in myeloma/lymphoma cases, embolization resulted in a significant decrease in blood loss (mean difference=1317 ml, p=0.02) and a reduced DOS (94.5 minutes, p=0.04). In colorectal cases, embolization resulted in a reduction in LOS (38.6 days, p=0.04) and DOS (212 minutes, p=0.03). In pulmonary cases, embolization reduced DOS (123.1 minutes, p=0.009). Comparison by type of surgery revealed that embolization reduced the LOS and DOS in type II surgeries (8.42 days, p=0.02; 66.8 minutes, p=0.02) and the DOS in type I surgeries. Combined stratification by tumor and surgery type revealed that embolization is associated with significant reduction in blood loss (2985ml, p<0.01) in the myeloma patients with type II surgery. Increased age resulted in a borderline significant increase in hemoglobin concentration drop (0.03, p=0.06).
Conclusion: Pre-operative embolization in spinal metastases has shown significant benefits in LOS and DOS in various groups of spinal metastases cases, but its absolute value in reducing blood loss per se may require further extended studies to verify.

96. IMPLANTATION OF LIQUID NITROGEN FROZEN TUMOR TISSUE AFTER POSTERIOR DECOMPRESSION AND STABILIZATION FOR METASTATIC SPINAL TUMORS

Kazuya Shinmura; Hideki Murakami; Satoru Demura, MD; Satoshi Kato, MD; Katsuhito Yoshioka, MD; Hiroyuki Hayashi; Noriaki Yokogawa; Takayoshi Ishii; Takashi Igarashi; Xiang Fang; Hiroyuki Tsuchiya
Japan

Summary: Implantation of a liquid nitrogen-treated tumor after posterior decompression and stabilization for metastatic spinal tumors enhanced antitumor immunity.
Introduction: The standard treatment for spinal cord compression caused by metastatic cancer is posterior decompression and stabilization. But if the patient shows prolonged survival, local recurrence is a concern. Furthermore, antitumor immunity may be suppressed, and cancer progression might be promoted because of surgical stress. We developed a new technique of implanting a tumor frozen in liquid nitrogen after posterior decompression and

stabilization, with the aim of enhancing antitumor immunity in order to prolong the survival period of the patient. This study aims to evaluate the immunity-enhancing effect of implantation of a liquid nitrogen-treated tumor.
Methods: We have performed 16 cases of implantation of liquid nitrogen frozen tumor tissue after posterior decompression and stabilization for metastatic spinal tumors since April 2011. After posterior decompression and stabilization, the tumor tissue was immersed in liquid nitrogen (-196°C) for 20 minutes. Then, the liquid nitrogen-treated tumor was implanted into the subcutaneous tissue of the axilla. To evaluate the immunity-enhancing effect, plasma cytokines (interferon [IFN]-γ and interleukin [IL]-12) were analyzed before surgery and 1 month after surgery. IFN-γ and IL-12, produced by immune system cells, induce an antitumor effect.
Results: In 10 (62.5%) of the 16 cases, plasma levels of IFN-γ increased after surgery, and the mean rate of increase in IFN-γ was 356.1%. In 12 (75.0%) of the 16 cases, plasma levels of IL-12 also increased. The mean rate of increase in IL-12 was 573.8%. Tumor growth was not observed at the axilla in all cases.
Conclusion: Recently, autologous cancer vaccine treatment, which involves the subcutaneous administration of an autologous treated tumor that induces the activation of cancer immunity, was investigated. Implantation of a liquid nitrogen-treated tumor enhanced antitumor immunity after surgery. This technique may provide systemic immunological enhancement. Further, the survival period might be prolonged due to the antitumor effect against disseminated tumor cells throughout the body.

97. INVASIVENESS REDUCTION OF RECENT TOTAL EN BLOC SPONDYLECTOMY: ASSESSMENT OF THE LEARNING CURVE

Takayoshi Ishii; Hideki Murakami; Satoru Demura, MD; Satoshi Kato, MD; Katsuhito Yoshioka, MD; Hiroyuki Hayashi; Noriaki Yokogawa; Takashi Igarashi; Xiang Fang; Hiroyuki Tsuchiya
Japan

Summary: In June 2010, we developed a "second-generation" total en bloc spondylectomy (TES) combined with tumor-induced cryoimmunology that did not require autograft harvesting from the iliac bone or fibula. The lack of autogenous bone harvesting from spinal tumor patients indicates the minimal invasiveness of second-generation TES. Second-generation TES is getting less invasive. Blood loss >700 mL was not noted in any surgery in recent TES. Thus, second-generation TES can no longer be considered a highly invasive surgery.
Introduction: Total en bloc spondylectomy (TES) is used for the complete resection of malignant vertebral tumors. In June 2010, we developed a "second-generation" TES combined with tumor-induced cryoimmunology that did not require autograft harvesting from the iliac bone or fibula. The lack of autogenous bone harvesting from spinal tumor patients indicates the minimal invasiveness of second-generation TES. Second-generation TES is getting less invasive. A retrospective study was performed to assess the surgical magnitude of second-generation TES and its learning curve.
Methods: Thoracic TES by posterior single approach was performed by a single surgeon in 63 patients between June 2010 and September 2013 at our university hospital. We evaluated three groups of patients: 20 undergoing surgery in the first year that second-generation TES was developed (group I), 20 in the second year (group II), and 23 in the third year (group III). Patient backgrounds showed no remarkable differences. Operating time, intraoperative blood loss, volume of concentrated red cell transfusion, and C-reactive protein (CRP) and creatine phosphokinase (CK) levels on postoperative days 1 and 3 and 1 week were compared among the three groups. The level of significance was $p < 0.05$ according to the Tukey-Kramer method.
Results: Operating time was 486±130 min (mean±standard deviation) in group I, 441±85 min in group II, and 396±75 min in group III. The operating time was significantly shorter in group III than in group I ($p<0.05$). Intraoperative blood loss was 901±646 mL in group I, 723±1310 mL in group II, and 411±167 mL in group III. Intraoperative blood loss was the least in group III. An increased number of surgeries was associated with a lower blood loss volume. As a result, blood loss >700 mL was not noted in any surgery in group III. Furthermore, transfusion was not required in 20 of 23 patients in group III. Postoperative CRP levels on postoperative day 3 in group III were lower than those in group I (mean, 6.12 vs. 10.07 mg/L; $p<0.05$). Postoperative CK levels did not differ among the three groups.
Conclusion: Thus, second-generation TES can no longer be considered a highly invasive surgery.

98. RELIABILITY ASSESSMENT OF A NOVEL CERVICAL DEFORMITY CLASSIFICATION SYSTEM

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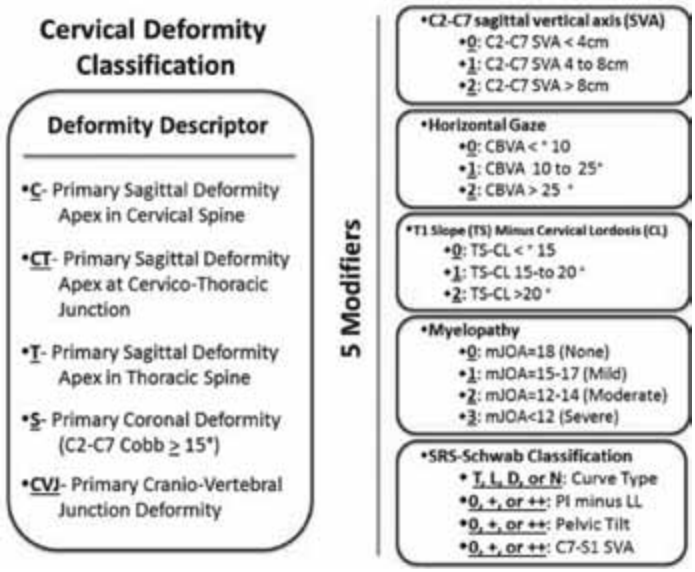
USA

Summary: There exists no universal comprehensive classification for cervical deformity. A novel classification system has been recently designed with a deformity descriptor and 5 modifiers that incorporate sagittal regional and global spino-pelvic alignment and neurological status. This classification provides a mechanism to assess cervical deformity within the framework of global spino-pelvic malalignment and clinically relevant parameters. The intra- and inter-observer reliabilities suggest moderate agreement and serve as the basis for subsequent improvement and study of the classification.
Introduction: Despite the complexity of cervical deformity and the significant impact on patient quality of life, there exists no comprehensive classification. An initial novel classification system has been recently designed with a deformity descriptor and 5 modifiers that incorporate sagittal regional and global spino-pelvic alignment and neurological status (Figure). Our objective was to characterize the intra- and inter-observer reliability of this classification.
Methods: A series of 10 cervical deformity cases, broadly representative of the classification system, were selected and sufficient radiographic and clinical history to enable classification were assembled. A panel of deformity surgeons was queried to

classify each case twice, with a minimum of 1 intervening week. Inter- and intra-rater reliability measures were based on calculations of Fleiss kappa coefficient values.

Results: Twenty spine deformity surgeons participated in this study. Inter-rater reliability (Fleiss kappa coefficients) for the deformity descriptor rounds 1 and 2 were 0.489 and 0.280, respectively, and mean intra-rater reliability was 0.584. For the modifiers, including the SRS-Schwab components, the inter-rater (round 1/round 2) and intra-rater reliabilities (Fleiss kappa coefficients) were: C2-C7 SVA (0.338/0.412, 0.584), horizontal gaze (0.779/0.430, 0.768), TS-CL (0.721/0.567, 0.720), myelopathy (0.602/0.477, 0.746), curve type (0.590/0.433, 0.564), PI-LL (0.554/0.386, 0.826), PT (0.714/0.627, 0.633) and C7-S1 SVA (0.071/0.064, 0.233), respectively. The parameter with the poorest reliability was the C7-S1 SVA, which may have resulted from differences in interpretation of positive and negative measurements.

Conclusion: The proposed classification provides a mechanism to assess cervical deformity within the framework of global spino-pelvic malalignment and clinically relevant parameters. The intra- and inter-observer reliabilities suggest moderate agreement and serve as the basis for subsequent improvement and study of the proposed classification.



99. POST-OPERATIVE CERVICAL DEFORMITY IN 215 THORACOLUMBAR ADULT SPINAL DEFORMITY PATIENTS: PREVALENCE, RISK FACTORS, AND IMPACT ON PATIENT-REPORTED OUTCOME AND SATISFACTION AT TWO-YEAR FOLLOW UP

Peter G. Passias, MD; Justin S. Smith, MD, PhD; Alex Soroceanu, MD, CM, MPH, FRCSC; Anthony J. Boniello, BS; Justin K. Scheer, BS; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Munish C. Gupta, MD; Eric Klineberg, MD; Virginie Lafage, PhD; Christopher P. Ames, MD; International Spine Study Group
USA

Summary: This study identifies a 63% incidence of postoperative cervical deformity (CD) in adult spinal deformity (ASD) surgery at 2 years. Predictors include preoperative CD, higher C2 and T1 slope, C2-S1 SVA and cervical lordosis C2-T3. Although cervical deformity is common in the postoperative period, it is not associated with effect on outcome or satisfaction. Significant improvements in 2-year HRQL scores occurred in the presence or absence of CD, and patient satisfaction was unaffected.

Introduction: Despite recognition of its occurrence, reliable predictors of the development of cervical deformity (CD) following ASD surgery are elusive and the effects unclear. This study quantifies the incidence of CD after ASD surgery, identifies predictors of development and determines the impact outcomes.

Methods: This was a retrospective review of a prospective multi-center database evaluating surgical ASD patients with complete 2-year follow-up. CD was defined by: T1S-CL>20°, C2C7 SVA>40mm, or C2C7 kyphosis>10°. Univariate testing was performed using t-tests, or tests of proportion. The impact of CD at 2 years on Health Related Quality of Life (HRQL) and satisfaction was measured using repeated measures mixed models or logistic regression as appropriate.

Results: 215 patients were included. 63% were found to have CD at 2 years post-op. CD patients had a higher incidence of pre-op CD (p=0.0001) and diabetes (p=0.05). They also had lower baseline C2-T3 lordosis (5.49 vs 11.97, p=0.003), lower C2 tilt (71.5 vs 79.28, p=0.0001) and higher C2 slope (18.49 vs 10.71, p=0.0001) and T1 (26.08 vs 22.2, p=0.036) slopes, and C2-S1 SVA (84.32 vs 57.57, p=0.002). Patients with and without CD at 2 years experienced significant improvements in their HRQL scores: SF-36 (p=0.0001), ODI (p=0.0001) and SRS (p=0.0001). Rates of improvement and overall improvement were similar. CD was not a predictor of 2-year patient satisfaction (p=0.367).

Conclusion: Predictors of CD at 2 years include the presence of the following at baseline; CD, diabetes, higher C2 and T1 slopes, higher C2-S1 SVA, and lower C2-T3 lordosis. Significant improvements in 2-year HRQL scores occurred in the presence or absence of CD, and patient satisfaction was unaffected. While this study identifies several predictors of CD, clinical significance remains unclear and further study is warranted.

100. UPPER CERVICAL COMPENSATION AND MAINTENANCE OF HORIZONTAL GAZE IN 150 THORACOLUMBAR DEFORMITY PATIENTS WITH AND WITHOUT DEFORMITY

Renaud Lafage, MS; Virginie Lafage, PhD; Justin S. Smith, MD, PhD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Thomas J. Errico; Shay Bess, MD; Munish C. Gupta, MD; Robert A. Hart, MD; Frank J. Schwab, MD; Themistocles S. Protopsaltis, MD; International Spine Study Group
USA

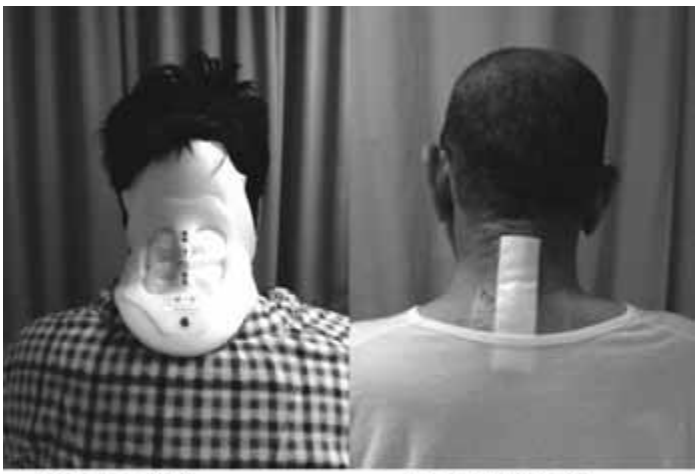
Summary: Patients with sagittal plane thoracolumbar deformities (TLD) have been shown to have increased subaxial cervical lordosis (CL) which corrects after realignment. This study demonstrates that when cervical deformity (CD) is present, patients compensate with upper cervical hyperlordosis. Maintenance of horizontal gaze is investigated with parameters that can substitute for Chin Brow Vertical Angle (CBVA), which is not readily measured on most spine radiographs.

Introduction: TLD patients have compensatory cervical hyperlordosis to maintain horizontal gaze, classically measured by the CBVA. Patients with concurrent cervical deformity need to compensate by other means, But, CBVA is not readily measured on most lateral spine radiographs. The objectives of this study were 1- investigate the role of upper cervical compensation in maintaining horizontal gaze in patients with TLD with and without concurrent CD; 2- evaluate if CBVA can be substituted by more accessible radiographic parameters (Figure 1).
Methods: Multicenter prospective data collection of TLD patients with 36" radiographs including the cranium and pelvis. The upper cervical and subaxial parameters were analyzed including cervical lordosis (CL), and C2-C7 plumbline (CPL). The T1 slope minus cervical lordosis (TS-CL) was used to identify patients with cervical deformity (CD) using linear regression analysis (CPL of 4cm corresponds to TS-CL of 20 deg). CD (TS-CL>20deg) were compared to those with no cervical deformity. Cranial orientation was defined by CBVA, Slope of Line of Sight (SLS), slope of McRae's line (C0S) and slope of McGreggor's line (Figure 1).
Results: There were160 patients (mean age of 55.6y; 86.3% Female). Cervical deformity was present in 35% of the patients. CD patients had significantly larger C0C2 angle (35 vs 28deg, $p<0.001$), CPL (41mm vs. 29mm, $p<0.001$), and C2 slope (25 vs. 9deg, $p<0.001$) and significantly smaller CL (4 vs. 12deg, $p<0.001$), without any significant difference in TLD. CBVA strongly correlated with SLS ($r=0.966$, $p<0.001$), C0S ($r=0.0.783$, $p<0.001$) and McGreggor's slope ($r=0.900$, $p<0.001$).
Conclusion: The compensatory mechanism of subaxial hyperlordosis is lacking for patients with concurrent cervical deformity who have a loss of CL and increased C2 slope requiring upper cervical hyperlordosis to maintain horizontal gaze. The SLS and the McGreggor's slope correlate strongly with CBVA, suggesting that they could be used as surrogates for the CBVA. Similar analysis should be undertaken in primary cervical deformity patients to determine the importance of upper cervical compensation.

101. COLLAR FIXATION VERSUS NO FIXATION AFTER CERVICAL LAMINOPLASTY: A RANDOMIZED CONTROLLED TRIAL

Tetsuro Hida; Yoshihito Sakai, PhD; Kenyu Ito; Sadayuki Ito; Shiro Imagama, MD; Atsushi Harada
Japan

Summary: We investigated the effect of collar-aided fixation on prognosis following laminoplasty of cervical spine in this randomized controlled study with a total of 90 patients with myelopathy. Patients exhibited good neurological symptoms and recovery of ADL with or without collar fixation. Omitting collar-aided fixation was demonstrated to be a beneficial option after laminoplasty of cervical spine.
Introduction: Traditionally, it has been common to apply external fixation using a collar after cervical laminoplasty for the purpose of resting the wound. However, some reports have been made claiming that use of a collar for a long period may induce such problems as muscle atrophy and joint contracture, and increase risks of malalignment and axial pain, and that, therefore, postoperative fixation may be omitted. However, these reports were all based on retrospective studies, and controversy remains as to the benefit of postoperative use of a collar. We investigated the effect of collar-aided fixation on prognosis following laminoplasty for cervical myelopathy in this randomized controlled study.
Methods: This trial involved 90 patients (mean age, 72.7years; 62 males and 28 females)with cervical compressive myelopathy who had undergone double-door laminoplasty. Prior to their operations, we randomly assigned 45 patients to the collar-fixation(CF) group where each of them underwent external fixation using a Philadelphia collar for 2 weeks following their operations, and 45 to the no-collar(NC) group where they wore no collar. Finally, we successfully completed one-year follow-up for 74 patients (39 patients in the CF group and 35 patients in the NC gourp) and we assessed them using the JOA score, SF-36, a visual analog scale (VAS) of cervical pain, lordotic angle of C2 to 7, prior to the operations and one year after the operations, and perioperative complications (infection, epidural hematoma, C5 palsy).
Results: JOA scores significantly improved in both groups ($P=0.002$,$P<0.001$). There was no significant difference between the two groups with regard to the recovery rate of JOA scores ($P=0.80$). The loss of lordotic angle of the cervical spine after operation was 6.5degrees and 7.1degrees in the CF goup and the NC group, respectively ($P=0.82$). VAS scores after operation were 2.9cm and 3.5cm, respectively.($P=0.68$). SF-36BP domain was similar in both groups($P=0.58$).The Incidences of complication were not difference between the groups.
Conclusion: Patients exhibited good neurological symptoms and recovery of ADL with or without collar fixation. Omitting collar-aided fixation was demonstrated to be a beneficial option after laminoplasty of cervical spine.



102. SELF-DESIGNED POSTERIOR ATLAS POLYAXIAL LATERAL MASS SCREW-PLATE FIXATION FOR UNSTABLE ATLAS FRACTURE

Dingjun Hao; Baorong He; Liang Yan
China

Summary: this retrospective study was to clinically validate feasibility, safety and value of open reduction and fixation using an atlas polyaxial lateral mass screw-plate construct in unstable atlas

fractures. All patients were followed up from 12 to 32 months, with an average of 22.5± 18.0 months. A total of 22 plates were placed, and all 44 screws were inserted into the atlas lateral masses. An open reduction and posterior internal fixation with atlas polyaxial lateral mass screw-plate is safe and effective surgical option in the treatment of unstable atlas fractures. This technique can provide immediate reduction and preserve C1-2 motion.

Introduction: The majority of atlas fractures can be effectively treated nonoperatively with external immobilization unless there is an injury to the transverse atlantal ligament. Surgical stabilization is most commonly achieved using a posterior approach with fixation of C1-2 or C0-2, but these treatments usually result in loss of the normal motion of the C1-2 and C0-1 joints.

Methods: From January 2011 to September 2012, 22 patients with unstable atlas fractures were treated with this technique. Patients' charts and radiographs were reviewed. Bone fusion, internal fixation placement, and integrity of spinal cord and vertebral arteries were assessed via intraoperative and follow-up imaging. Neurological function, range of motion, and pain levels were assessed clinically upon follow-up.

Results: All patients were followed up from 12 to 32 months, with an average of 22.5± 18.0 months. A total of 22 plates were placed, and all 44 screws were inserted into the atlas lateral masses. The mean duration of the procedure was 86 min and the average estimated blood loss was 120 ml. CT scans 9 months after surgery confirmed that fusion was achieved in all cases. There was no screw or plate loosening or breakage in any patient. All patients had well preserved range of motion. No vascular or neurological complication was noted, and all patients had a good clinical outcome.

Conclusion: An open reduction and posterior internal fixation with atlas polyaxial lateral mass screw-plate is safe and effective surgical option in the treatment of unstable atlas fractures. This technique can provide immediate reduction and preserve C1-2 motion.

103. CERVICAL INTERFACET SPACERS AND MAINTENANCE OF CERVICAL LORDOSIS

Lee A. Tan, MD; David C. Straus, MD; Vincent C. Traynelis, MD
USA

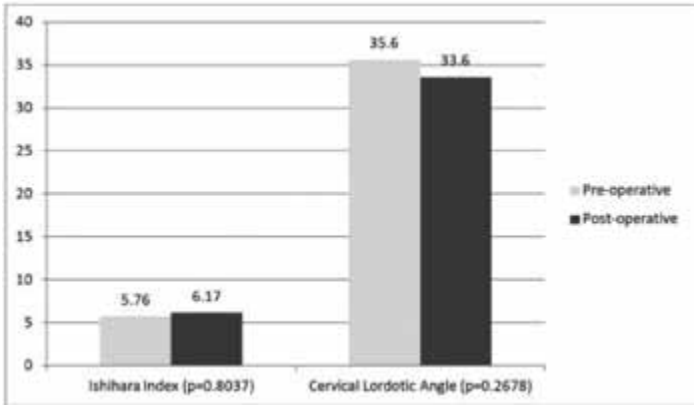
Summary: The cervical interfacet spacer (CIS) is a relatively new technology that increases foraminal height and area by facet distraction. One concern with the use of CIS is the theoretical risk of inducing iatrogenic kyphosis. In our experience of placing CIS s in over 100 levels, we found no evidence of significant worsening cervical lordosis.

Introduction: The cervical interfacet spacer offers indirect neuroforaminal decompression while simultaneously enhancing fusion potential due to the relatively large osteoconductive surface area and compressive forces exerted on the grafts. One concern with the use of CIS is the theoretical risk of inducing iatrogenic kyphosis. This work tests the above hypothesis.

Methods: Records from patients undergoing posterior cervical fusion at Rush University Medical Center between March 2011 and December 2012 were reviewed. The cervical interfacet spacers were used in all patients. Pre- and post-operative radiographic data were reviewed and the Ishihara indices and cervical lordotic angles were measured and recorded.

Results: Sixty-four patients were identified in whom 154 cervical levels were implanted with machined allograft interfacet spacers. Of these, 15 patients underwent anterior-posterior fusions, 4 underwent anterior-posterior-anterior fusions, and the remaining 45 patients underwent posterior fusions only. In the 45 posterior fusions only patients, a total of 110 levels were treated with spacers. 14 patients (31%) had a single level treated, 16 patients (36%) had two levels treated, 5 patients (11%) had three levels treated, 5 patients (11%) had four levels treated, 1 patient (2%) had five levels treated and 4 patients (9%) had six levels treated. Complete radiographic data were available for 38/45 (84%) of these patients. There was no significant difference in the Ishihara index (5.76 pre-operatively and 6.17 post-operatively, p=0.8037). Our analysis had 80% power to detect a change of 4.25 in the Ishihara index at p=0.05. There was no significant difference in the pre- and post-operative cervical lordotic angles (35.7 degrees pre-operatively and 33.6 degrees post-operatively, p=0.2678). Our analysis had 80% power to detect a 7 degree change in the cervical lordotic angle at p=0.05. Average clinical follow-up was 237 days (range 48-524 days).

Conclusion: In our experience of placing CIS in over 100 levels, we found no evidence of significant worsening cervical lordosis. Their long-term impacts on fusion rates and clinical outcomes particularly radiculopathy and post-operative C5 palsies remain active areas for further studies.



The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

104. CORRELATION OF MYELOPATHY TO REGIONAL NECK DISABILITY: A SURGICAL APPROACH-SPECIFIC ANALYSIS IN 217 PATIENTS

Christopher P. Ames, MD; Justin S. Smith, MD, PhD; Shian Liu, BS; Christopher I. Shaffrey, MD; Han Jo Kim, MD; Paul Arnold; Vincent Challier, MD; Jens Chapman, MD; Themistocles S. Protopsaltis, MD; Frank J. Schwab, MD; Justin K. Scheer, BS; Eric Massicotte, MD, MSc FRCSC; S. Tim Yoon; Virginie Lafage, PhD; Michael G. Fehlings, MD, PhD
USA

Summary: Outcomes for cervical spondylotic myelopathy (CSM) have been measured by numerous health-related quality of life (HRQOL) scales; however, there is no literature analyzing the correlation of

myelopathy improvement to regional neck disability changes after surgery. This analysis reveals that the regional specific Neck Disability Index (NDI) is negatively correlated with the disease-specific modified Japanese Orthopaedic Association (mJOA) at baseline and post-operatively in patients with CSM, and that this correlation may differ depending on the surgical approach.

Introduction: Outcomes for CSM have been measured by numerous HRQOL scales such as the disease-specific mJOA and the regional-specific NDI. However, there is no literature analyzing the correlation of myelopathy improvement to regional neck disability changes after surgery.

Methods: Post-hoc analysis of a prospective, multicenter database of patients with CSM. 217 patients (78%) met inclusion criteria: symptomatic CSM, age over 18, and 6 month follow-up with mJOA and NDI. The patient population had a mean age of 57 years and was 42% female (n=92). NDI and mJOA were analyzed at baseline and 6 months postop for the entire group. Correlations were also analyzed by subgroups: anterior approach group (AAG, n = 141) and posterior approach group (PAG, n = 76).

Results: From baseline to 6 months, there was a statistically significant improvement in both mJOA (BL 12.87 to 6M 15.25, $p<0.0001$) and NDI (BL 42.25 to 6M 31.61, $p<0.0001$) in the overall group. There was a significant small negative correlation between NDI and mJOA at baseline ($R=-0.34$, $p<0.0001$) and at 6 month follow-up ($R=-0.44$, $p<0.0001$, see Fig 1). Within the AAG, there was also a significant negative correlation between NDI and mJOA at baseline ($R=-0.31$, $p<0.0001$) and 6 months ($R=-0.53$, $p<0.0001$). Within the PAG, there was also a significant negative correlation between NDI and mJOA at baseline ($R=-0.43$, $p<0.0001$) and 6 months ($R=-0.34$, $p=0.003$).

Conclusion: Overall, NDI has a significant negative correlation with mJOA at baseline and post-operatively in patients with CSM. This correlation increases post-operatively in the overall group. The PAG showed a decrease in the correlation coefficient after surgery, while the AAG showed an increase. This could be because the posterior approach tended to be a more extensive surgery for multi-level disease in older patients, compared with the anterior approach, resulting in more soft tissue disruption and a delay in neck active motion. Regardless of the approach, mJOA still remains significantly correlated with NDI.

105. CERVICAL SPONDYLOTIC MYELOPATHY: DOES SURGICAL APPROACH INFLUENCE POST-OPERATIVE SAGITTAL ALIGNMENT AND OUTCOMES?

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Canada

Summary: The effect of surgical approach on outcomes in cervical spondylotic myelopathy (CSM) has not been clearly established in the literature. This analysis of a posterior approach group (PAG) versus an anterior approach group (AAG) revealed that patients undergoing a posterior approach were in general older and had more disability. Analysis demonstrated the PAG had a significantly higher post-operative C2_C7 sagittal vertical axis (SVA) which worsened from baseline to post-op, but similar mJOA scores to the AAG.

Introduction: The effect of surgical approach on outcomes for CSM is controversial. Fehlings et al, showed that patients treated with anterior techniques tend to be younger, less impaired, and had more focal pathology. In this study we compared outcomes of an AAG versus a PAG with a focus on the effect of sagittal alignment.

Methods: Post-hoc analysis of a prospective, multicenter database of patients with CSM. 117 patients met inclusion criteria, were non-randomized to an AAG (n=51) or PAG (n=62), with post-operative static lateral radiographs, Nurick assessment, and HRQOLs at 6 months and/or 1 year. The AAG underwent anterior decompression and fusion, PAG either laminoplasty or laminectomy with fusion. Sagittal regional and focal parameters were compared by multivariate regression.

Results: At baseline, the groups showed significant age difference (AAG 51 yrs, PAG 62 yrs, $p<0.001$), rheumatological comorbidity (AAG 3%, PAG 19%, $p=0.011$), and mJOA (Table). The PAG had significantly more regional malalignment at baseline but there were no focal alignment differences between the two (Table). Surgical features were significantly different for greater than 3 levels treated (AAG 27%, PAG 97%, $p<0.001$) and blood loss (AAG 152mL, PAG 380mL, $p<0.001$). After surgery, both AAG and PAG improved significantly in mJOA and Nurick grade, however there was no statistically significant difference in mJOA post-operatively. AAG had a decrease in SVA while the PAG had a significant increase in SVA. There were no relevant post-operative focal alignment differences.

Conclusion: The PAG had older patients with more disability. Even when age, baseline mJOA, and regional parameters were controlled, the PAG cohort still correlated with worse CGH_C7 SVA and TS-CL. It is interesting to note the PAG had a lower mJOA than the AAG at baseline, they both improved and were not significantly different post-operatively. This suggests that both techniques relieve symptomatic disease, but patients in the posterior group may continue to progress in sagittal misalignment.

106. THE IMPACT OF DYNAMIC ALIGNMENT, MOTION AND CENTER OF ROTATION ON MYELOPATHY GRADE AND REGIONAL DISABILITY IN CERVICAL SPONDYLOTIC MYELOPATHY

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USA

Summary: Elements of stenosis in cervical spondylotic myelopathy (CSM) are both static and dynamic, where the dynamic elements magnify the canal deformation of the static state. Novel methods of dynamic motion analysis in CSM reveal that reduced motion cones correlated with worse myelopathy grades and that a more posterior center of rotation (COR) and smaller range of motion (ROM) were both correlated with worse general health scores.

Introduction: Cervical stenosis is a defining feature of CSM. Matsunaga et al proposed that elements of stenosis are both static and dynamic, where the dynamic elements magnify the canal deformation of the static state. We hypothesize that dynamic motion may be associated with myelopathy severity and neck disability and present novel methods of dynamic motion analysis in CSM.
Methods: Post-hoc analysis of a prospective, multicenter database of patients with (CSM). 110 patients (34%) met inclusion criteria: symptomatic CSM, age over 18, baseline flexion/extension radiographs, and HRQOLs (mJOA, NDI, SF-36, and Nurick grade). The mean age was 57+12 years with 41% female (n=46). Correlations with HRQOLs were analyzed for regional and focal parameters in flexion and extension. Baseline dynamic parameters (F/E cone relative to a fixed C7, center of rotation, range of motion arc relative to the COR) were also analyzed for correlations to HRQOLs.
Results: At baseline, the mean HRQOLs demonstrated disability and the mean radiographic parameters demonstrated sagittal malalignment. Among regional parameters, there was a significant correlation between increased C2-C7 angle in flexion and Nurick grade (R=0.189, p 0.048) with no significant correlations in extension (Fig 1). Focal parameters including C7 slip were significantly correlated with disability (Flex R=-0.377, p 0.003; Ext R=-0.261, p 0.027). Reduced flexion/extension motion cones, a more posterior center of rotation, and smaller range of motion correlated with worse HRQOLs (Fig 1).
Conclusion: Dynamic motion analysis may play an important role in understanding CSM. Focal parameters demonstrated a significant correlation with worse HRQOLs especially C7 slip in flexion and extension. Novel methods of motion analysis demonstrated reduced motion cones correlated with worse myelopathy grades. More posterior center of rotation and smaller range of motion were both correlated with worse general health scores (PCS & Nurick).

107. IMPACT OF REGIONAL AND FOCAL CERVICAL ALIGNMENT ON MYELOPATHY SEVERITY: REPORT OF 151 PATIENTS

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Canada

Summary: Regional and focal cervical alignment is potentially important in assessment of patients with cervical spondylotic myelopathy (CSM), and potentially correlates with worse health related quality of life outcomes (HRQOLs) such as the modified Japanese Orthopaedic Association (mJOA) and Neck Disability Index (NDI). Analysis demonstrated that cervical C2_C7 SVA (cSVA) correlates with myelopathy severity and furthermore, focal malalignment of adjacent segments also correlated with worse HRQOLs and may also be an important factor to consider.
Introduction: Cervical sagittal alignment (C2-C7 SVA) has been correlated to myelopathy severity but kyphosis as a regional parameter has not been demonstrated to correlate with HRQOL measures. We hypothesized that regional and focal sagittal cervical alignment may also correlate with HRQLs in cervical spondylotic myelopathy (CSM) patients.
Methods: Post-hoc analysis of a prospective, multicenter database of CSM patients. 151 patients met inclusion criteria (47%): symptomatic CSM, age>18, baseline lateral radiographs, mJOA and NDI. Average age was 56.3+11.7 yrs with females making up 43.9% (n=69) of the study population. Regional alignment and HRQOLs were analyzed with patients stratified into a high cSVA group (hiSVA, n=45, 0.5SD>mean) or a low cSVA group (loSVA, n=43, 0.5SD<mean). Focal alignment (kyphosis and olisthesis between adjacent vertebrae) analysis was also conducted.
Results: The hiSVA (mean cSVA 39.4+7.4mm) cohort had a significantly worse mJOA than the loSVA (mean cSVA 11.31+5.3mm) cohort (mean mJOA 12.5 vs 13.7, p=0.037). No significant correlations between C2-C7 lordosis and HRQOLs existed. There were significant correlations with focal alignment and worse clinical assessments: max sagittal slip with mJOA (R=-0.24, p=0.002) and Nurick (R=0.18, p 0.024). Level of slip was also significant, with olisthesis at higher levels correlating with worse health status (Table 1). Number of kyphotic segments also positively correlated with NDI (R=0.19, p<0.001).
Conclusion: Similar to prior studies, high baseline cSVA correlated with significantly worse mJOA. Interestingly, the mean cSVA of the hiSVA cohort was 39.4+7.4mm, suggesting that 40mm may be a potential threshold below which cervical sagittal malalignment should be corrected. Regarding focal alignment, increased olisthesis is correlated with worse mJOA and Nurick grade, especially at higher cervical levels. Even focal abnormalities all along the cervical spine are correlated with worse NDI, demonstrating that while level of olisthesis may matter, the number of vertebrae with a kyphotic relationship may also cause pain and disability.

108. CHANGES IN FORAMINAL AREA WITH ANTERIOR DECOMPRESSION VERSUS KEYHOLE FORAMINOTOMY IN THE CERVICAL SPINE: A CADAVERIC INVESTIGATION

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Summary: To determine which cervical decompression method most consistently increases neuroforaminal area and how that area is affected by neck position.
Introduction: Anterior cervical discectomy and fusion (ACDF) with or without uncovertebral joint resection (UVR) and posterior keyhole foraminotomy (F) are established operative procedures to treat cervical disc degeneration and radiculopathy. Studies demonstrated reliable results with each procedure, but none compared change in neuroforaminal area between indirect and direct decompression techniques.
Methods: Six human cervical functional spinal units (C5-6 and C6-7) underwent sequential decompression. Each level was randomly assigned to a surgical sequence consisting of bilateral foraminotomy (F), ACDF, and ACDF with uncus resection (ACDF+UVR). ACDF was performed with fibular strut allograft and anterior plating. Biomechanical testing was performed after each procedure to

measure minimum cross-sectional area of each foramen in three different neck positions: neutral, flexion, and extension. Five treatment groups were analyzed: Intact, F, ACDF, ACDF+UVR, and F+ACDF. The primary outcome measure was minimum cross-sectional area (mmsq) of each foramen.

Results: Neuroforaminal area increased significantly with F vs. intact in all positions (71, 73, 54 mmsq in neutral, flexion, extension; Table. 1). ACDF did not produce increase differences in area vs. intact in any position (55, 52, 40 mmsq in neutral, flexion, extension). Increased area observed in neutral with F (71 mmsq) was maintained in extension (54 mmsq). Decreases in area was observed for ACDF in extension (40 mmsq) vs. neutral (55 mmsq). F+ACDF did not largely increase area compared to F in any position (67, 71, 53 mmsq in neutral, flexion, extension). UVR did not produce any statistically large changes in area across positions (51, 55, 36 mmsq in neutral, flexion, extension).

Conclusion: F and F+ACDF produced the greatest increase in area and maintained the area in extension more than anterior-only procedures. UVR did not largely alter the area compared to ACDF alone. In a stable cervical spine, F may be preferable to directly decompress the neuroforamen; yet, ACDF continues to be an important role for indirect decompression and decompression of more centrally located herniated discs. Findings pertain mostly to bony stenosis of the neuroforamen and may not apply to soft disc herniation.

109. AREA UNDER THE CURVE: ANALYSIS OF APPROACH RELATED RECOVERY TIME IN 165 OPERATIVE CERVICAL SPONDYLOTIC MYELOPATHY PATIENTS WITH TWO-YEAR FOLLOW UP

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USA

Summary: We propose a novel method for assessing health related quality of life outcomes (HRQOLs) in patients with cervical spondylotic myelopathy (CSM) by taking into account each patient's baseline at post-operative time points and analyzing the "area under the curve" (AUC), a proxy for suffering time. AUC analysis applied to comparing a posterior approach group (PAG) and anterior approach group (AAG) found that patients in the PAG suffer less in the first two years of their post-operative course.

Introduction: Much debate about post-operative outcomes regarding surgical approaches for CSM exists in the literature with no clear evidence of superiority. We propose a novel method for assessing HRQOLs by taking into account each patient's baseline at post-operative time points and analyzing the AUC, a proxy for suffering time.

Methods: Post-hoc analysis of a prospective, multicenter database of patients with CSM. 165 patients met inclusion criteria: symptomatic CSM, age over 18, and 2 year follow-up with modified Japanese Orthopaedic Association (mJOA) and Neck Disability Index (NDI). The AAG (n=110) and PAG (n=55) were compared at baseline, 1 year, and 2 years for each HRQOL. This comparison was repeated with normalization, using the patient's baseline as the anchor, followed by an integration and comparison of AUC.

Results: Post-hoc analysis of a prospective, multicenter database of patients with CSM. 165 patients met inclusion criteria: symptomatic CSM, age over 18, and 2 year follow-up with modified Japanese Orthopaedic Association (mJOA) and Neck Disability Index (NDI). The AAG (n=110) and PAG (n=55) were compared at baseline, 1 year, and 2 years for each HRQOL. This comparison was repeated with normalization, using the patient's baseline as the anchor, followed by an integration and comparison of AUC.

Conclusion: For the first time AUC analysis was applied to evaluating patients with CSM. Non-normalized HRQOLs demonstrated the AAG started higher and met better standards at all times points compared to the PAG. Normalized mJOA demonstrated the PAG actually did better at 2 years, while NDI suggested that the AAG did better, though this was not significant. AUC analysis further supported the superiority of the PAG, with statistical significance at 1 and 2 year time points, suggesting that patients who undergo the posterior approach may suffer less in the first two years of their post-operative course.

110. INTRAOPERATIVE ASSESSMENT OF THE MAXIMAL INSERTIONAL TORQUE FOR LATERAL MASS SCREWS: MAGERL TECHNIQUE VERSUS ROY-CAMILLE TECHNIQUE

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Summary: Multicenter, biomechanical analysis of maximal insertional torque for mid-cervical spine intraoperatively. The maximal insertional torque (MIT) of LMS (C3-6) during the surgery was compared with Magerl technique and Roy-Camille technique. The average MIT of Magerl technique was significantly higher than that of Roy-Camille technique.

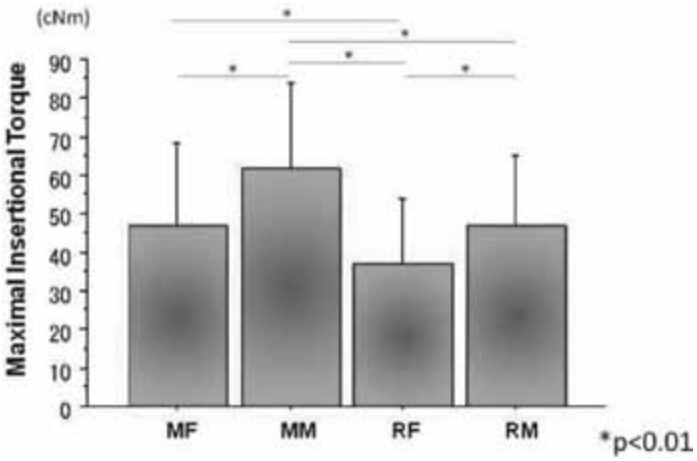
Introduction: In posterior subaxial cervical fixation system, screws are usually inserted into the lateral mass. Many authors have reported only on the stiffness and pullout strength of lateral mass screws (LMS) None of the previous studies tested the insertional torque of LMS during the surgery. The purpose of this study was to assess, in cervical vertebrae(C3-6), the maximal insertional torque (MIT) of LMS during the surgery.

Methods: During posterior spinal fusions, cervical multiaxical screws (Alphatec Spine, Carlsbad, CA) were placed at various cervical levels (C3-6) after drill of 2.0mm, final (MIT) was recorded for each screw revolution with an analogue torque wrench. Sixtyfour cases were included in this study. Fourtysix were cervical spondylotic myelopathy, 12 were ossification of ossification of posterior longitudinal ligament, 4 were pyogenic spondylitis and 2 were vertebral fractures. 386 LMSs were implanted in 64 spines from C3 to 6 (Magerl technique: 236, Roy-Cammille technique: 150). LMSs at C1 and laminar screws at C2 or C7 were excluded in this study.

Results: There were no injuries to the spinal cord. The average MIT for Magerl technique was 62.0±21.8 cNm in male group (groupe: MM) and 47.0±21.7 cNm in female group (group: MF). The MIT for Roy-Camille technique was 47.0±18.4 cNm in male (group: RM)

and 37.2±16.6 cNm in female (group: RF). The MIT for Roy-Camille technique was 51.0±17.9 cNm in male (group: RM) and 42.4±15.9 cNm in female (group: RF). The average MIT of Magerl technique was significantly higher than that of Roy-Camille technique ($p<0.01$ in male, $p<0.01$ in female). MIT of the LMSs was not correlated with screw length in both group.

Conclusion: In this study, Magerl technique for midcervical spine was significantly stronger than Roy-Camille technique in the point of insertional torque. Intraoperative IT is one of the good indicators to evaluate the purchase of screws. If intraoperative MIT is very low, we can change the screw size or trajectory, or use some additional implants. Further postoperative assessments with sequential X-rays were needed to reveal the meaning of MIT during the surgery for posterior spinal fusions.



111. SAGITTAL ALIGNMENT OF CERVICAL SPINE IN ADULT IDIOPATHIC SCOLIOSIS

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Summary: To analyze the sagittal alignment of cervical spine (CS) in adult idiopathic scoliosis (IS) and its association with age, alignment of the thoracic, lumbar and global spinal column and health related quality of life (HRQL) parameters, a prospective mullticenter database was retrospectively reviewed. The results of the study suggest that CS alignment is likely a component of the global sagittal alignment strongly affected by thoracic kyphosis, and most probably does not affect HRQL by itself.

Introduction: Alignment of the cervical spine (CS) in adolescent idiopathic scoliosis (IS) as well as in asymptomatic adult populations has recently been studied and described as being less lordotic in the AIS population. However, few studies have examined the sagittal alignment of the CS in adult IS or its association with other radiological variables and clinical relevance. The aim of this study was to analyze the sagittal alignment of CS in adult IS and its association with age, alignment of the thoracic, lumbar and global spinal column and health related quality of life (HRQL) parameters.

Methods: A retrospective review of prospectively collected data from a multicenter database was performed. Of 468 consecutive adult IS patients, 213 were included in the study; the remainder were excluded due to poor quality X-rays on which the CS was not visible, or previous surgery. X-rays were measured for the following CS paramaters: [Cranial base- C2 (C0-C2) lordosis, C2-C7 lordosis, thoracic (T1) slope, thoracic inlet angle (TIA) and odontoid T1 offset using a measurement software. These measurements were then evaluated for possible associations with patient age and with pre-existing alignment parameters and HRQL parameters using Pearson correlation analysis.

Results: The average and standard deviations for CS alignment parameters were 32.3±10.2o for C0-C2; 5.7±14.1o for C2-C7; 23.9±11.3o for T1 slope, 70.5±14.7o for TIA and 20.8±16.5o for Od-T1 offset. CS alignment showed a significant ($p<0.05$) correlation with age, T kyphosis and several other sagittal alignment parameters such as global tilt, but not with the HRQL parameters as expected (Table 1).

Conclusion: The results of this study demonstrate that the sagittal alignment of the CS in adult IS is less lordotic than the normal average while less kyphotic than that of IS of a younger age. It correlates with age, thoracic kyphosis and some global sagittal alignment parameters. These findings suggest that CS alignment is likely a component of the global sagittal alignment strongly affected by thoracic kyphosis, and most probably does not affect HRQL by itself.

112. MASTERS-D: ONE-YEAR FOLLOW UP OF A PROSPECTIVE MULTICENTER OBSERVATIONAL DATA-MONITORED STUDY OF MINIMALLY INVASIVE FUSION TO TREAT DEGENERATIVE LUMBAR DISORDERS

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Summary: This study presents one year effectiveness and generalizability of minimally invasive posterior lumbar interbody fusion (MILIF) through a posterior approach for the treatment of degenerative lumbar disorders (DLD) in a prospective multi-center observational data-monitored trial.

Introduction: This study presents the 12 months outcome of a multicenter prospective observational study on Minimally Invasive Fusion (MILIF) for Degenerative Lumbar Disorders (DLD) (NCT01143324).

Methods: Nineteen centers distributed in 14 countries treated 252 patients, 83% of the patients underwent 1-level (1L) and 17% 2-level (2L) MILIF (TLIF: 95%;PLIF: 5%) for the treatment of leg pain (52%), back pain (39%) or claudication (9%) due to DLD (including spondylolisthesis (53%), stenosis (71%), and/or disc pathology (94%)). A minimum of 30 MILIF cases were a prerequisite for surgeons to participate in the study.Patient demographics, intra-operative data, complications, time to first ambulation and to study-defined recovery, surgical duration, blood loss, fluoroscopy time and adverse events

(AEs), patient outcome scores (VAS back and leg, ODI, EQ-5D) were assessed pre-op and at study-defined times through 12m post-op.
Results: Ninety nine percent (249/252) of patients were available at 4w and 93% (233/252) at 12m. Of the 1L surgeries, 91% occurred at L4-5 or L5-S1, 74% of the 2L surgeries were at L4-S1. Fusion rates were: 90.8% in 1L and 90.7% for 2L. Mean surgical duration, blood loss, fluoro-time were 128 vs. 182 mins, 164 vs 233 ml, and 115 vs. 154 secs in 1L and 2L cases, respectively. The mean time to first ambulation, and study-defined recovery were, respectively: 1.3 and 3.2 days. All patient outcomes improved significantly ($p<.0001$) between pre-op;4w;12m: VAS back 6.2;2.9;2.9, VAS leg 5.9;2.5;2.2, ODI% 45.5;34.5;22.4, EQ-VAS 52.9;65.4;71.0, EQ-5D index 0.34;0.61;0.71. There was a constant improvement of EQ-5D subscales and pain medication reduction to 12m. Thirty nine patients (15.5%) presented 50 AEs, attributed to surgery, approach, or device, 9 of which were considered serious. Three AEs were attributed to the minimally invasive approach (1 serious). No deep surgical site infection was detected and 7 additional surgeries occurred (4 adjacent, 3 at target level) .
Conclusion: This is the first and largest international, prospective, multicenter monitored observational study of MILIF to date. Our study shows early favorable clinical patient outcomes in MILIF, with sustained improvement and low major peri-operative morbidity.

113. EFFECT OF SUPERIOR ADJACENT SEGMENT DEGENERATION AFTER LUMBAR POSTEROLATERAL FUSION USING TWO DIFFERENT PEDICLE SCREW INSERTION POSITIONS WITH NINE-YEAR MINIMUM FOLLOW UP

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Summary: This prospective randomized study was to test the hypothesis that different pedicle screw insertion positions would increase the likelihood of superior adjacent segment degeneration (ASD). The position of the pedicle screw farther from the facet joint surface can reduce the degeneration of superior adjacent segment.
Introduction: Lumbar fusion surgery is a widely accepted treatment for lumbar diseases, such as lumbar stenosis, trauma, tumor and spondylolisthesis. Fusion and clinical success rates have increased due to improvements in instrumentation and bone graft material. In contrast, numerous complications and problems of fusion surgery have been reported, with ASD being one of the most important.
Methods: This prospective study included 210 patients with low-grade isthmic spondylolisthesis (IS). From January 1999 to December 2003, patients were randomized underwent posterolateral fusion (PLF) using two different pedicle screw insertion positions. The patients were followed up postoperatively and were assessed with regard to radiological and clinical outcomes. Radiologic outcomes were assessed mainly on the basis of disc degeneration, facet joint degeneration and bone fusion. Clinical outcomes were evaluated mainly with use of visual analog scale (VAS) for pain and the Oswestry Disability Index (ODI).
Results: 178 of 210 (84.7%) patients were available for at least 9-year radiological and clinical follow-up data: 85.3% (87/102) patients in Group A and 84.3% (91/108) patients in Group B. At the last follow-up, bone fusion was achieved in all patients. ASD was proven in 110 (61.8%) of 178 patients. The incidences of radiographic and symptomatic ASD were 57.9% (103/178) and 3.9% (7/178), respectively. The incidence of ASD in Group B was significantly lower than Group A. Results of clinical outcomes showed lower VAS and ODI scores in two groups compared with those preoperative, but Group B had greater improvement on the ODI scores compared with Group A in patients with ASD.
Conclusion: The degeneration of superior adjacent segment is closely related to the position of the pedicle screws during lumbar fusion surgery. The position of the pedicle screw farther from the facet joint surface can reduce the degeneration of superior adjacent segment.

114. RISK FACTORS FOR RE-OPERATION IN PATIENTS TREATED SURGICALLY FOR DEGENERATIVE SPONDYLOLISTHESIS: A SUBANALYSIS OF THE EIGHT-YEAR DATA FROM THE SPORT TRIAL

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Summary: A retrospective subgroup analysis was performed on surgically treated patients from the degenerative spondylolisthsis (DS) arm of the Spine Patient Outcomes Research Trial (SPORT), randomized and observational cohorts. Our study hypothesis was that specific patient baseline characteristics would be risk factors for re-operation. Analysis revealed a 22% incidence of re-operation eight years following initial surgery, 54% occurring within the first two years. Risk factors for undergoing a re-operation were identified as history of neurogenic claudication and taking antidepressants.
Introduction: Surgery for DS is common with good clinical outcomes. Several high quality studies have examined outcomes following DS surgery, but few have identified risk factors for re-operation. Our study hypothesis was that certain patient characteristics are risk factors for re-operation.
Methods: A retrospective subgroup analysis was performed on surgically treated patients enrolled in the DS arm of the multicenter SPORT trial, randomized and observational cohorts. Included patients had neurogenic claudication for at least 12 weeks, clinical neurological signs, spinal stenosis, and DS on standing lateral x-rays. In our subgroup analysis, patients were stratified into no re-op vs. re-op. Baseline characteristics were analyzed using multivariate regression from patient data 8 years post-op. A Cox regression model Stepwise Method was implemented in SAS with $p=0.10$ significant for entry and $p=0.05$ significant for retention with calculation of hazard ratios (HR).
Results: Of the 406 patients, 73% underwent instrumented fusion, 21% non-instrumented fusion, and 6% decompression alone. At 8 years, the re-op rate was 22%, with 25 (28%) occurring within one year, 49 (54%) within 2 years, 64 (70%) within 4 years, and 78 (86%) within 6 years. 41 revisions (10%) were for progressive DS, 33 (8%) for complication or other reason, and 13 (3%) for new condition. Patients with a higher risk for re-op were more likely to be on antidepressants ($p=0.008$, HR 2.08) or have pseudoclaudication ($p=0.02$, HR 1.82). Patients of older age, smokers, diabetics, obese, or on workman's compensation did not have a greater risk for re-operation, Table.

Conclusion: The incidence of re-operation for patients with DS was 22% at 8 years following initial surgery, 54% occurring within 2 years. Patients with a history of neurogenic claudication and patients taking antidepressants were approximately 1.8 and 2 times as likely to undergo re-operation. Smoking, obesity, diabetes, older age, and workman's compensation were not associated with a higher risk of re-operation.

Table: Risk factors. p=0.5 being significant levels of entry and stay

Step	Effect Entered	Effect Removed	DF	Number In Model	Score Chi-Sq	Prob Chi-Sq
1	Antidepressants		1	1	7.03	0.008
2	Psuedoclaudication		1	2	5.44	0.0197
3	Sat_symp		1	3	3.6	0.0579
4	Instrumented fusion		1	4	4.26	0.039
5	PT		1	5	4.81	0.0283
6	NSAID		1	6	3.02	0.0823
7	Age		1	7	3.55	0.0594
8	Sciatica Bothersome Index		1	8	2.13	0.1441
9	Pain radiating		1	9	2.41	0.1208
10	Race		1	10	1.81	0.1781
11	Guess SNO		1	11	1.99	0.1587
12	Injection		1	12	1.84	0.1744
13	Hypertension		1	13	1.36	0.244
14	BMI		1	14	1.4	0.2368
15	Heart disease		1	15	1.48	0.2235
16	BP primary back pain		1	16	0.93	0.3356
17	Guess SSU		1	17	0.57	0.4492
18	PF		1	18	0.48	0.49
19	Opioids		1	19	0.47	0.49

115. EVOKED ELECTROMYOGRAPHY (EMG) THROUGHOUT RETRACTION TO MONITOR NERVE INTEGRITY DURING THE MINIMALLY INVASIVE LATERAL TRANSPSOAS INTERBODY FUSION: PRELIMINARY RESULTS FROM A PROSPECTIVE, MULTICENTER STUDY

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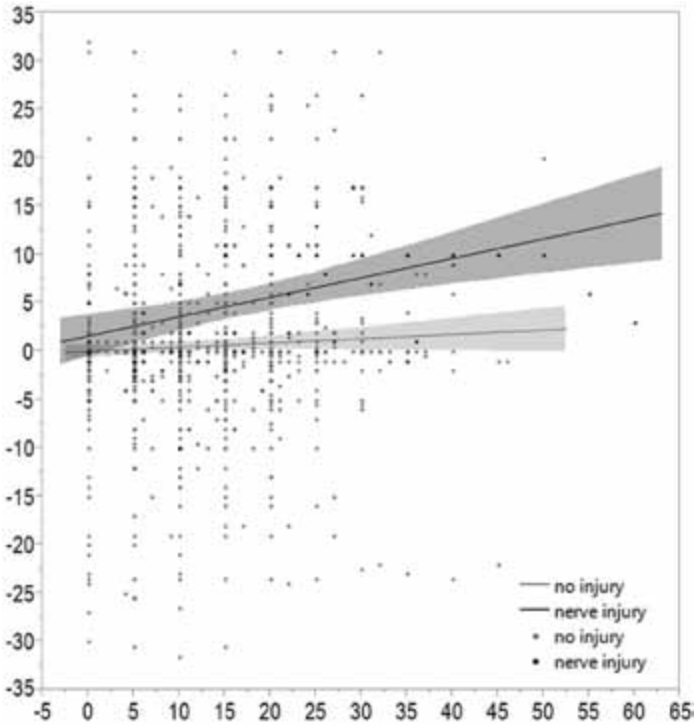
USA

Summary: Prolonged retraction time and increasing evoked EMG thresholds throughout retraction may be predictors of declining nerve integrity in minimally invasive lateral transpsoas interbody fusion.
Introduction: Nerve retraction and compression have been shown to induce neuropraxia. It has been hypothesized that serial evoked EMG from an insulated but electrified retractor may effectively monitor nerve integrity during the retraction phase of lateral approaches to the spine, with threshold increases potentially indicating a decline in nerve integrity. This study evaluates the utility of evoked EMG throughout the entirety of the lateral approach to predict post-op changes in motor function.
Methods: 318 patients from 21 sites undergoing L4-5 minimally invasive lateral transpsoas interbody fusion were enrolled in this prospective, multi-center study. Pre-and post-op lower-extremity motor function were collected to identify new post-op motor neuropraxia (MN). Initial EMG threshold from the stimulated retractor, threshold values every 5 minutes throughout retraction time, and retraction size in the anterior/posterior (AP) and cranial/caudal (CC) directions were collected.
Results: At post-op 4.6% patients had a new symptomatic distal MN on the approach side. Retraction time was significantly longer in patients with a corresponding MN (32 vs. 23 min, p=0.031). There were no significant differences between patients with/without a corresponding post-op MN and initial center-blade reading (p=0.600), CC retraction (p=0.551) or AP retraction (p=0.419).
There was a significant positive relationship between presence of post-op nerve injury and total retraction time (p<0.001), and change in center-blade reading over time (p<0.001). Figure 1 depicts change in initial center-blade threshold readings over time for patients with/without new symptomatic post-op MN.
Conclusion: These results provide evidence that prolonged retraction time and increasing evoked EMG thresholds throughout retraction are predictors of declining nerve integrity.
In addition to a careful approach with evoked EMG, monitoring evoked EMG readings throughout retraction and limiting retraction time may prove effective for reducing the incidence of post-op MN. Of note, average CC retractor aperture was < 9mm in patients with and without neuropraxia. While these results do not imply that retraction aperture is directly related to post-op neuropraxia, the authors caution that wide retractor openings are not recommended.



116. EFFECT OF TERIPARATIDE ON POSTERIOR LUMBAR INTERBODY FUSION IN PATIENTS WITH OSTEOPOROSIS

Keung Nyun Kim
Republic of Korea

Summary: This study was performed to evaluate the efficacy of teriparatide for posterior lumbar interbody fusion (PLIF) in patients with osteoporosis prospectively. There was no significant improvement in overall fusion rate and clinical outcome in lumbar interbody fusion of women with osteoporosis after injection of teriparatide. But the teriparatide group showed fast bony union and high BMD score.

Introduction: Teriparatide has already been approved as a treatment for severe osteoporosis. Teriparatide accelerated the bone fusion and reduced pedicle screw loosening in lumbar posterolateral fusion in women with osteoporosis. But no clinical study has not been reported yet in posterior lumbar interbody fusion(PLIF) cases. This study was performed to evaluate the efficacy of teriparatide for posterior lumbar interbody fusion (PLIF) in patients with osteoporosis prospectively
Methods: Forty-five patients who underwent PLIF and diagnosed the osteoporosis by bone marrow density between March 2010 and October 2011. The teriparatide group(n=25) was injected the teriparatide 20μg subcutaneously daily for 3 month cycles alternating with 3 months periods administration of bisphosphonate orally weekly. The bisphosphonate group(n=20) was administrated the oral risendronate sodium 30mg or sodium alendronate 91.37mg per weekly during minimal 1 year. The mean follow-up period was 30.1±6 months (range, 24 - 38 months). Patients were evaluated the radiographic examination at 1, 3, 6, 12 and 24 months after surgery, and CT was performed at 12 months follow-up visit. BDM evaluation was performed at 12 and 24 months follow-up visit.
Results: The teriparatide group showed earlier fusion than the bisphosphonate group. Average period of bone fusion was 5.8±5.0 months in the teriparatide group, but 10.0±7.5 months in the bisphosphonate group. The bone fusion rate in teriparatide group was higher than bisphosphonate at 6 months (p=0.016). But there was no difference in both groups at postoperative 12 and 24 months. ODI score was not significantly different between both groups. Bone mineral density(BMD) in teriparatide group significantly improved than bisphosphonate group at postoperative 2 years (p=0.020).
Conclusion: There was no significant improvement in overall fusion rate and clinical outcome in lumbar interbody fusion of women with osteoporosis after injection of teriparatide. But the teriparatide group showed fast bony union and high BMD score.

117. IMPACT OF SURGICAL APPROACH ON CLINICAL OUTCOMES IN THE TREATMENT OF LUMBAR PSEUDARTHROSIS

Roger K. Owens, MD; Mladen Djurasovic, MD; Charles H. Crawford, MD; Steven D. Glassman, MD; John R. Dimar, II, MD; Leah Y. Carreon, MD, MSc
USA

Summary: In this study of 134 patients with pseudarthosis, revision surgery resulted in poor to modest improvement; with only 17-28% of patients reaching MCID for ODI regardless of surgical approach. This further emphasizes the importance of achieving a solid fusion with the index surgery.
Introduction: Pseudarthrosis following lumbar fusion for degenerative conditions of the lumbar spine remains a significant problem. Although rates of non-union following fusion vary, current data appears clear that patients who develop a pseudarthrosis have sub-optimal outcomes. This study aimed to examine if treatment of pseudarthrosis can be affected by surgical approach.
Methods: We reviewed the inpatient medical records of 134 randomly selected patients (63 females, 65 males; mean age 50.37) who were treated for non-union following lumbar fusion. Sixty patients underwent posterolateral fusion (PSF), 18 underwent PSF with transforaminal interbody fusion (TLIF), 32 underwent anterior and posterior spinal fusion (AP) and 24 underwent anterior lumbar interbody fusion (ALIF) from 2002 to 2010. Preoperative and two-year postoperative patient reported outcomes were examined.
Results: Significant differences between the treatment groups were observed in length of stay (P=0.000), estimated blood loss (P=0.000) and operating room time (P=0.000). In the AP fusion group, minimal clinically important difference (MCID) was reached in 47% of patients for back pain, 28% for leg pain and 28% for ODI. PSF had the highest percentage of patients reaching MCID for SF-36 physical composite score (PCS) at 25%. ALIF and TLIF subgroups reached MCID for ODI 17% of patients. Linear regression analysis showed that even after controlling for factors such as age, gender and body mass index, the type of surgical approach did not impact the change in ODI scores.
Conclusion: Although this was not statistically significant, the AP fusion group reached MCID more frequently in all outcomes except SF-36 PCS. All surgical approaches examined for treatment of lumbar pseudarthrosis resulted in only poor to modest improvement in ODI with 17-28% of patients reaching MCID for ODI. This further emphasizes the importance of achieving a solid fusion with the index surgery.

118. LIFE QUALITY IMPROVEMENT AND PATIENT SATISFACTION AFTER INSTRUMENTED LUMBAR FUSION IN THE ELDERLY COMPARED WITH YOUNG POPULATION

Felix Tome-Bermejo, MD, PhD; Luis Alvarez; Angel R. Pinera, MD; Carmen Duran; Belen Lopez-San Roman
Spain

Summary: This retrospective review compares the clinical outcomes of 127 patients younger than 65 years old , with 67 patients older than 75 who underwent a posterolateral lumbar fusion.
Introduction: The value of lumbar spine fusion in elderly patients is not well documented. As most of the literature regarding lumbar fusion in older patients has focused on the prevalence of complications, the purpose of this study was to determine the clinical outcomes for older compared with younger patients undergoing lumbar arthrodesis.
Methods: This retrospective review with 194 patients who underwent a single or double level lumbar fusion. Outcome measure included VAS, ODI, and COMI questionnaires, as well as X-ray assessment of fusion. The patients were divided into two groups: 127 patients younger than 65 years and 67 patients who were 75 years of age or older. Outcome measures were evaluated on the basis of the mean change and the percentage of patients reaching a minimum clinically important difference threshold. .
Results: The mean age in the younger group was 47 and 77,8 in the elderly group. Substantial improvements from baseline were noted in all of the clinical and health-related quality-of-life measures. The mean improvements in the ODI score at 2 year postoperatively were 30 points for the younger patients and 31,6 points for the older patients. The older patients also demonstrated a similar improvement in the VAS scale for back and leg pain at all time intervals. For the 2nd and 3rd item of the COMI, older population demonstrate greater improvement (p<0,001 and p=0,056 respectively). The proportion of patients who were satisfied with their operations was similar in both groups (72.4% and 76,2%, respectively) (p = 0.3956). Perioperative

complications, although an obvious concerns, did not appear to adversely affect clinical and health-related quality-of-life outcomes at one year postoperatively.
Conclusion: This study demonstrates a substantial benefit for patients seventy-five years of age or older with an spinal instability who are treated with a lumbar decompression and instrumented fusion. We conclude that age itself cannot be considered a contraindication for appropriately selected patients.

119. THE RADIOGRAPHIC ANALYSIS OF THE INDIRECT DECOMPRESSION AFTER ANTERIOR LUMBAR INTERBODY FUSION (ALIF) OR DIRECT LATERAL INTERBODY FUSION (DLIF)

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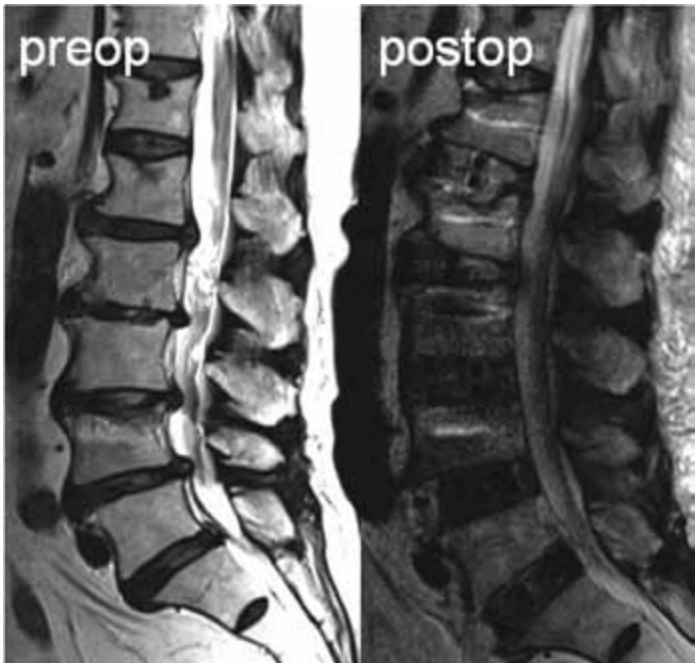
Republic of Korea

Summary: This study aims to investigate the indirect decompression effect of neural canals after ALIF (anterior lumbar interbody fusion) or DLIF (direct lateral interbody fusion) procedures. The results showed significant improvements postoperatively in terms of disc height, segmental angle, cross-sectional area (CSA) of dural sac, AP diameter of dural sac in mid-sagittal MR plane and the foraminal area. However, central stenosis with dural sac CSA of less than 65mm2 could not reach 100mm2 of dural sac CSA after anterior-alone surgery.
Introduction: ALIF/DLIF have the decompression effect, namely "indirect decompression", which means spinal canal and foramina can be enlarged by distraction of the disc space without laminectomy. This study was designed to evaluate the radiographic results of the indirect decompression after ALIF or DLIF for the treatment of lumbar stenosis.
Methods: 30 patients (62 levels) with lumbar spinal stenosis underwent ALIF or DLIF procedure. The mean operated level per patient was 2.1. L1-2 level was operated in 2 cases (DLIF), L2-3 in 8 cases (DLIF), L3-4 level in 14 cases (DLIF), L4-5 level in 22 cases(17 DLIF, 5 ALIF), L5-S1 in 16 cases (ALIF). All patients undertook the MRI preoperatively and before discharge postoperatively. Below parameters were compared preoperatively and postoperatively using plane radiographs and MR images: disc height (anterior/posterior/mean), segmental angle, cross-sectional area (CSA) of dural sac, antero-posterior (AP) diameter of dural sac in mid-sagittal MR plane, the area of foramen.
Results: All parameters were significantly increased postoperatively ($p<0.001$, paired t-test). There was no significant difference in the change of the CSA of dural sac between ALIF and DLIF group ($p=0.542$, independent t-test). However, the postoperative disc height and postoperative segmental angle differed significantly between ALIF and DLIF group (17.3mm vs. 15.0mm, $p=0.002$; 19.9° vs. 10.5°, $p<0.001$). There were 19 levels that could not reach 100mm2 of dural sac CSA after surgery. Their mean CSA of dural sac was 49.3mm2 preoperatively and 69.3mm2 postoperatively. The postoperative CSA of dural sac can be estimated by linear regression model using the preoperative CSA of dural sac (Y=30.14 + 1.08X, R2=0.771). Using this equation, the preoperative dural sac CSA of a minimum 65 mm2 is required to achieve the postoperative dural sac CSA of more than 100 mm2.
Conclusion: There were significant improvement postoperatively in terms of disc height, segmental angle, CSA of dural sac, AP diameter of dural sac in mid-sagittal MR plane, and the area of foramen after ALIF or DLIF. Central stenosis with dural sac CSA of less than 65mm2 may require additional posterior decompression.



120. DEGENERATIVE SPONDYLOLISTHESIS VERSUS SPINAL STENOSIS: AS-TREATED ANALYSIS OF THE SPINE PATIENT OUTCOMES RESEARCH TRIAL

En Xie, PhD, MD; Yu Sheng Dou
China

Summary: To compare baseline characteristics and surgical and nonoperative outcomes between degenerative spondylolisthesis (DS) and Isthmic spondylolisthesis (IS) patients.Comparison of Baseline Characteristics and Outcomes.
Introduction: DS and IS patients are often combined in clinical studies despite differences in underlying pathology and treatment.
Methods: The DS cohort included 2471 patients (1721 [69.7%] underwent surgery), and the IS cohort included 1737 patients (1177[67.7%] underwent surgery). Baseline characteristics were compared between the 2 groups. Changes from baseline for surgical and nonoperative outcomes were compared at 1 and 2 years using longitudinal regression models. Primary outcome measures included the SF-36 bodily pain and physical function scores and the Oswestry Disability Index.
Results: The DS patients included more females (67% vs. 39%, $P < 0.001$) and were older (61.1 year vs. 52.6 years, $P = 0.021$) compared with the IS patients. There were no significant baseline differences on any of the main outcome measures. DS patients undergoing surgery were much more likely to be fused than IS patients (77% vs. 17%, $P < 0.001$) and improved more with surgery than IS patients on all primary outcome measures (DS vs. IS): physical function (+37.7 vs. +21.1, $P< 0.05$ at 1 year; + 37.3 vs. +20.7, $P < 0.001$ at 2 years), bodily pain (+32.7 vs. +21.7, $P < 0.05$ at 1 year; +32.7 vs. +27.1, P

< 0.05 at 2 years), and Oswestry Disability Index (–27.1 vs. –22.1, P < 0.001 at 1 year; –26.7 vs. –21.3, P < 0.001 at 2 years). Patients treated nonoperatively improved less than those treated surgically, and there were no significant differences in nonoperative outcomes between the 2 cohorts.

Conclusion: Overall, DS and IS patients had similar baseline characteristics. DS patients improved more with surgery than IS patients.

121. DRASTIC REDUCTION WITH ONE-LEVEL FUSION IN TREATMENT OF HIGH-GRADE L5 SPONDYLOLISTHESIS CAN RESTORE GLOBAL SPINOPELVIC ALIGNMENT

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Japan

Summary: We report surgical outcomes of high-grade spondylolisthesis in 13 patients who underwent one-level surgical reduction and fusion between 2006 and 2011. Spondylolisthesis of L5 and lumbosacral kyphosis results in abnormal sacro-pelvic orientation as well as global sagittal imbalance of the spine. Nearly complete surgical reduction of L5 slippage with restoration of lumbosacral lordosis allows to restore not only local sacro-pelvic alignment but also global spinopelvic alignment and balance.

Introduction: In high-grade spondylolisthesis, it has been demonstrated that the presence of a local lumbosacral deformity, L5 slippage and lumbosacral kyphosis, results in an abnormal sacro-pelvic orientation as well as global sagittal imbalance of the spine. In our institute, we conducted one-level posterior fusion with complete reduction of L5 slippage with restoration of lumbosacral lordosis in treatment of high-grade spondylolisthesis of L5. The purpose of this study was to assess the improvement in the sagittal spinopelvic alignment after surgical reduction.

Methods: Thirteen consecutive patients with high-grade spondylolisthesis (F:10, M:3) underwent corrective surgery. Following radiographic parameters were measured: slip angle (SA), %slip, sacral slope (SS), pelvic tilt (PT), pelvic incidence (PI), thoracic kyphosis (TK), lumbar lordosis (LL1-5: L1-5) and the sagittal vertical axis (SVA).

Results: A mean follow up period was 4 years (2-8). An average age at surgery was 38 years. A mean SA and %slip improved from 15.3° to -4.9° and from 51.0% to 4.8%, respectively. A mean PI was 74.1° in these high-grade spondylolisthesis patients, which exceeded normal range. Mean preoperative SS, PT, TK, LL1-5 and SVA were 48.0°, 26.1°, 12.9°, 63.9° and 25.8mm, respectively. Mean final SS, PT, TK, LL1-5 and SVA were 56.3°, 17.8°, 24.5°, 53.3° and 4.3mm, respectively. No major complications including L5 nerve root palsy were noted.

Conclusion: Morphological characteristics of sacro-pelvic component in high-grade spondylolisthesis were high PI that is mainly due to large SS. Increased SS accelerate slippage of L5 that can bring about global sagittal imbalance. However, SVA in the patients with high-grade L5 spondylolisthesis was generally maintained by following compensatory mechanisms: retroversion of the pelvis, increased lumbar lordosis, and decreased thoracic kyphosis. Such non-physiological postures worsened patients QOL. Drastic reduction of L5 slippage by corrective surgery with one-level PSF allowed to restore spinopelvic alignment that means decrease PT, LL1-5, and increase TK. We believe that nealy complete reduction is essential for normalization of global spinopelvic alignment for high-grade L5 spondylolisthesis.

122. CLINICAL OUTCOMES TEN YEARS AFTER LUMBAR FUSION FOR DEGENERATIVE SPONDYLOLISTHESIS

Andrew J. Cordiale, DO; Leah Y. Carreon, MD, MSc; Erin L. Adams, BS; Kelly R. Bratcher, RN, CCRP; Steven D. Glassman, MD
USA

Summary: In a cohort of patients who underwent instrumented lumbar fusion for degenerative spondylolisthesis, a significant improvement in clinical outcomes was seen ten years after surgery. One-third of patients required revision surgery for adjacent segment disease or nonunion an average of 3.6 years after the index surgery. Patients who had revision surgery showed less improvement than the patients that did not have revision surgery.

Introduction: Several studies report improved function and decreased pain and disability in patients who have undergone instrumented fusion for degenerative spondylolisthesis, but none have reported data at ten years after surgery.

Methods: Patients with complete preoperative and ten-year postoperative outcomes data following one- or two-level posterolateral lumbar fusion for degenerative spondylolisthesis were identified from a clinical database. Outcomes included the ODI, SF-36 PCS, SF-36 MCS and numeric rating scales (0-10) for Back and Leg pain. Standard demographic, surgical and clinical outcomes data were collected through telephone interviews and medical chart reviews. Data on additional surgeries and interventions after the index surgery were collected. T-tests were used to compare preoperative and ten-year postoperative outcome measures. A sub-analysis comparing patients who had revision surgery to those who did not was also performed.

Results: Sixty-seven patients were included in the analysis, with a mean age of 59.7 ± 14.0 years at the time of surgery. There were 44 females and 23 males. There was a statistically significant improvement in all outcome scores from pre-op to ten years post-op for ODI (49.3 to 32.9, p<0.0001), SF-36 PCS (31.9 to 39.0, p<0.0001), SF-36 MCS (42.1 to 49.2, p=0.004), Back pain (7.5 to 4.4, p<0.0001), and Leg pain (7.4 to 4.4, p<0.0001). Twenty of 67 patients (30%) had revision surgery an average of 3.6 years after the index surgery (range, 1 to 11 years); ten for adjacent segment disease (ASD), five for nonunion and five for both ASD and nonunion. Patients who had revision surgery had less improvement in their outcome scores compared to those who did not, but none of these differences, except leg pain score, reached statistical significance: ODI 14.2 vs 17.4, p=0.515; SF-36 PCS 1.9 vs 9.3, p=0.066; SF-36 MCS 5.7 vs 7.8, p=0.723; Back pain 2.6 vs 3.4, p=0.427 and Leg pain 1.1 vs 3.9, p=0.021.

Conclusion: In this cohort, there was significant improvement in clinical outcomes ten years after lumbar fusion for symptomatic spondylolisthesis. One-third of patients required revision surgery for adjacent segment disease or nonunion; these patients showed less improvement than the patients who did not have revision surgery.

123. SPINO-PELVIC ALIGNMENT FOLLOWING SURGICAL CORRECTION DEVELOPMENTAL SPONDYLOLISTHESIS USING A STANDARDIZED REDUCTION TECHNIQUE: A PROSPECTIVE STUDY

Jesse Shen; Hubert Labelle, MD; Jean-Marc Mac-Thiong, MD, PhD; Julie Joncas, BSc; Stefan Parent, MD, PhD
Canada

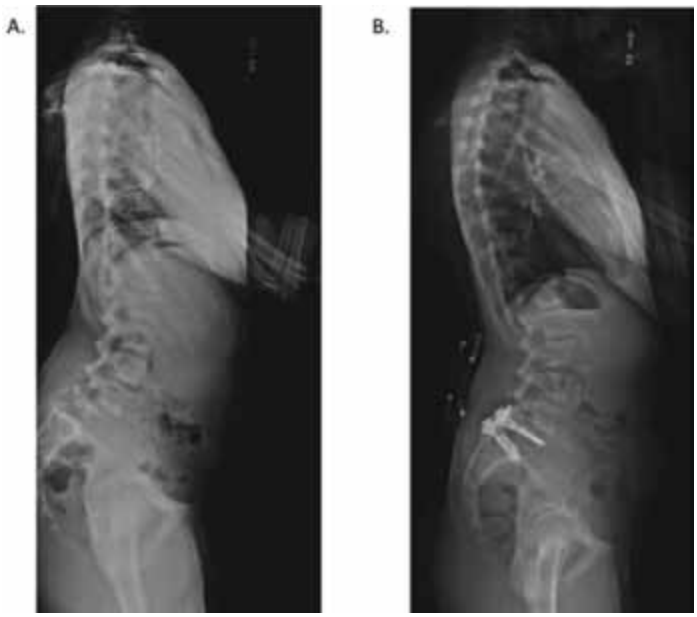
Summary: This is a prospective analysis of spino-pelvic sagittal alignment of 22 patients following surgical correction for L5-S1 developmental spondylolisthesis using a standardized technique. The results showed an improvement in surgical outcomes scores and an improvement in pelvic balance for most patients with an unbalanced pelvis pre-operatively.

Introduction: This is a prospective single-center analysis of changes in spino-pelvic sagittal alignment after surgical correction of L5-S1 developmental spondylolisthesis. Surgical reduction of L5-S1 spondylolisthesis remains a controversial subject because the indications of this treatment and its effect on spino-pelvic alignment remains poorly defined. Recent evidence indicates that reduction might be indicated for patients with an unbalanced or retroverted pelvis.

Methods: This is a prospective single-center case series analysis of 22 patients (mean age of 15 ± 1.7 years) with developmental spondylolisthesis who were treated with surgery using a standardized technique. All patients in the study had at least two years follow-up after surgery. Spinal and pelvic alignment was measured on standing lateral digitized radiographs using dedicated computer software. SRS-30 and SF-12 scores were also analyzed.

Results: In this study cohort, 12 patients were noted to have high-grade spondylolisthesis and 10 patients with low-grade spondylolisthesis after measuring standing lateral radiographs. After subdividing the high-grade spondylolisthesis group into balanced (mean sacral slope of 57.2 ± 6.9 and pelvic tilt of 26.2 ± 4.2) and unbalanced (mean sacral slope of 44.0 ± 5.9 and pelvic tilt of 34.2 ± 9.7), an improvement was noted in pelvic alignment as 83% (5 out of 6 patients) of unbalanced patients switched to a balanced pelvis post-operatively. No patient in this cohort switched from a balanced pelvis to an unbalanced pelvis post-operatively. All patients were seen to have improvements in both SRS-30 and SF-12 scores post-operatively.

Conclusion: The results of this study emphasize the importance of sub-dividing patients with spondylolisthesis based on severity or grade of deformity and pelvic balance. The results suggest that patients with an unbalanced pelvis may have an improvement in their pelvic balance after undergoing surgery. This study also suggests that these patients have surgical outcome scores that are similar or better than patients with balanced pelvis. Therefore, this study supports the contention that reduction techniques might be considered for high-grade spondylolisthesis patients with an unbalanced pelvis.



A. Pre-operative unbalanced High-grade spondylolisthesis B. Post-operative balanced spondylolisthesis.

124. A PROSPECTIVE TRIAL COMPARING L4L5 INSTRUMENTED POSTEROLATERAL FUSION FOR DEGENERATIVE SPONDYLOLISTHESIS PERFORMED WITH LOCAL BONE GRAFT ALONE VERSUS POSTERIOR ILIAC CREST GRAFT AND LOCAL BONE VERSUS BETA TRICALCIUM PHOSPHATE AND LOCAL BONE GRAFT

Saumyajit Basu, MD; Gaurav R. Dhakal, MS(orth)
India

Summary: This is a prospective randomized controlled clinical study comparing the radiological evidence of posterolateral fusion (for low grade degenerative L4/5 spondylolisthesis with stenosis) with Iliac Crest Bone Graft (ICBG), Local Bone(LB) and Beta Tri-calcium Phosphate(BTCP). The results were independently assessed (using Lenke grades) through a 64-slice CT scan done after a minimum follow-up of 2 years. Dense fusion mass is maximally appreciated in the ICBG group but there is no difference between the other two -- there was no pseudoarhrosis.

Introduction: There are studies evaluating the clinical efficacy of the three types of bone grafts (ICBG, LB, BTCP) used for instrumented posterolateral fusions for low grade degenerative spondylolisthesis. Purely radiological studies are fewer and 2 year follow-up CT scan evaluation studies are not there. We studied the radiological denseness of the fusion mass by a prospective randomized controlled clinical study involving the three types of bone graft materials.

Methods: Between Jan 2008 and September 2010, 30 patients (male =12,female=16) with degenerative low grade spondylolisthesis at L4L5 with stenosis randomly underwent decompressive laminectomy and single level instrumented posterolateral fusion with either of the three graft materials. Each group consisted of 10 patients and all were followed for a minimum of two years after which a CT scan was done to evaluate the status of the fusion mass. Lenke et al.,classification was used to grade the fusion mass.

Results: At the end of two years, no pseudoarthrosis was observed in either of the three groups. In the local bone (LB) graft group;5 patients

(50%) had definite fusion (Lenke A) and 50% had a probable solid fusion mass(Lenke B). 9 patients (90.0%) in the iliac crest group had a Lenke A fusion while 1 patient (10.0%) had a Lenke B fusion. In the beta tri-calcium phosphate group;6 patients (60.0%) had a Lenke A fusion while 4 patients (40.0%) had Lenke B fusion mass.
Conclusion: Although iliac crest bone graft continues to remain as the gold standard in fusion procedures, its usage is limited by the donor site morbidity. However, the chance of radiologically demonstrable dense fusion mass is enhanced with the usage of iliac crest graft. Further, there seems to be no significant advantage using beta tri-calcium phosphate as far as the quality of fusion mass is concerned when compared to local bone graft in single level instrumented posterolateral fusion.

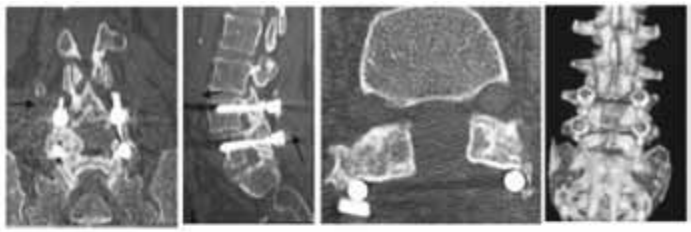


Figure 1. Lenke A fusion mass with the use of ICBG. The arrows depict the solid continuous fusion mass.

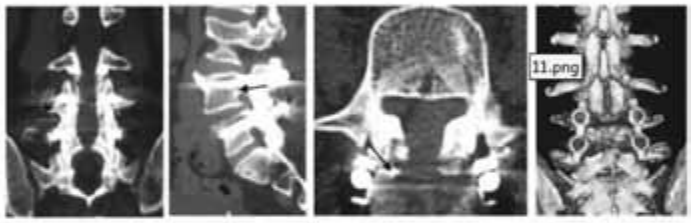


Figure 2. CT scan sections showing Lenke A fusion mass with beta TCP and local bone graft. The arrows point to the continuous solid fusion mass.

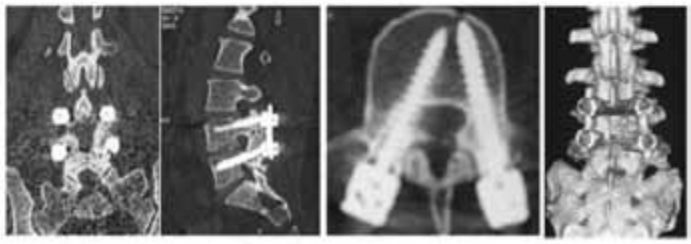


Figure 3. CT scan sections showing Lenke B fusion mass with local bone only. The arrow in the coronal section points to the unilateral small fusion mass.

125. SAGITTAL SPINOPELVIC PARAMETERS IN PATIENTS WITH DEGENERATIVE LUMBAR SPONDYLOLISTHESIS

Chang Ju Hwang, MD, PhD; Won Kyeong Kim; Dong-Ho Lee, MD, PhD; Jung-Ki Ha; Mi Young Lee; So Jung Yoon; Choon Sung Lee, MD, PhD
Republic of Korea

Summary: We compared various sagittal spinopelvic parameters and cross sectional area ratio of lumbar extensor musculature between patients with or without degenerative lumbar spondylolisthesis (DLS). In all sagittal spinopelvic parameters, no significant difference was found between non-DLS group and DLS group. CSA ratio is significantly smaller in DLS group than in non-DLS group. Contrary to the results of previous studies, a high PI may not be a predisposing factor in developing DLS.

Introduction: Although gross sagittal imbalance is rarely associated with degenerative lumbar spondylolisthesis (DLS), a few studies recently suggested that a high pelvic incidence may be a predisposing factor in the pathogenesis of DLS. The purpose of this study is to compare various sagittal spinopelvic parameters between patients with or without DLS.
Methods: We retrospectively reviewed 165 patients who underwent surgery for low back and/or radicular pain. Patients were divided into two groups: the patients without DLS (non-DLS group; n=85) and the patients with DLS (DLS group; n=80). Following parameters were measured in preoperative standing whole spine radiographs: pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), lumbar lordosis (LL), thoracic kyphosis (TK), positioning of C7 plumb line, and segmental lordosis at each segment. In magnetic resonance imaging of lumbar spine, cross sectional area (CSA) ratio (paraspinal muscles : disc) at L4-5 level was measured in order to identify the influence of lumbar musculature on sagittal balance.
Results: In all sagittal spinopelvic parameters, no significant difference was found between non-DLS group and DLS group. Mean PI value of DLS group (56.4 degrees) was almost similar to that of non-DLS group (57.5 degrees). CSA ratio is significantly smaller in DLS group than in non-DLS group ($p < 0.05$).
Conclusion: This study showed that sagittal spinopelvic alignment was not different between patients with and without DLS. Contrary to the results of previous studies, a high PI may not be a predisposing factor in developing DLS. Although patients with DLS were characterized by smaller CSA ratio at L4-5 level than patients without DLS, it is inconclusive whether atrophy of back extensor muscles play a role in the pathogenesis of DLS.

126. FINE-TUNED SURGICAL PLANNING IN ADULT SPINAL DEFORMITY: DETERMINING THE LUMBAR LORDOSIS NECESSARY BY ACCOUNTING FOR BOTH THORACIC KYPHOSIS AND PELVIC INCIDENCE

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Summary: Pragmatic estimations of lumbar lordosis (LL) have been proposed based upon pelvic incidence (PI): PI-LL<10. However, the applicability of this relationship remains limited in the setting of abnormal thoracic kyphosis (TK). A multi-linear regression analysis on 509 operative (OP) and non-operative (NonOP) patients with adult spinal deformity (ASD), accounts for abnormal thoracic kyphosis providing a new, simple formula for the PI & LL spino-pelvic relationship: LL=(PI+TK)/2+10. This model was then validated on 409 patients who underwent a 3-column osteotomy (3CO).
Introduction: Reaching ideal spino-pelvic alignment requires harmony between sagittal curvatures and PI. While pragmatic estimations of LL have been proposed based upon PI, their applicability remains limited in the setting of abnormal TK. The

objective of this study was to establish and validate a new simplified formula of spinal alignment which accounts for abnormal TK.
Methods: Formula development based on a retrospective review of a multi-center prospective database of OP and NonOP ASD patients with 1y follow-up and optimal spino-pelvic alignment: pelvic tilt (PT) and T1 spino-pelvic inclination (T1SPI) within 2 standard deviations of published normative values. Multi-linear regression was used to predict LL based on PI and TK. The validity of the model was then tested on multicenter database of patients after 3CO.
Results: Of 509 patients with 1y follow-up, 42% had posterior global alignment, 31% anterior malalignment, and 27% (n=137) optimal spino-pelvic alignment and were retained for analysis. Among this group, analysis of PI-LL distribution showed 60% had a LL within 10° of PI, and patients with PI-LL<-10° had a smaller PI (43° vs 55°, p<0.001) and larger TK (50° vs 35°, p<0.001). Low PI patients required LL in excess of PI, and large PI required lower LL. For TK values within normative values, PI-LL offered adequate estimation of ideal global alignment. Regression analysis revealed PI and TK had similar impact on LL (p<0.001, r2>0.55) and lead to the following equation of optimal lordosis: LL=(PI+TK)/2+10. Validation of the predictive formula on 409 patients revealed when post-op LL was within 10° of optimal, 85% and 92% of patients reached an optimal PT and T1SPI respectively, and 77% reached an optimal alignment in both.
Conclusion: While the reported simplified alignment formula of LL~PI remains useful for patients with TK values within normal range, abnormal TK requires a modified formula. This study reports an improved, simple and validated formula to estimate optimal regional alignment requirements in the thoracic and lumbar region to achieve global optimal alignment.

127. POSTERIOR SURGICAL CORRECTION WITH OR WITHOUT INTERBODY IN MATCHED CURVES PROVIDES SIMILAR CORRECTION IN ADULT SPINAL DEFORMITY

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Summary: Deformity matched cohort of 56 ASD patients with Posterior Interbody (PI) or Posterior Only (PO) surgical correction. Baseline demographics and health related quality of life measures (HRQOL) are similar. At 2 years, radiographic correction and HRQOL are significantly improved in both groups, and radiographic improvement, final correction and fusion rates are similar. Intra-operative complications and EBL are higher for PI group, however revision for rod fracture is higher in the PO group at 2 years.
Introduction: Multiple options exist for surgical correction of adult spinal deformity. The choice of surgical procedure is often based upon surgeon preference, patient profile and curve pattern.
Methods: Prospective, multicenter database. Inclusion criteria age>18, adult spinal deformity, no prior fusion surgery, >4 levels fused, fusion to sacrum, complete radiographic and HRQOL outcomes, min 2yr follow-up. Complications were defined as minor or major per previously published criteria. Health related quality of life measures were determined for each patient for baseline, one and two years. Outcome measures included Oswestry Disability Index (ODI), SF36, and SRS-22. Posterior approaches were propensity matched for Posterior Interbody (PI) and Posterior Only (PO) based on baseline SVA, PI-LL mismatch and PT by using linear regression.
Results: 56 patients met inclusion criteria and were matched; PI (28) and PO (28). Baseline demographics were similar for age (65 vs 63), BMI, co-morbidity, SVA (73 vs 63mm), PT (23 vs 23), LL (34 vs 38) and PI-LL (18 vs 18); P>0.05. Baseline HRQOL measures similar for both groups, except for SF-36 mental (45 vs 37; p=0.03), and SRS-appearance (2.4 vs 2.1; p=.04). At 1 and 2 years HRQL improved significantly for each group, and there is no difference between groups. Radiographic improvement, 1yr and 2yr measures were all similar. Total EBL was greater for PI (2823 vs 1782cc; p=.014), with similar OR time and hospital stay. More Smith-Peterson Ostotomies were performed in PI group (3.2 vs 1.9 per pt; p=.005), with similar rate of PSO, and BMP dose and frequency. Intra operative major complications occurred more often in the PI group (25% vs 4%; p=.02). There was no difference in posterior fusion grade, however by 2 years more revision surgery occurred for implant complications in PO (5 vs 1) for late rod fracture (3 vs 1).
Conclusion: The addition of interbody to posterior deformity correction does not significantly improve radiographic parameters, HRQOL or fusion grade at 2 years. However, implant related complications were higher in the posterior only group, and were related to rod fracture.

128. IMPACT OF OBESITY ON COMPLICATIONS AND PATIENT-REPORTED OUTCOMES IN ADULT SPINAL DEFORMITY SURGERY

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Summary: This study looks at the impact of obesity on complications and HRQOL in adult spinal deformity surgery. Obese patients had a higher relative risk of overall complications, major complications, and wound infection. Despite increased complications, they did benefit from ASD surgery, as demonstrated by an improvement on HRQOL scores, although the benefit was less than that of non obese patients.
Introduction: Adult spinal deformity (ASD) surgery is known for its high complication rate. This study examines the impact of obesity on complication rates and patient-reported outcomes in operatively treated ASD patients.
Methods: Retrospective review of a multicenter prospective database of ASD patients treated surgically. Obesity was defined as BMI ≥30. Outcomes included complications (total, minor, major, implant-related, radiographic, infection, revision, and neurologic injury), blood loss (EBL), operative time, length of stay (LOS), and patient reported

questionnaires (VAS back / leg pain, ODI, SF-36, LSDI, SRS). The impact of obesity was studied using multivariate poisson, linear, or logistic regression modeling. Models accounted for confounders, as determined by univariate analysis.
Results: 395 patients were identified (284 non-obese, 112 obese), with 2-yr follow up on 225 patients. Regression models showed that obesity increased the risk of overall complications (IRR 1.28, p=0.01), major complications (IRR 1.57, p=0.005), and wound infection (OR 4.74, p=0.006). Absolute weight, but not BMI, increased the incidence of implant-related complications (weight : IRR 1.12 per 10kg increase in weight p=0.05, BMI p=0.69) Obesity did not increase the number of minor complications (p=0.33), radiographic complications (p=0.75), neurologic complications (p=0.48) or need for revision surgery (p=0.74). Obesity was not significantly associated with OR time (p=0.15), LOS (p=0.9) or EBL(p=0.38).Both groups experienced significant improvement over time, as measured on the ODI (p=0.0001), SF36 (p=0.0001), and SRS (p=0.0001). However, the overall improvement was less for obese patients (SRS p=0.02, ODI p=0.003, SF36 p=0.001). They also had a lower rate of improvement over time (SRS p=0.008, ODI p=0.0001 SF36 p=0.0001).
Conclusion: This study reveals that obese patients have an increased risk of complications following ASD correction. Despite increased complications, obese patients do benefit from ASD surgery, however their improvement in HRQOL is less than that of non-obese patients.

129. HIGH POST-OPERATIVE C2-7 SVA IS ASSOCIATED WITH PROXIMAL JUNCTIONAL KYPHOSIS

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Summary: Cervical Sagittal decompensation measured by high C2-7 SVA is associated with PJK even when other aspects of the spine such as Pelvic Tilt, Lumbar Lordosis and T1 Slope were not significantly different between those with PJK and without PJK.
Introduction: Cervical sagittal alignment parameters and their association with PJK has not been clearly delineated in Adult Spinal Deformity (ASD) patients.
Methods: A prospective multicenter database of operative ASD patients were analyzed. Inclusion criteria were patients >18 years old meeting one of the following criteria: Coronal Cobb >20 degrees, C7-S1 Sagittal Vertical Axis (SVA) >5cm, Pelvic Tilt (PT) >25 degrees or Thoracic Kyphosis (TK) >60 degrees AND who underwent primary surgery, ≥5 Levels with a Lower Instrumented Vertebrae (LIV) of the Sacrum/Ilium were included. Revision cases were excluded. Patients were then separated into those with PJK (Group P) and those without PJK (Group N). Cervical Sagittal Radiographic parameters collected included C2-7 SVA, Cervical Lordosis (CL) and T1 Slope (T1S). Comparisons were made at baseline, 6-week post-op and 1 year post-op. Statistical Analysis was performed with a Fischer Exact T-Test for continuous variables with a p-value <0.05 as significant.
Results: Of the 448 patients in the database, 239 met inclusion criteria for the study and 190 had complete radiographic data for analysis. The incidence of PJK was 30% (57/190). All demographics, except for age were similar between groups (62.6 vs. 60.3 Group P vs. N, p =0.02) Group P had similar baseline cervical sagittal alignment parameters compared to Group N (Table 1). However, post-operatively, Group P demonstrated a higher C2-7 SVA and a significantly greater pre and post-op C2-7 SVA difference while maintaining similar T1S-CL values. Other radiographic risk factors that reached significance at 6 weeks and 1 year post-operatively in the PJK group were a higher C2-T1-vertical angle. Pelvic Tilt (PT) and Lumbar Lordosis (LL) were not significantly different at any timepoint. SRS and ODI scores were similar at 2 year follow up (SRS 3.8 vs. 3.6, p=0.19, ODI 25.2 vs. 29.1, p=0.37)
Conclusion: Patients with PJK have higher C2-7 SVAs as well as higher pre and post-op differences in C2-7 SVA while maintaining similar T1S, T1S-CL, LL and PT. Further study on the factors that drive high C2-7 SVA will be important in understanding PJK.

130. ADVERSE EVENTS HAVE LIMITED IMPACT ON CLINICAL OUTCOME FOLLOWING SURGERY FOR ADULT SPINAL DEFORMITY

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Summary: At 2 year minimum follow up after thoracolumbar fusion for adult deformity, the occurrence of a major complication was not associated with significant differences in change from baseline of HRQL scores, and patient satisfaction, was not affected by the presence of major or minor complications.
Introduction: Complications following spinal fusion for adult deformity continue to be of concern to patients and surgeons. The impact of complications on self-reported patient outcomes remains incompletely understood. This study assessed the effect of peri-operative complications on HRQoL measures at minimum 2 year follow up.
Methods: A prospective multicenter cohort of 256 adult patients undergoing thoracolumbar fusion for adult spinal deformity was retrospectively analyzed. Complications were subdivided as any (major + minor), major, minor, or none. Impact of complications on change from baseline for Scoliosis Research Society-22 questionnaire (SRS-22) subscales and total score, Visual Analogue Scale (VAS) back and leg pain scores, Oswestry Disability Index (ODI), and 36-Item Short Form Health Survey (SF36) MCS and PCS scores were assessed at 2 year minimum followup.
Results: There were 171 complications consisting of 97 (57%) major and 74 (43%) minor among 256 patients at 2-year follow-up. There was no significant difference in change from baseline for ODI (mean Δ -13.7 vs -15.8, p=0.4), PCS (mean Δ 6.55 vs 6.82, p=0.2), and SRS total (mean Δ 0.75 vs. 0.75, p=0.2) in the major complication group compared to patients with no complication. Change from baseline was significantly impacted by the presence of any complication only for SRS-Activity (mean Δ 0.49 vs 0.55, p=0.03), and SRS-Mental

(mean Δ 0.29 vs 0.39, p=0.03). Minor complications also led to a significant difference in change in SRS-Mental (mean Δ 0.23 vs 0.56, p=0.03). SRS-satisfaction scores were not significantly affected by the presence of a major or minor complication.
Conclusion: At 2 years, the occurrence of a major complication was not associated with significant differences in change from baseline of HRQL scores. There were significant differences in overall change in SRS activity and mental subscores in patients experiencing any complication, and in SRS mental subscore in patients with minor complications. Overall patient satisfaction was not significantly affected by the presence of major or minor complications.

131. PERIOPERATIVE COMPLICATIONS DO NOT AFFECT PATIENT SATISFACTION FOLLOWING ADULT SPINAL DEFORMITY SURGERY

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Summary: Patients undergoing thoracolumbar fusion for adult deformity have increased satisfaction with treatment over pre-operative state by 6 weeks post-operatively and maintain similar levels of satisfaction out to 2 years post-operatively regardless of the occurrence of perioperative complications.
Introduction: Patient satisfaction after adult spinal deformity surgery remains incompletely assessed compared to radiographic and clinical outcomes. We are not aware of reports of impact of complications on patient satisfaction with surgery over their course of recovery. The goal of this study was to evaluate the change in patient satisfaction after adult thoracolumbar deformity surgery in patients experiencing perioperative complications.
Methods: A prospective multicenter cohort of 256 adult patients undergoing thoracolumbar fusion for adult spinal deformity was analyzed retrospectively at minimum 2 year follow-up. Complications were defined as any (major + minor), no, major or minor. Clinical satisfaction was assessed using Scoliosis Research Society-22-(SRS-22) satisfaction scores (SAT), which allows a comparison to satisfaction with preoperative treatment. Comparisons in SAT were made at 6 weeks, 1 year, and 2 year follow up for patients experiencing any, no, minor, or major complications.
Results: 112 (44%) patients experienced a complication (58 major and 54 minor) within the first six weeks after surgery. For patients with no, minor, and major complications, there was significant improvement in SRS-satisfaction compared to baseline at 6 weeks, 1 year and 2 years ($p<0.0001$ for all groups). There was no significant change in patient satisfaction from 6 weeks to 2 years for any group (p=0.337 any complication, p=0.306 major, p=0.7406 minor). There was no difference in satisfaction between patients with any, no, minor, or major complication at any post-operative time point. (Figure 1)
Conclusion: Patients undergoing thoracolumbar fusion for adult deformity express increased satisfaction with treatment over pre-operative state by 6 weeks post-operatively and maintain similar levels of satisfaction out to 2 years post-operatively. Occurrence of perioperative complications does not seem to have substantial effects on overall patient satisfaction. Determinants of patient satisfaction may be related to other factors, such as pre-operative expectations, inpatient experience and relationship with surgeon.

132. THE EFFECT OF ANTIFIBRINOLYTIC THERAPY ON COMPLICATIONS, BLOOD PRODUCT UTILIZATION, AND FUSION IN ADULT SPINAL DEFORMITY

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Summary: This study looks at the use of antifibrinolytic therapy (AF) in adult spinal deformity surgery. It shows that AF therapy was associated with decreased blood product utilization, and decreased major perioperative complications.
Introduction: Antifibrinolytic therapy (AF) has been shown to be effective in preventing blood loss in some settings. Its effect on major and minor perioperative complications, blood product utilization, vascular events and postoperative fusion in patients undergoing adult spinal deformity (ASD) surgery remains unclear.
Methods: A multicenter prospective consecutive database of surgical ASD patients was reviewed. All patients with data on AF use were included. Parameters of blood product utilization included transfusion rates, and units of PRBCs and FFP transfused. Thromboembolic events included stroke, DVT, and PE. Multivariate logistic, ordinal logistic, or poisson regression, was used as appropriate, accounting for confounders.
Results: 403 patients were included. 137 patients received Aminocaproic Acid (ACA), 81 received Tranexamic Acid (TXA), and 185 received no AF. The use of AF was associated with a decrease in transfusion (ACA OR 0.38 p=0.043, TXA 0.31 p=0.047), a decrease in the number of units of PRBCs transfused (ACA IRR 0.45 p=0.0005, TXA IRR 0.7 p=0.0005), and a decrease in the number of FFP transfused (ACA IRR 0.65 p=0.003, TXA IRR 0.67 p=0.006). The use of AF was associated with an increase in minor intra-operative complications (ACA IRR 2.15 p=0.008, TXA IRR 2.12 p=0.011). The use of TXA (but not ACA) was associated with a decrease the incidence of major peri-operative complications compared to no AF (IRR 0.37, p=0.019). AF use was not associated with an increase in thromboembolic events. The use of AF did not impact the fusion rates at 2 years.
Conclusion: The use of TXA or ACA was associated with increased minor intra-operative complications. TXA was associated with decreased major perioperative complications. AF was associated with decreased utilization of blood products without an increased rate of thromboembolic events. Given the nature of this study, transfusion threshold was not standardized across the study sites. Future studies with rigid criteria for transfusion should be prospectively performed to better evaluate impact of AF in the setting of surgery for ASD.

133. HAVING A REGULAR DOCTOR PREVENTS LATE REFERRALS FOR AIS

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Summary: Health care pathways upstream of initial consultation in orthopaedics were documented in 831 consecutive patients referred for suspected adolescent idiopathic scoliosis in absence of a screening program. Having access to a regular source of care, facilitating scoliosis detection and the patient's journey through the health system, led to a significantly reduced likelihood of being referred late to orthopaedics (OR=0.32 [0.17-0.59]). Continuity of care is an effective strategy to prevent late referral and management of adolescent idiopathic scoliosis as opposed to numerous uncoordinated consultations.

Introduction: In communities lacking screening programs for Adolescent Idiopathic Scoliosis (AIS), we expect a great diversity of health care pathways upstream of initial consultation in orthopaedics as well as non optimal timing of patient referral. The objectives of this study were: 1) to characterize the health care pathways of children with suspected AIS in a community without a screening program; 2) to investigate the relationships between these health care pathways and the appropriateness of referral to specialized orthopaedic clinics.

Methods: The 831 consecutive children referred for an initial visit for suspected AIS in all five out-patient paediatric orthopaedic clinics of South-West Québec (Canada) were characterized according to criteria of appropriateness of referral to orthopaedics as Inappropriate, Appropriate or Late. Parents were interviewed in order to document health care use prior to the orthopaedic consultation. Characterization of the health care pathways was done by constructing a taxonomy using multiple correspondence analyses prior to hierarchic classification techniques. Associations between the health care pathways and the appropriateness of referral were assessed by multinomial regression analyses.

Results: We constructed a taxonomy of five distinct health care pathways: 1- Continuous involvement of the Regular source of care, 2- Lay detection & later involvement of the Regular source of care, 3- Detection by other medical doctor, 4- Detection by other health care professional, 5- Lay detection & Consultation discontinuity. Lay persons played an important role in AIS detection (53% of cases) but did not prevent late referrals. Continuity of care, as opposed to numerous uncoordinated consultations, was an effective strategy to prevent late referrals (OR=0.32 [0.17-0.59]) although related to an increased probability of inappropriate referrals.

Conclusion: The results emphasize the importance of continuity of involvement of a regular source of care with the patient to facilitate AIS detection and the patient's journey through the healthcare system. This suggests interventions such as advocating for access to a regular source of care for each adolescent and translating knowledge on AIS management.

134. UNPLANNED HOSPITAL READMISSIONS FOLLOWING PEDIATRIC SPINAL FUSION SURGERY: RATE AND ASSOCIATED FACTORS

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Summary: Our aim was to investigate the rate and causes of unplanned readmissions after pediatric spinal fusion surgery, and to investigate the association of patient and surgical characteristics with readmission. We reviewed the clinical records of 861 children with spinal fusion surgeries performed by a single surgeon from 2000 through 2009.The rate of 90-day unplanned readmission after pediatric spinal fusion surgery is 7%, and it varies by patient diagnosis, number of levels fused and intraoperative blood loss.

Introduction: Our aim was to investigate the rate and causes of unplanned readmissions after pediatric spinal fusion surgery, and to investigate the association of patient and surgical characteristics with readmission.

Methods: We reviewed the clinical records of all children with spinal fusion surgeries performed by a single surgeon from 2000 through 2009. Patients were excluded if: age≥ 18 years at surgery, fusion spanned <5 vertebral levels, or growing rod instrumentation was used. Unplanned readmission was defined as: inpatient hospitalization within 90 days of index surgery due to a complication of surgery. Readmissions for staged surgery or unrelated medical problem were not considered unplanned readmissions. 861 patients (average age: 14±2.7 years) met the inclusion criteria.

Results: The rate of 90-day unplanned readmission after pediatric spinal fusion surgery was 7.7%. The unplanned reoperation rate was 4.4%. Time elapsed between initial discharge and readmission was 28±18 days.

The most frequent causes of readmission were: superficial wound infections/wound breakdown in 30 patients (3.5%), deep wound infections in 8 patients (0.9%), instrumentation failure in 8 patients (0.9%), other medical complications in 8 patients (0.9%), neurological complications in 6 patients (0.7%), and pulmonary complications in 6 patients (0.7%). Of the 66 unplanned readmissions, 58% required operative management and 42% were treated with medical management alone.

There was a significant variability in readmission rate by patient diagnosis (P<0.01): AIS 3.8%; Scheuermann's kyphosis 6.7%; genetic and syndromic scoliosis 9.2%; cerebral palsy 13.5%; and other neuromuscular causes of scoliosis 14.8%. There was a significant difference in readmission rate by: number of levels fused (13.7 vs. 12.3, P<0.01) and intraoperative blood loss (1.8L vs. 1.3 L, P<0.01). There was no significant difference by age and surgical approach (posterior vs. anterior-posterior).

Conclusion: The rate of 90-day unplanned readmission after pediatric spinal fusion surgery is 7%, and it varies by patient diagnosis, number of levels fused and intraoperative blood loss. These factors may be of consideration in the postoperative management of children receiving spinal fusion.

135. SPINAL VELOCITY PROVIDES MORE ACCURATE ASSESSMENT OF CURVE PROGRESSION THAN HEIGHT VELOCITY IN PROGRESSIVE FEMALE IDIOPATHIC SCOLIOSIS

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Summary: The height velocity (HV) is traditionally utilized to provide information of the longitudinal linear growth potential and subsequently to guide the design of treatment strategy. The existence of distal-to-proximal growth gradient in adolescents, however, has made scoliosis surgeons wonder whether spinal growth velocity provides superior information to height velocity for predicting the likelihood of significant curve progression in progressive scoliosis patients.
Introduction: To calculate the spinal velocity (SV) and peak spinal velocity (PSV) in progressive idiopathic scoliosis (IS) girls and subsequently to analyze their value of utilization in the assessment of curve progression.
Methods: Pre-pubertal IS girls receiving standardized brace treatment and being followed up regularly were retrospectively reviewed, while only those with main curve progression of 5° or more during brace treatment were finally enrolled in this analysis. During the follow-up, the following data were collected and recorded: chronologic age, standing height, Cobb angle of the main curve, spinal length and Risser sign. The HV, SV and angle velocity (AV) of each visit were calculated. Peak height velocity (PHV) and PSV of the whole follow-up period were identified subsequently by construction of growth velocity curves. Multiple linear regression analysis was used to analyze the contributions of each maturity assessments to AV, while logistic regression model was constructed to identify the high risk factors of AV more than 5° per year.
Results: Thirty IS girls were included in this study. Correlation was found between SV and HV (r=0.314, P=0.001). AV was significantly correlated with SV (r=0.414, P<0.001) and HV (r=0.275, P=0.005), respectively. The multiple linear regression analysis showed that AV was influenced by SV (B=0.199, P=0.001) instead of HV (B=0.187, P=0.354). The logistic regression analysis demonstrated that PSV (OR=5.052, p=0.001) rather than PHV (OR=1.979, p=0.144) was the high risk indicator for the occurrence of AV more than 5° per year.
Conclusion: Variations of curve progressive velocity were influenced more directly by SV rather than HV, and congruously onset of PSV were endowed with high risk of the occurrence of AV more than 5° per year in progressive IS girls, indicating the high clinical value of measurement of spinal growth in the treatment of idiopathic scoliosis.

136. A NEW CLASSIFICATION SYSTEM OF SPINAL CORD FUNCTION FOR GUIDING SURGICAL STRATEGIES OF SEVERE SPINAL DEFORMITY

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Summary: in this study, 172 severe spinal deformity correction cases were retrospected, and a new classification system of spinal cord function for guiding surgical strategies of severe spinal deformity were concluded.

Introduction: The Frankel classification grading system for spinal cord injury, which divides patients into five grades, fails to group all patients precisely. The aim of this study was to assess a new grading system of spinal cord function for patients with spinal deformity.
Methods: A total of 172 patients with severe spinal deformity who were treated surgically at our hospital from January 2008 to April 2013 were included in this retrospective study. Based on the neurophysiological monitoring, MRI and neurological symptoms, the patients were categorized into three groups: group A, normal spinal cord and evoked potentials and no neurological symptoms; group B, spinal cord malformity and/or abnormal evoked potentials but no neurological symptoms; group C, neurological symptoms with or without spinal cord malformity/abnormal evoked potentials. The primary outcome variables were scoliosis and kyphosis correction rates, intraoperative blood loss, operative time, intraoperative changes in evoked potentials, postoperative neurological complication, and types of osteotomy. Analysis of variance (ANOVA) and planned comparison were used for statistical analysis.
Results: There were 105 (61%) patients in group A, 41 (24%) in group B, and 26 (15%) in group C. There were significant differences across the three groups in scoliosis correction rate (P<0.001), kyphosis correction rate (p<0.001), operative time (p=0.046), intraoperative changes in evoked potentials (p<0.01), postoperative neurological complication (p<0.001), and types of osteotomy (p<0.001). The rate of Patients postoperative neurological complication among three groups have significant difference: group A < group B < group C .
Conclusion: This new classification system should be useful for guiding surgical decisions in treating patients with severe spinal deformity.

137. DOES PLANNED STAGING FOR POSTERIOR-ONLY VERTEBRAL COLUMN RESECTIONS IN SPINAL DEFORMITY SURGERY INCREASE PERIOPERATIVE COMPLICATIONS?

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USA

Summary: In a consecutive series of 183 VCRs, 44 were planned two-stage posterior-only (2-PoVCR) procedures. Propensity-matching was used to compare 35 2-PoVCRs to single-stage VCRs with no difference in complication rate. In addition, binary logistic regression analysis was performed and suggested that age and BMI influenced the occurrence of a complication, although not clinically significant. Overall, propensity matching and binary logistic regression demonstrate that staging posterior-only VCRs does not lead to increased complications.
Introduction: A vertebral column resection (VCR) for severe spinal deformity is a technically challenging and lengthy procedure with a potentially high complication rate. Planned staging has the advantage of distributing operative time into 2 shorter more manageable intervals. The goal of this study was to compare the perioperative complication rates between single- and 2-stage posterior-only VCRs (2-PoVCR).

Methods: Adult and pediatric spinal deformity patients undergoing a VCR were retrospectively identified from a single institution's surgical database from 1985 to 2013. Propensity scoring was used to match single-staged and 2-PoVCR patients. Each group was matched for preoperative risk factors including: age, sex, BMI, preop PFTs, number of fusion levels, revision surgery, preop radiographic parameters (major coronal Cobb, coronal balance, sagittal balance, and max kyphosis), neurologic status (none, weakness, myelopathy, or paraplegia), diagnosis (angular kyphosis (AK), global kyphosis (GK), kyphoscoliosis (KS), or severe scoliosis (SS)), and VCR region (thoracic (T), thoracolumbar (TL), or lumbar (L). Perioperative complications were defined as occurring within 2 months of initial surgery. Additionally, a binary logistic regression analysis was performed with complications as the outcome.
Results: 183 consecutive patients were identified as undergoing a VCR with 172 meeting the inclusion criteria (posterior-only). 44 patients underwent planned 2-PoVCR while 124 had a single-staged VCR. Consistent with propensity-matching, no statistically significant difference between the single- and 2-PoVCR cohorts existed for all matching parameters, except PFTs. There was no significant difference ($p = 0.290$) between complication rates for single-stage (12/35; 34%) and 2-PoVCR (8/35; 23%). Stepwise binary logistic regression analysis showed that age ($p = 0.014$; OR 0.94 CI 0.89-0.99) and BMI ($p = 0.030$; OR 1.13 CI 1.01-1.26) influenced the occurrence of a complication. However, the confidence intervals nearly include 1, suggesting these are not clinically significant.
Conclusion: Planned staging of posterior-only VCRs does not increase the occurrence of perioperative complications in adult and pediatric spinal deformity patients.

138. IS AGE ASSOCIATED WITH INCREASED COMPLICATIONS RATES IN CERVICAL SPINE SURGERY? A REVIEW OF 11,765 CASES FROM THE SCOLIOSIS RESEARCH SOCIETY DATABASE 2004-2007

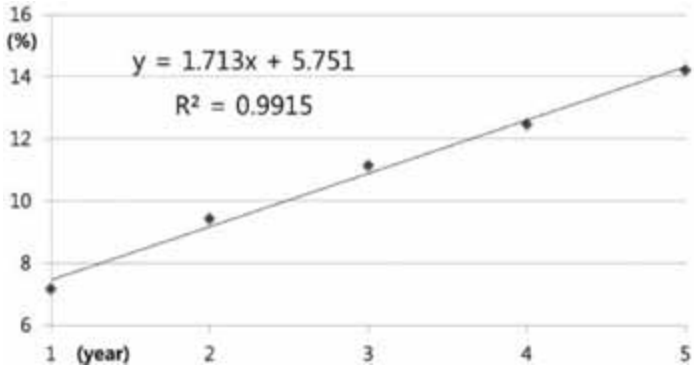
Branko Skovrlj, MD; Samuel K. Cho, MD; Motasem Al Maaieh; John Caridi, MD; Yongjung J. Kim, MD; K. Daniel Riew, MD
USA

Summary: Patients who experienced complications, including death, following cervical spine surgery for degenerative conditions were significantly older than those without complications.
Introduction: Increasing life expectancy and advances in medical sciences have led to more aggressive treatments being offered to the elderly including spine surgery. A few studies have identified advanced age as a risk factor to develop complications following spine surgery. However, these reports are often limited by relatively small number of study subjects.
Methods: The Scoliosis Research Society Morbidity and Mortality database was queried for all cervical spine surgeries from 2004-2007. Patient demographics, diagnoses, and complications were analyzes. Two-tailed t-test and chi-square test were performed.
Results: Of 11,765 patients, 427 (3.63%) had complications. Patients with complications were 4.4 years older (55.7 vs. 51.3 years, $p<0.001$). Mortality rate was 0.16%. Patients who died were 14.7 years older than those who did not have complications (70.0 vs. 51. 3 years, $p<0.001$). There was a trend toward increasing complication rates with advanced age across all diagnoses. Patients > 60 years with cervical disc herniations were 2.0 times more likely to experience complications ($p=0.03$). Patients with cervical stenosis experiencing complications were significantly older compared to those who did not experience complications (59.2 vs. 56.9 years, $p<0.001$), and those older than 60 were 1.3 times more likely to experience complications ($p=0.05$) Patients with spondylotic radiculopathy with complications were significantly older than those who did not experience complications (55.2 vs. 52.5 years, $p=0.02$).
Conclusion: Advanced age was associated with increased complication rates including mortality following cervical spine surgery. Other factors such as such diagnoses may also influence surgical outcome and merit further investigation.

139. REOPERATION RATE AFTER SURGERY FOR SPINAL STENOSIS WITHOUT SPONDYLOLISTHESIS: A NATION-WIDE COHORT STUDY

Chi Heon Kim, MD, PhD; Chun Kee Chung, MD, PhD
Republic of Korea

Summary: The longitudinal reoperation rate after surgery for spinal stensosi was 4.7% at 3 months, 7.2% at 1 year, 9.4% at 2 years, 11.2% at 3 years, 12.5% at 4 years, and 14.2% at 5 years. Adding fusion surgery was not effective in reducing the reoperation rate.
Introduction: Lumbar spinal stenosis is one of the most common degenerative spine diseases. Surgical options are largely divided into decompression only and decompression with arthrodesis. Recent randomized trials showed that surgery was more effective than non-operative treatment for carefully selected patients with lumbar stenosis. In a previous population-based study, the 10 year reoperation rate was 17%, and fusion surgery was performed in 10% of patients. Recently, the lumbar fusion surgery rate has doubled, and a substantial portion of the reoperations are associated with a fusion procedure. With the change in surgical trends, the longitudinal surgical outcomes of these trends need to be re-evaluated.
Methods: A national health insurance database was used to identify a cohort of patients who underwent an initial surgery for lumbar stenosis without spondylolisthesis in 2003; a total of 11,027 patients were selected. Individual patients were followed for at least 5 years through their encrypted unique resident registration number. After adjusting for confounding factors, the reoperation rates for decompression and fusion surgery were compared. The primary end-point was any type of second lumbar surgery. Cox proportional hazards regression modeling was used to compare the adjusted reoperation rates between decompression and fusion surgery.
Results: Fusion surgery was performed in 20% of patients. The cumulative reoperation rate was 4.7% at 3 months, 7.2% at 1 year, 9.4% at 2 years, 11.2% at 3 years, 12.5% at 4 years, and 14.2% at 5 years. The adjusted reoperation rate was not different between decompression and fusion surgery ($p = 0.82$). The calculated reoperation rate was expected to be 22.9% at 10 years.
Conclusion: Adding fusion surgery was not effective in reducing the reoperation rate. With current surgical trends, the reoperation rate seemed to be higher than in the past, and consideration of this problem is required.



A simple formula for calculating the crude reoperation rate at each time is as follows: reoperation rate = 5.75 + 1.71 x postoperative year (R2=0.99)

140. ALARM POINT OF TRANSCRANIAL ELECTRICAL STIMULATION MOTOR EVOKED POTENTIAL FOR INTRAOPERATIVE SPINAL CORD MONITORING IN PATIENTS WITH PREOPERATIVE PARALYSIS

Sho Kobayashi, PhD; Yukihiro Matsuyama, MD; Shigenori Kawabata, MD, PhD; Muneharu Ando; Zenya Ito; Yasushi Fujiwara; Tsukasa Kanchiku; Akio Muramoto, MD; Kazunobu Kida; Kei Yamada, MD, PhD; Kanichiro Wada; Naoya Yamamoto; Takanori Saito, Professor; Toshikazu Tani, MD
Japan

Summary: This is a retrospective study to investigate alarm point of transcranial electrical stimulation motor evoked potentials (TcMEP) for intraoperative spinal cord monitoring in patients with preoperative paralysis. We observed all true positive patients with preoperative MMT grade of 2 or 3 (moderate paralysis) in whom TcMEP decrease by 80% or more.
Introduction: TcMEP is widely used for intraoperative spinal cord monitoring. But there is no definite alarm point of TcMEP despite so many studies. We report the alarm point of TcMEP for intraoperative spinal cord monitoring in patients with and without preoperative paralysis.
Methods: We performed intraoperative spinal cord monitoring using TcMEP in 1299 cases of scoliosis (n=416), ossification of posterior longitudinal ligament (OPLL) (n=427) or spinal cord tumor (n=456) between 2010 and 2013. A 70% decrease of amplitude was set as alarm point. TcMEP variability and the pre- and postoperative motor deficit were analyzed.
Results: TcMEP yielded 55 true positive cases, 101 false positive cases and 2 false negative cases. Thus Sensitivity was 95%, and specificity was 92%. Fifty five true positive cases included 34 preoperative neurological intact cases and 21 paralysis cases. Forty-nine true positive patients with preoperative MMT grade of 5 or 4 represent TcMEP decrease by 70% or more. We observed all 6 true positive patients with preoperative MMT grade of 2 or 3 (moderate paralysis) in whom TcMEP decrease by 80% or more. In 56 cases amplitudes of TcMEP decreased during surgery, but recovered at final. False negative cases recovered fully from their transient motor deterioration.
Conclusion: The alarm point of a 70% decrease of amplitude achieved higher sensitivity and specificity, however 80% decrease of amplitude were a considerable alarm point of TcMEP in preoperative moderate paralysis patients. We recommend these criteria for intraoperative spinal cord monitoring of scoliosis, OPLL and spinal cord tumor surgery.

141. SEVENTY-TWO PERCENT OF SPINE FUSION PATIENTS HAVE POST-OPERATIVE FEVERS, BUT THE FEVERS ARE NOT CLINICALLY RELEVANT

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USA

Summary: The frequency and clinical significance of postoperative fevers in pediatric patients undergoing posterior spinal fusion (PSF) was investigated. A retrospective review of consecutive cases at a single institution was performed. Seventy two percent (201/278) of patients experienced a postoperative fever (Tmax>38o) and 9% (27/278) Tmax>39o. There was no significant correlation between fever and positive blood culture, urine culture, pneumonia or surgical site infection (SSI) (p=1.00).
Introduction: Prior series suggest there is no association between postoperative fever and infection in the overwhelming majority of pediatric patients undergoing general orthopedic procedures but none have focused on spinal procedures. Our objective was to determine the frequency and clinical significance of postoperative fevers in pediatric patients undergoing posterior spinal fusion (PSF).
Methods: A retrospective review of consecutive patients undergoing PSF at a single institution between 6/2005 and 4/2011 was performed. Patients undergoing PSF with minimum 2 year follow-up were included. Exclusion criteria included previous spine surgery, anterior spine surgery or delayed wound closure.
Results: 278 patients average age 13 years (1-22) met inclusion criteria, with the following diagnosis: adolescent idiopathic scoliosis 43%, neuromuscular/syndromic scoliosis 39%, congenital scoliosis 11%, spondylolisthesis 4%, Scheuermann's kyphosis 3%. Seventy-two percent (201/278) of patients had a Tmax>38o postoperatively, and 9% (27/278) Tmax>39o. The percentage of febrile patients trended down following the first postoperative day (table I). Infection rate was 4% (12/278). There was no correlation between Tmax>38o, Tmax>39o, or timing of fever and positive blood or urine cultures, pneumonia or SSI.
Conclusion: 72% of pediatric patients undergoing posterior spinal fusion experienced postoperative fever Tmax>38o, and 9% of patients had Tmax>39o. There was no significant correlation between fever and positive blood culture, urine culture, pneumonia or SSI. Although the majority of patients undergoing posterior spinal fusion had a postoperative fever, this did not correlate to later development of spine infection.

142. PELVIC DEROTATION FOR CORRECTION OF FIXED SAGITTAL IMBALANCE: A NOVEL TECHNIQUE

Michael D. Kasten, MD; David M. Prior, MD
USA

Summary: Fixed Sagittal Imbalance poses a difficult challenge to the deformity surgeon. Utilizing a new method of correction in addition to

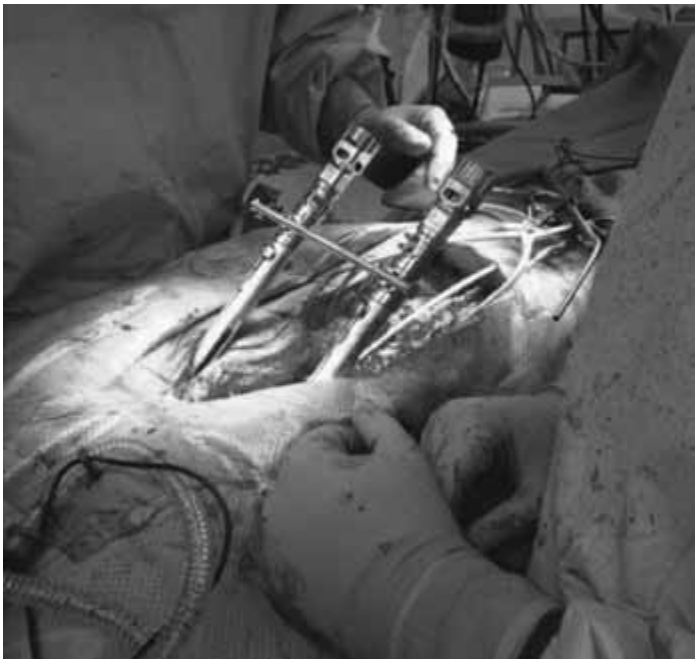
previously established osteotomy techniques, excellent correction can be attained.

Introduction: The results of patients treated for advanced sagittal deformity have been analyzed previously. Postoperative sagittal vertical axis (SVA) less than five centimeters, and lumbar lordosis within ten degrees of pelvic incidence have been found to be markers of a good outcome. Improvement of balance for patients with fixed deformity can be achieved with posterior only approaches. We have devised a technique of anteverting the pelvis during the correction of fixed sagittal imbalance which has dramatically improved the global sagittal profile.

Methods: A new technique has been devised which has allowed one to attempt to antevert the pelvis during the surgical correction of patients with significant sagittal imbalance. This involves attachment of derotational towers directly to large iliac wing bolts prior to final closure of pedicle subtraction osteotomies (PSO) and Smith-Peterson osteotomies (SPO) in the lumbar spine. Large anteversion forces are applied to the derotation towers with increasing lumbar lordosis through the osteotomy sites. The maneuver seems to translate the distal spinal segments more anteriorly and provides greater forces for correction. Three patients with severe fixed sagittal deformity have been treated by a single surgeon utilizing the pelvic derotation technique. Each surgical procedure involved either multiple SPOs or single PSO in the lumbar spine.

Results: Average starting SVA was 23.0 cm positive. This improved to an average of 2.4 cm positive post correction. Lumbar lordosis increased an average of 29.4 degrees after correction.

Conclusion: Preliminary results from this technique demonstrate that powerful anteversion forces applied during closure of corrective osteotomies of the lumbar spine are advantageous in severe sagittal deformity. The use of pelvic derotation is a powerful tool for restoring global spinopelvic balance. To our knowledge, this is the first description of utilizing pelvic derotation for correction of fixed sagittal imbalance, and further exploration of this technique is warranted.



The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

143. HOW DO INDIVIDUALS WITH FUSED SPINAL SEGMENTS FOR ADOLESCENT IDIOPATHIC SCOLIOSIS COMPENSATE FOR THE LOSS OF SPINAL RANGE OF MOTION DURING RUNNING?

Kathy Simpson, PhD; Rumit S. Kakar, PT; Yumeng Li; Yang-Chieh Fu; Marika Walker; Cathleen Brown Crowell, PhD; Timothy S. Oswald, MD
USA

Summary: Spinal fusion for AIS affects little the spinal motion patterns of frontal and sagittal planes during high-effort running. However, the spine twists as one unit in the transverse plane. The axial twisting occurs primarily between the lower trunk and the pelvis in a pattern similar to that of control participants.

Introduction: To better determine what running activities can be prescribed after spinal fusion surgery for adolescent idiopathic scoliosis (SF-AIS), we need to understand typical and SF-AIS spinal motions exhibited during running. Hence, the purpose of the study was to identify potential adaptations of spinal kinematics used during high-effort running by individuals with SF-AIS.

Methods: Participants: 10 SF-AIS (posterior-approach spinal fusion; minimum 1 yr post-op time; moderately physically active) and 10 controls (CON), pair matched for age, mass, height and physical activity level. During treadmill running, SF-AIS ran at speed rated as "hard effort" (15/20 on Borg Scale); matched CON speed was same as SF-AIS speed. Using 7 high-speed cameras, 24 retro-reflective marker locations on the participant were captured. The motion patterns and timing of the peak segmental angles were compared descriptively among the pelvis and 3 trunk segments: upper (UT: C7 to T8), middle (MT: T9 to T12), and lower (LT: L1 to L5) to understand the synchronicity of motions among the trunk and pelvic motions of SF-AIS vs. CON.

Results: CON and SF-AIS tended to show similar sagittal and frontal plane motion patterns, although SF-AIS MT and UT spine moved more as a single unit. The pelvis and LT of both groups also moved as one unit for lateral bending. Both groups also displayed similar interparticipant variations of sagittal and frontal plane motion patterns. These motions likely are similar because the trunk remains upright and, thus, requires little range of motion in these planes. However, for transverse rotations, SF-AIS showed more synchronized rotations between adjacent spinal segments. Axial twisting of the trunk of SF-AIS occurred predominantly between the pelvis and LT in a pattern similar to CON. CON UT and pelvis rotated synchronously in opposite directions, with little twisting occurring in MT.

Conclusion: During running at a high-effort speed, axial spinal rotations for SF-AIS are generated primarily between the LT and pelvis. The clinical and running performance consequences of this reduced axial rotation are not yet known. However, sagittal and frontal plane motions are relatively typical and do not require any compensatory adaptations.

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

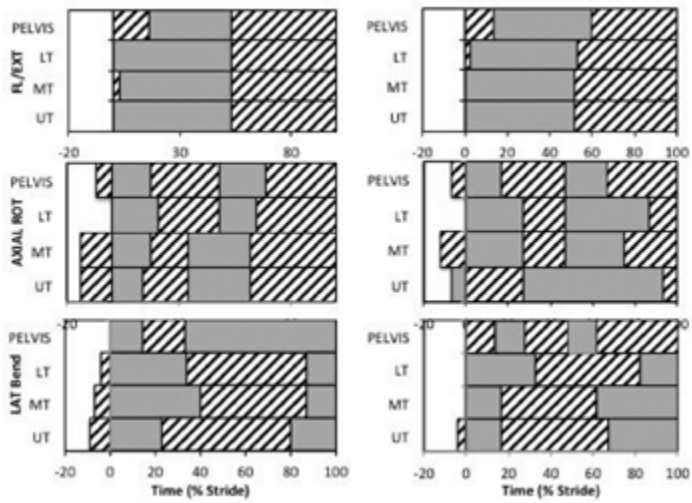


fig 1. Segmental motions: SF-AIS: left; CON: rt; solid = +, hatched = neg. motion.

144. A CONTROLLED ANTERIOR SEQUENTIAL INTERBODY DILATION TECHNIQUE FOR CORRECTION OF CERVICAL KYPHOSIS

Darryl Lau, MD; Rishi Wadhwa, MD; Hai Le; Praveen V. Mummaneni, MD
USA

Summary: We present our technique and results for treatment of cervical kyphosis using anterior sequential interbody dilation. Primary outcomes including kyphosis correction, Nurick scores, complications, fusion status, hospital stay, pain and reoperations were identified. We found a significant correction in cervical alignment, pain and Nurick scores. Patients with severe kyphosis gained a sagittal cobb correction of 24.7 degrees. In summary, the anterior sequential interbody dilation technique is a safe and effective alternative of correcting cervical kyphosis.

Introduction: Cervical kyphosis can lead to spinal instability, cord injury, and disability. The correction of cervical kyphosis is technically challenging, especially in severe cases. We present our technique of anterior sequential interbody dilation in the treatment of cervical kyphosis and evaluate perioperative outcomes, degree of correction, and outcomes.

Methods: From 2006 to 2011, a consecutive cohort of adult patients with cervical kyphosis who underwent sequential interbody dilation was identified. The sequential interbody dilation technique entailed incremental increased interbody distraction with sequential placement of progressively larger spacers in the discectomy and/or corpectomy spaces. Primary outcomes of interest included kyphosis correction, blood loss, hospital stay, complications, Nurick score, pain, fusion status, and reoperation. A subgroup analysis among patients with preoperative kyphosis of 0-9 degrees (mild), 10-19 degrees (moderate), and 20 or greater degrees (severe) was performed.

Results: A total of 100 consecutive patients were included: 74 mild, 19 moderate, and 7 severe. 87% of patients had long-term follow-up. Mean age was 53.1 years and 54.0% were male. Estimated blood loss was 305.6 cc and length of stay was 5.2 days. Overall complication rate was 9.0% and there were no deaths. Only 16.0% underwent supplemental posterior fusion. Mean follow-up was 27.7 months. There were no cases of pseudarthrosis. Reoperation rate was 4.0%. There was significant correction in cervical alignment ($p<0.001$) and mean overall kyphosis correction was 12.4 degrees. At follow-up, there was significant improvement in pain ($p<0.001$), Nurick score ($p=0.037$), and myelopathy ($p=0.002$). Patients with severe kyphosis gained a sagittal cobb correction of 24.7 degrees, those with moderate kyphosis gained 17.8 degrees, and those with mild kyphosis gained 10.1 degrees. A mean maximal sagittal correction of 32.0 degrees was obtained if 5-levels were addressed.

Conclusion: Sequential interbody dilation is a feasible and effective method of correcting cervical kyphosis. Complications and reoperation rates are low. Similar benefits are seen among all severities of cervical kyphosis and greater correction can be achieved in more severe cases.

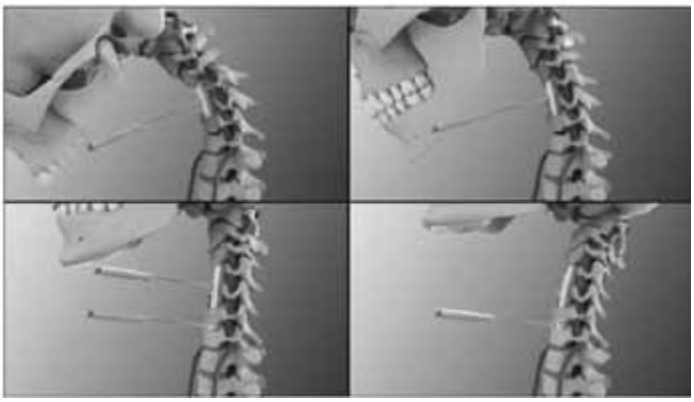


Image showing kyphotic cervical spine and sequential interbody dilation with interbody spacers and correction of kyphosis. (2 level anterior corpectomy and 1 level discectomy with fusion)

145. PARTIAL PEDICLE SUBTRACTION OSTEOTOMY (PPSO): A MODIFICATION FOR PSO IN TREATMENT OF SAGITTAL DEFORMITIES

Ahmed M. Elbadrawi, MD; Mohamed Wafa, MD
Egypt

Summary: Partial Pedicle Subtraction Osteotomy (PPSO) is a new modification of the traditional pedicle subtraction osteotomy , in which we perform partial pedicle osteotomy; preserving the inferior third of the pedicle. This allows more smooth correction of the deformity, minimizes the injury or irritation of the nerve root below this pedicle, decreases the incidence of subluxation and dorsal impingement. Since the correction occurs with theoretically smaller wedges, better closure and union of the osteotomy site is expected.

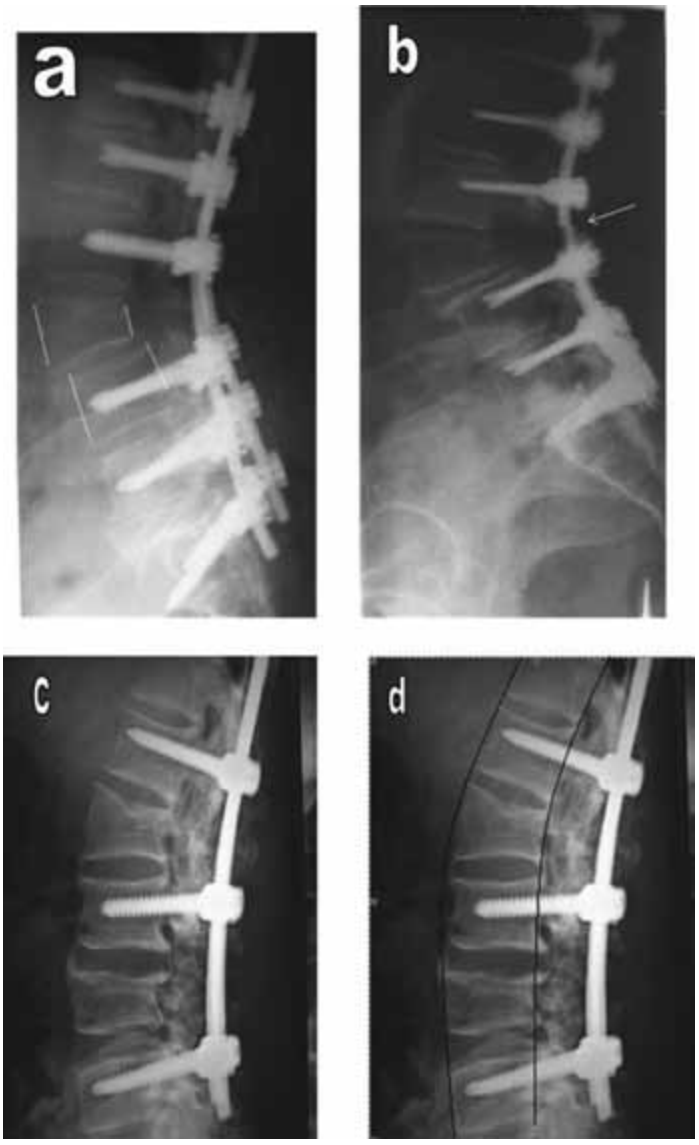
Introduction: Pedicle subtraction osteotomy is one of the most common spinal osteotomies used for correcting kyphotic deformities. The main disadvantage of this osteotomy is the complete dissociation between the vertebral body and the posterior elements that creates anterior displacement of the involved segment. There is also reduction of the vertical dimension of the neural foramen. A new modification is to perform partial subtraction to avoid both complications

Methods: Our study included 33 patients with sagittal plan deformity (16 cases of ankylosing spondylitis, 8 cases of old fractures, 5 cases of congenital kyphosis and 4 cases of postlaminectomy kyphosis after cord tumour resection.). All patients were treated by our modifications of the pedicle subtraction osteotomy technique. Radiographic analysis

included assessment of kyphosis by regional Cobb angle, and the C7 sagittal plumb line in pre and post plain x-rays. Clinically, the patients are assessed by the Oswestry functional score.

Results: Our series included 23 male and 10 females. The age group was of a mean 42.3 years. The vertical plumb line distance from the first sacral segment improved to 3.4 cm compared to a mean of 9.3 preoperatively. The degree of correction for single osteotomy was of a mean of 22.4°. The intervertebral foramen below the osteotomised pedicle showed unchanged vertical dimension after the osteotomy. The complications included 2 cases of dural tears,3 cases of superficial wound infection and one case developed transient postoperative paraparesis. The follow up of the patients was of mean 27.4 months .At the end of follow up, radiologically, there is a loss of correction of mean of 2 degrees with no case of pseudoarthrosis or metal failure. According to Oswestry disability score, 88% of patients were able to return to their normal to moderate daily activities with good self image and overall satisfaction. .

Conclusion: Although being technically demanding PPSO has low rate of neurological complication with better chances of union than the traditional PSO osteotomy.



(A): A case of traditional pedicle subtraction osteotomy complicated with subluxation (spondylolythesis) of L3 (white lines).
(B): Another case complicated with both subluxation metal failure (white arrow).
This may be attributed to large degree of correction through only one osteotomy at L3. Also L3 is connected to the spinal column only by the intervertebral discand anterior longitudinal ligament with much stresses implied on the metal implants till the intertransverse fusion occurs.
(C), (D): A case of partial pedicle subtraction osteotomy done at L2,L4 at the end of follow up shows no evidence of any subluxation, smooth correction of lumbar lordosis (black lines), intervertebral foramen maintained and union of the osteotomies sites. Near normal anatomy of L2 , L4 due to union of the remained lower 1/3 of the pedicle with the posterior fusion mass (black arrows).

146. THE RIB CONSTRUCT: AN EFFECTIVE METHOD FOR MANAGEMENT OF SEVERE THORACIC KYPHOSIS

AlaaEldin A. Ahmad, MD; Richard H. Gross, MD
Palestine

Summary: We report results in 8 patients with severe thoracic kyphosis and greater than 2 year followup treated with the rib construct(RC) for superior fixation. 1 had early failure. The remaining 7 had average preop kyphosis of 119 degrees, postop 78. Preop scoliosis 69, postop 58. The RC produces superior results for this difficult problem compared with other currently used fixation methods.

Introduction: A number of recent publications document the difficulty of surgical treatment of early onset spinal deformity in the presence of pre-existing thoracic hyperkyphosis, described as more than 40 degrees in one paper or 61-88 degrees in another. Instrument failure or development of proximal junctional kyphosis were the major complications.

Methods: This paper studies 7 patients with severe thoracic kyphosis and >24 months followup culled from an ongoing study of 59 patients with early onset deformity treated in 2 institutions. 1 patient with juvenile osteoporosis had early failure of instrumentation with fractured ribs, and is not included. Diagnoses included VATER syndrome, Coffin Siris syndrome, oxidative phosphorylation defect, neurofibromatosis, spastic quadriparesis, and congenital(2). All had prior spine surgery; 2 growing rods and 5 fusion in situ. Average followup 40.5 months. 2 instrumented to pelvis, 5 to lumbar spine. All instrumented ribs 2-5, except 3-6 in patient with failed instrumentation.

Results: Average preop thoracic kyphosis 119 degrees, postop 78. Average preop scoliosis 69 degrees, postop 58. 1 patient with spastic quadriparesis (ventilator dependent) died of unrelated cause 33 months postop. 1 had deep wound infection requiring instrumentation removal, replaced 12 months later. 2 superior hook dislodgements, replaced without compromising final result. No proximal junctional kyphosis. The instrumentation failure occurred early in our experience, overenthusiastic compression of the ribs may have been a factor.

Conclusion: The rib construct is effective in managing patients with early onset thoracic hyperkyphosis

147. POST-OPERATIVE CORONAL IMBALANCE AFTER POSTERIOR THREE-COLUMN OSTEOTOMY FOR CONGENITAL FIXED THORACOLUMBAR KYPHOSCOLIOSIS: INCIDENCE AND RISK FACTORS

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China

Summary: Postoperative coronal decompensation occurred in 22% of patients after posterior three-column osteotomy correction with VCR or PSO for congenital fixed thoracolumbar kyphoscoliosis. All decompensated to the convex side.
Introduction: The current study aimed to demonstrate the postoperative coronal imbalance after three-column osteotomy correction for congenital fixed thoracolumbar kyphoscoliosis and to determine its risk factors.
Methods: This study reviewed patients with congenital fixed thoracolumbar kyphoscoliosis who were treated with posterior three-column osteotomy correction between January 2008 and June 2012. C7 translation was defined as the shift of the center of C7 vertebra as to the center sacral vertical line (CSVL). Preoperative coronal pattern was deemed as balanced if C7 translation less than 2cm on both sides. Otherwise, it was categorized into two types: convex imbalance, C7 translation ≥ 2 cm on the convex side; and concave imbalance, C7 translation ≥ 2 cm on the concave side. Postoperative coronal decompensation was defined as C7 translation ≥ 2 cm on either side.
Results: Totally 55 males and 63 females were included. Before surgery, 71 patients (60%) had balanced coronal pattern, and there were 45(38%) with convex imbalance and 2 (2%) with concave imbalance, respectively. Overall, C7 translation slightly increased (from 1.1 cm to 1.5cm) after surgery. After surgery, coronal decompensation occurred in 26 patients (22%), all of whom had postoperative imbalance on the convex side. The patients with postoperative decompensation had larger C7 translation (3.1 cm vs. 0.2 cm) and changes in C7 translation (1.8 cm vs. -0.8 cm) than those without. The decompensation patients tended to be more frequent with preoperative convex imbalance, a more tilted L4 (≥20°) or L5 (≥15°), and a more caudally located but unlevelled LIV, preoperatively. Occurrence of postoperative convex decompensation was significantly associated with a postoperative residual tilt of LIV ≥10°, and a UIV translation over 2 cm or with positive tilt ≥5°.
Conclusion: Postoperative coronal decompensation might occur after correction with VCR or PSO for congenital fixed thoracolumbar kyphoscoliosis. Convex imbalance and a large L5 tilt before surgery, and a more caudal LIV location which had a considerable residual tilt after surgery, may be predictive in the occurrence of postoperative coronal decompensation. To horizontalize the LIV is possibly useful to prevent this complication.

148. ANTERIOR-ONLY APPROACH TO SPINA BIFIDA (MM) SCOLIOSIS

Glenn N. Boyce, MBBS; Susan S. Thomas, MA; Joseph I. Krajbich, MD
USA

Summary: Retrospective cohort study with literature review of anterior only approach to the treatment of MM scoliosis patients. Data show that this approach leads to effective curve correction, low infections & pseudarthosis rates. Proximal deformities remain the main long term complications
Introduction: Posterior and combined anterior-posterior approaches to MM carry high risk of deep infection, wound healing issues & pseudarthosis rates, as the posterior approach is through significantly compromised soft & bony tissues. Anterior only approach can potentially avoid these. Ours is a cohort treated by this approach
Methods: Review was conducted for MM pts treated by anterior only surgery over 20 yrs. Preoperative & postoperative data were reviewed with emphasis on complications. Medline search was conducted. Articles were analyzed for correction obtained & complications. Our combined data were compared with posterior & combined approach procedures
Results: 11 pts with MM scoliosis & anterior only approach were identified. Preoperative deformity from 41-107°. Average follow up 3.5 yrs. Instrumented levels ranged from 5-10. There were 0 infections, 0 hemodynamic compromises, 1 neurological complication. The average correction was 65%, pelvic obliquity 66%. 1 proximal screw partially pulled out but healed without additional surgical intervention. There were 0 pseudarthosis. There were 4 patients with proximal deformity & 1 distal one. 3 of these required more proximal procedure. We found 7 studies in the literature with combined number of 102 patients (incl. ours) with anterior only approach. There was 1 deep infection, 7 neurological complications and 2 pseudarthoses
Conclusion: Our experience & literature review supports the view that anterior approach in MM scoliosis can avoid major complications of infection, delay in wound healing, pseudarthosis & hardware failure. Proximal deformity remains a significant issue potentially requiring second operation in the future. However, extension into the thoracic spine still avoids the compromised tissue in the lumbar area. Anterior only procedure should be considered as a treatment alternative in MM patients.

149. HEMIVERTEBRA RESECTION COMBINED WITH WEDGE OSTEOTOMY FOR THE TREATMENT OF SEVERE RIGID CONGENITAL KYPHOSCOLIOSIS IN ADOLESCENCE

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China

Summary: To compare clinical, radiographic, and health-related quality of life (Scoliosis Research Society [SRS]-24) outcomes in adolescent patients undergoing hemivertebra resection only (HR) or hemivertebra resection combined with wedge osteotomy (HRWO). And evaluate the surgical outcomes of adolescent patients with hemivertebra treated by hemivertebra resection combined with wedge osteotomy (HRWO).
Introduction: Congenital scoliosis caused by hemivertebra causes extremely severe curves in some patients.Until now there have been many reports on hemivertebra resection,the results of these procedures have been variable and not promising, especially in an adolescent patient with fixed kyphoscoliotic deformity.
Methods: Between 2006 and 2011, 25 patients with severe rigid congenital kyphoscoliosis who underwent hemivertebra resection only (HR)or hemivertebra resection combined with wedge osteotomy (HRWO) were evaluated by retrospective charts and radiographic

views in our hospital. The patients were divided into two groups(HR group and HRWO group) according to the surgical methode. Both groups were compared for curve correction, complication rate and perioperative data. Paired samples T test was used for statistical evaluation.
Results: Hemivertebra resection only was performed in 12 patients (group A) and by combined with both-ends wedge osteotomy in 13 patients (group B). The mean coronal Cobb angle was measured as 50.9° before surgery,25° after surgery and 29° at the latest follow-up for group A; 62°, 20°and 22°for group B. The correction ratio was 51% in group A and 68% in group B. The loss of correction was 8% in group A and 3% in group B . Preoperative kyphosis of 65 °in group A was corrected to 26 °after surgery and 28°at the latest follow-up for group A; 72°, 10°and 15°for group B. The correction ratio was 60% in group A and 86% in group B. The mean preoperative coronal imbalance of 3.5 cm was corrected to 1.5cm (57.1% correction) and the sagittal imbalance of 2.8 cm was corrected to 1.3 cm (53.6% correction)in group A;4.0cm,0.5cm(83.8% correction) and 2.9cm,0.4cm(90.3% correction) in group B. There were no neurological complications. There were no instances of infection or muscle necrosis.
Conclusion: Hemivertebra resection, combined with WO(HRWO), through a single posterior approach is a technically challenging but safe and effective procedure for severe rigid kyphoscoliosis, especially in an adolescent patient with fixed kyphoscoliotic deformity.

150. CONCAVE SIDE OPENING WEDGE OSTEOTOMY WITH GROWING ROD FOR THE TREATMENT OF CONGENITAL SCOLIOSIS IN YOUNG CHILDREN

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Summary: Young children with congenital scoliosis due to unsegmented bar have a poor prognosis unless treated. An effective treatment involves lengthening the bone-bar by cutting and distracting it. In combination with a growing rod, excellent correction is achieved with no neurological disturbance at the latest follow up (ave 7.5 y).
Introduction: Unilateral unsegmented bar has a poor prognosis if left untreated. Surgical treatment is often necessary and an array of techniques are available. These techniques aim to either slow down/arrest growth contralateral to the unsegmented bar area or remove the region causing unbalanced growth (hemivertebra excision, vertebral column resection). As a result, the spinal column is shortened. Further options comprise distraction-based lengthening procedures including the application of growing rods or in rare cases VEPTR. Such lengthening methods include several segments and not only affect the focus of the deformity (main curve) but also the secondary curves.
A more effective treatment method to selectively treat the driving region of the deformity (unsegmented bar) is to cut the bar and perform distraction to compensate for the lost growth. To improve overall correction, it is usually necessary to apply growing rods. The results of such a technique, the opening wedge osteotomy, are analysed and described here.
Methods: 8 consecutive patients with congenital scoliosis due to unsegmented bar were treated with the combination of a concave side opening wedge osteotomy through a posterior approach followed by application of growing rods. Their radiological and clinical data were evaluated prospectively.
Results: There were 8 patients, with an average follow-up of 6.6 (0.5 to 16) years. The mean age at surgery was 4.3 (2.5 - 5.5) years. Before surgery, the mean scoliotic curve was 56.0° (41° - 68°). After surgery, the curve averaged 28.5° (20° - 44°), yielding a correction of 27.5° (49%). There were 2 intraoperative monitoring alerts in the first 3 cases, and the final correction was hence delayed for one week in those 2 cases. 1 patient was reoperated due to spinal imbalance. There were 3 cases with implant-related complications during the course of growing rod treatment. No patients showed any neurological abnormalities at the final follow up.
Conclusion: Concave side opening-wedge osteotomy using a posterior approach in combination with growing rod is an effective and safe surgical technique for correction of congenital scoliosis.

Initials	Age yrs	sex	N° of instr levels	N° of distractions	Halo-traction	Complications	F/U yrs
ML	4.5	F	T2 - L3	8	no	no	16
PE	3.5	F	T1 - L2	8	no	Screw loosening	10
ZsM	2.5	M	T5 - L1	3	no	Intaop neurol - postponed surg Screw loosening	8
KN	5	M	T2 - T11	5	no	Intaop neurol - postponed surg	7
PM	3.5	M	T1 - L1	4	yes	Screw breakage - no consequences	5.5
SJ	3.5	F	T1 - T9	2	no	no	3.5
DG	5.5	M	T1 - T5	1	no	Postop dysbalance, hence 2nd surgery	2.5
MT	5	F	T7 - L1	0	no	no	6 mths

151. POSITIONAL BRACHIAL PLEXUS INJURY FOLLOWING CORRECTIVE OSTEOTOMIES FOR THORACOLUMBAR KYPHOSIS SECONDARY TO ANKYLOSING SPONDYLITIS: INCIDENCE, RISK FACTORS AND PROGNOSIS

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Summary: Postoperative brachial plexus injury (BPI) have been reported to occur in patients in the prone position after prolonged spinal surgery. However, the incidence, risk factors and prognosis of BPI following corrective osteotomies for thoracolumbar kyphosis in ankylosing spondylitis (AS) patients has not been well described.

Introduction: To investigate the incidence, risk factors and prognosis of positional BPI following Smith-Peterson osteotomies (SPO) or pedicle subtraction osteotomy (PSO) in AS patients with thoracolumbar kyphosis.
Methods: A retrospective review of AS patients undergoing SPO or PSO in our center from April 2000 to October 2013 was performed. The degree of global kyphosis, the surgical data, and the postoperative neurological function were reviewed. The incidence and risk factors of brachial plexus injuries were analyzed.
Results: Six (2.6%) of the 228 patients experienced a postoperative BPI. Four risk factors of BPI were identified: (1) long operative time (more than 4 hours);(2) patients had global kyphosis greater than 100°;(3)with arms abducted more than 90°and (4) application of shoulder pad. All patients had complete both sensory and motor recovery, and the average duration of recovery was 5 weeks (range, 2-16 weeks).
Conclusion: The prognosis of BPI following corrective surgery in AS patients is good. However, spine surgeons should be aware of and take some measures to prevent this reversible neurological complication. In the prone position, the arms should be positioned to less than 90°abduction to reduce the risk of injury. In addition, intraoperative electrophysiological monitoring and adjusting the position of upper extremity regularly may prevent this iatrogenic complication.

152. SELECTIVE THORACIC FUSION IN THE SCOLIOSIS ASSOCIATED WITH SYRINGOMYELIA AND CHIARI MALFORMATION TYPE 1

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Summary: Scoliosis associated with syringomyeria and Chiari malformation had very similar curve type like idiopathic scoliosis. But whether thoracolumbar/lumbar curve could achieve spontaneous correction and avoid trunk decompesation after selected thoracic fusion(STF) in those cases is unknown. Our results showed STF could be safely performed in selected patients
Introduction: To evaluate the surgical result of selective thoracic fusion for scoliosis associated with syringomyelia and Chiari malformation type 1.
Methods: From 2001.1 to 2009.1, Ninety three cases of scoliosis associated with syringomyeria Chiari malformation type 1 were retrospectively reviewed. There were 11 cases who underwent STF and were followed up more than 2 years, which included 8 females and 3 males, the mean age was 14.9 yrs (9-21yrs). Curve type, Coronal and Sagittal Cobb angle, AVR, AVT, flexibility, trunk shift were recorded and analyzed.
Results: There were 9 double curves and 2 triple curves, the Lenke type of thoracolumbar/lumbar curve included 2 Lenke A, 7 Lenke B and 2 Lenke C. The average coronal Cobb angle of thoracic curve before and after surgery were 62.6° and 19.0° respectively, and the average correction rate was 69.6%. The average coronal Cobb angle of thoracolumbar/lumbar curve before and after surgery were 36.1° and 11.6° respectively, and the average spontaneous correction rate was 67.9%. The followed up time ranged from 24 to 48 months (mean 29.5 months), the average loss of correction rate was 7%. Only one trunk decompensation was noted at final follow-up. Pedicle screw nut loosening occurred in one patient and this patient underwent revision surgery, no neurological complication was noted at final follow-up.
Conclusion: STF could be safely performed in scoliosis associated with syringomyeria and Chiari malformation type 1. Thoracolumbar/lumbar curve in these patients had similar spontaneous correction ability compared with idiopathic scoliosis (IS) patients. The satisfactory result could be achieved according to the STF criteria for IS.

153. RESTORING SAGITTAL BALANCE IMPROVES CLINICAL OUTCOMES FOR NON-AMBULATORY CEREBRAL PALSY PATIENTS WITH SPINAL DEFORMITY

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Summary: This is the first study to show, in a population of nonambulatory children with cerebral palsy and spinal deformity, that restoration of sagittal balance to neutral or slightly positive sagittal vertical axis (SVA) and T1 pelvic angle (T1PA) was associated with improved transfers, overall function, and higher caregiver satisfaction. T1PA is an angular measurement independent of patient position that can be evaluated on prone intra-operative X-rays or sitting X-rays to evaluate overall alignment and improve clinical outcomes.
Introduction: A positive sagittal balance (>5 cm) has been associated with adverse outcomes in adult deformity patients but no such guidelines exist for primarily seated patients. This study evaluated the association between restored sagittal balance and clinical outcomes in cerebral palsy (CP).
Methods: From a multicenter database, we reviewed prospectively collected data from patients with CP who underwent PSF to the pelvis. Demographic, clinical outcome, sitting tolerance, and seated radiographic data were studied. Using Pearson's correlation, we evaluated the relationship between multiple radiographic measurements and clinical outcomes using the CPCHILD Questionnaire - 6 domains, each scored 0 to 100 (best).
Results: 93 patients (age 13.7±2.7 yr) who underwent PSF (2008 - 2011) with 2-year follow-up were included. Mean radiographic parameters: major Cobb (29±16°), pelvic obliquity (8.1±6.8°), T2-T12 kyphosis (36±16°), T12-S1 lordosis (-53±17°), and sagittal vertical axis (SVA, -0.3±6.6cm). Clinical outcomes: daily living (43±18), transfers/mobility (43±18), comfort/emotions (80±18), social (55±29), health (61±19), overall function (70± 22), total score (56±15), and sitting tolerance (294±166min). There was a linear correlation between SVA and transfers ($r = 0.27$, $p = 0.026$), social (0.24/0.38), overall function (0.25/0.30), and total score (0.30/0.015). No correlation was found with other measurements. Given that SVA may vary with patient position, pelvic incidence (PI), sacral slope (SS), and T1 Pelvic Angle (T1PA, see figure) were measured on a subset of patients. Higher PI improved sitting (0.40/0.035), while higher T1PA improved transferring (0.52/0.006), overall function (0.51/0.006), and total score (0.39/0.043) with a trend towards better health (0.33/0.091).

Conclusion: Restoration of sagittal balance to a neutral or slightly positive SVA/T1PA are associated with better transferring, function, social interaction, and total care-giver satisfaction in CP. Beyond a certain threshold, however, a positive SVA or T1PA is likely detrimental. T1PA can be evaluated intra-operatively in the prone position to improve the clinical outcomes of these children.

154. DO PONTE OSTEOTOMIES ENHANCE CORRECTION IN AIS? AN ANALYSIS OF 191 LENKE 1A AND 1B CURVES

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Summary: We sought to determine if Ponte osteotomies improve coronal, sagittal, and axial correction in patients undergoing surgery with pedicle screws for Lenke 1A and 1B curves. 191 patients who underwent Ponte osteotomies demonstrated improved deformity correction but increased blood loss. There were no intra-op or post-op neurologic events in this cohort.
Introduction: There is a paucity of data studying the risks and benefits of Ponte osteotomies in patients with AIS. We sought to determine if Ponte osteotomies improve correction in patients with AIS and Lenke 1A and 1B curve types treated with pedicle screw constructs.
Methods: A prospectively collected multicenter database was reviewed to identify patients with Lenke 1 A and B curve types treated with pedicle screw constructs and 2 year follow-up. Patients were excluded if they had a thoracoplasty or anterior release. The patients were stratified based on whether they had (PO) or did not have (No PO) Ponte osteotomies. Data were collected preoperatively and at 2 years, and the groups were compared using unpaired Student's t-test and Fisher's exact test.
Results: 191 patients met the inclusion criteria, with a mean age of 14.7 ± 2.2 years. 125 patients (65.4%) had Ponte osteotomies with an average of 4.3 ± 1.5 Pontes per patient. Those treated with Ponte osteotomies had similar clinical and radiographic parameters (major Cobb PO: 51.5 ± 8.6°, No PO: 50.8 ± 8.1°, p=0.6) to the patients who did not have Ponte osteotomies except that they had stiffer and more lordotic curves (flexibility: PO: 47.3%, No PO: 54.5%, p=0.04; T5-12 kyphosis PO: 18.7°, No PO: 23.2°, p=0.02). At 2 years, the patients treated with Ponte osteotomies had significantly better thoracic Cobb angle correction (PO: 67.1%, No PO: 61.8%, p=0.01), and an increase in T5-T12 kyphosis (PO: +3.0°, No PO: -0.4°, p=0.04). Regarding rib prominence, the Ponte group started with a higher pre-op inclinometer (PO: 15.4 ± 4.2°, No PO: 14.3 ± 5.0°, p=0.13) and at 2 years this was less than the No Ponte group (PO: 6.9 ± 3.7°, No PO: 7.7 ± 4.7°, p=0.16), although this did not reach statistical significance. The patients who had Ponte osteotomies were found to have an increased EBL (PO: 970.1 cc, No PO: 778.9 cc, p=0.05), with a trend toward increased cell saver transfused (PO: 282.2 cc, No PO: 203.1 cc, p=0.06). There were no neurologic events in this cohort.
Conclusion: Although the use of Ponte osteotomies was not randomized, these data suggest that greater deformity correction in all 3 planes may be possible when Ponte osteotomies are performed for the stiffer and more lordotic Lenke 1A and 1B curves.

155. MONITORING THE THORACIC/THORACOLUMBAR SCOLIOSIS CURVES PROGRESSION USING SURFACE TOPOGRAPHY ASYMMETRY ANALYSIS OF THE TORSO IN ADOLESCENTS

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Summary: An analysis of torso asymmetry using 3D markerless torso surface topography (ST) data was used to predict curve progression (>5°) from radiographs with 74% overall accuracy and < 4% of false negatives.
Introduction: Current ST methods rely on surface markers to obtain measurements for scoliosis. The aim of this study is to assess the ability of a 3D markerless asymmetry analysis in detecting >5° thoracic/thoracolumbar (T-TL) curve progression during a one year follow-up.
Methods: Full torso ST scans from 100 adolescents with idiopathic scoliosis (AIS) (Cobb angle: 10-69°) were randomly selected. Inclusion criteria were AIS, having T-TL curve, treated non-operatively, and having baseline and follow-up ST scans and corresponding out of brace radiographs within 12±3 months from baseline. ST scans were analyzed using our 3D markerless asymmetry analysis to generate contour maps illustrating left-right asymmetry about the best plane of symmetry(Fig.1). Regions with 3mm deviation or more represent torso deformity due to scoliosis. The change over one year in the maximum deviation (ΔMaxDev) and in the root mean square of deviation (ΔRMS) of deformed area in the T-TL regions were used as dependent variables to detect >5° progression in Cobb angle (ΔCobb>5°). Decision tree analysis was used to categorize curves into progression and no-progression groups. The effect of body mass index (BMI) on detecting progression was investigated in patients with BMI <25 (N=81).
Results: In the decision tree model, ΔRMS=0.85mm and ΔMaxDev=8.8mm were the thresholds to detect curve progression. There were 4 of 19 T-TL curves having progressed with BMI>25 that were classified as no-progression (false negative). Excluding the subjects with BMI>25 led to improved identification of T-TL curves with progression. The sensitivity, specificity and accuracy of classification tree for patients with BMI<25 were 85.7%, 71.6%, and 74.1%, respectively.
Conclusion: Overall, the classification tree model using ST data may allow reducing by 43% the number of x-ray used to monitor T-TL curves by identifying 48/81 cases as curves with no progression for patients with BMI<25. A different decision tree may be required for patients with BMI's over 25.

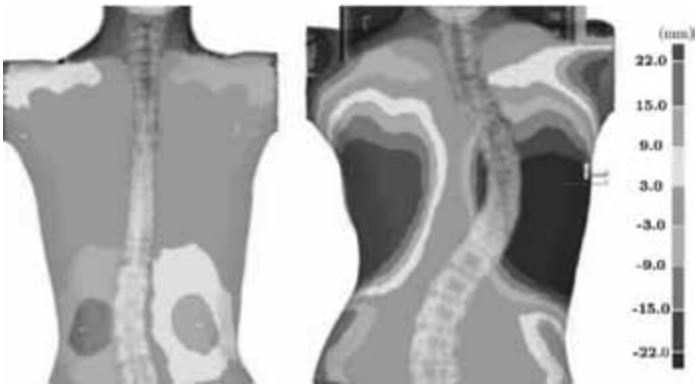

Figure1-Back view of deviation colour map of patients with AIS. The spine shape was acquired from the corresponding radiograph and scaled to matched the ST

156. THE OPTIMAL SURGICAL APPROACH FOR LENKE 5 CURVES: IS THE ANTERIOR APPROACH READY FOR A COMEBACK?

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Summary: The debate between anterior versus posterior surgery for Lenke 5C curves has re-surfaced with modern posterior techniques. This prospective, multicenter study found that although ASIF resulted in shorter fusions, this was at the expense of increased disc angulation below the lowest instrumented vertebrae (LIV), less lumbar lordosis, and a lower % correction of the lumbar prominence than PSIF. Two-year clinical outcome scores were similar in both groups, however longer-term follow-up may provide better insight into which trade-off is most ideal.

Introduction: Historically the anterior approach was the treatment of choice for Lenke 5 curves; recently the posterior approach has gained popularity for its ease, versatility and correction with screw fixation. The objective of this study was to prospectively compare both radiographic and clinical outcomes between anterior and posterior instrumented fusions in Lenke 5C curves.

Methods: A prospective, longitudinal multicenter surgical AIS database identified consecutive patients with Lenke 5C curves treated either by open anterior instrumentation and fusion (ASIF) with a dual rod system or posterior instrumentation and fusion (PSIF) with a pedicle screw-rod construct and wide posterior release. Pre and 2 year postoperative radiographic data, SRS outcome scores, and peri-operative comparisons were made between the 2 approaches.

Results: 69 patients were treated with ASIF (2002-2008) and 92 with PSIF (2002-2011). The stable and end vertebrae were similar in the 2 groups (p=0.91;p=0.62). The only differences pre-operatively were a greater curve flexibility and coronal trunk shift in the anterior group (p=0.008;p=0.05). Post-operatively the LIV distribution in the ASIF group was L1: 2.9%, L2: 23.2%, L3: 69.6%, and L4: 4.3%, compared to L2: 5.4%, L3: 67.4%, and L4: 27.4% for the posterior cases (p<0.001). There were no differences in the % correction (ASIF:59.2%, PSIF:59.6%; p=0.82), length of hospital stay(ASIF:5.6, PSIF:5.7; p=0.75), post-op day conversion to oral pain medication(ASIF:3.2, PSIF:3.2; p=0.66), and SRS outcome scores(p=0.1).Although number of levels fused was significantly lower in the anterior group (4.7 versus 6.3; p<0.001), PSIF resulted in significantly less disc angulation below LIV (ASIF:3.4, PSIF:1.8; p=0.008), greater lordosis (p<0.001), and % correction of lumbar prominence (p=0.01).[Table 1]

Conclusion: ASIF for Lenke 5C curves resulted in significantly shorter fusions by 1.6 levels on average compared to modern posterior techniques. This may be at the expense of increased disc angulation distal to LIV, less lumbar lordosis, and less correction of the lumbar prominence, which seem more favorable with a posterior approach.

157. IONM ALERTS DURING SURGERY FOR AIS: TRIGGERING EVENTS AND THE SURGEON'S RESPONSE

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Summary: In a prospective AIS dataset, the incidence of IONM alerts was 5.8% with no false negatives or permanent neurologic deficits. The most common reported triggering events were related to patient position, hypotension, and instrumentation. 2/788 cases were aborted secondary to IONM alerts. Advances in neuromonitoring allow the operating surgeon to continue surgery after a discrete event has been identified, corrective action taken, and a significant return of IONM. Despite these findings, our cohort showed little consistency among the surgeons' responses to the event.

Introduction: Neuromonitoring during surgery for AIS is to reduce the risk of neurologic injury. However, little data exists on factors triggering alerts and actions taken. Our purpose was to elucidate these factors from a large, prospective AIS database.

Methods: A prospective AIS dataset was queried to identify patients experiencing an IONM alert. An IONM event was defined as a somatosensory-evoked potentials (SSEP) and/or motor-evoked potentials (MEP) reduction of >50%. Pertinent data including an IONM questionnaire completed following surgery was reviewed. Patients with IONM events (IO) were compared to patients with no events (NO).

Results: The incidence of IONM alerts was 5.8% (46/788). 5 patients had >1 IONM alert. A triggering event was identified in 37/46(80.4%) of the questionnaires. Positioning (24%), hypotension (24%), and instrumentation (22%) were the most common triggering events (surgeons could identify more than one reason). Curve correction (13%), traction (13%), and resection (3%) were the remaining reasons given for the change. Most common reported responses: surgical pause (39%), increase BP (33%), implant redirection/removal (20%), repositioning of patient (20%), less correction (15%), and removing traction (11%). A Stagnara wake-up was performed in 27% of patients with 1 IONM event and in all patients with >1 IONM (1 IONM: 11/41 vs. >1 IONM: 5/5; p<0.01). Steroids were given in 6.5% of patients with IONM changes.

Conclusion: We report an IONM alert rate of 5.8% with no false negatives, or permanent deficits. The most common reported triggering events were related to patient position, hypotension, and instrumentation. 2/788 cases were aborted secondary to IONM alerts. Advances in neuromonitoring allow the operating surgeon to continue surgery after a discrete event has been identified, corrective action

taken, and significant return of IONM. Despite these findings, our cohort showed little consistency among the surgeons' responses to the event.

158. CHARACTERISTICS AND SURGICAL TREATMENT OF SCOLIOSIS IN THE 22Q11 DELETION SYNDROME: AN ANALYSIS OF 1067 PATIENTS

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Summary: 22q11DS is a common genetic disorder with a scoliosis prevalence of almost 20%. Most curves resemble idiopathic like curves, surgery is needed in 12.5%. Almost half experienced complications. Proactive screening for scoliosis in this group is recommended and an extensive preoperative workup should be done to minimize surgical risks.
Introduction: The 22q11 deletion syndrome (22q11DS) is a common genetic multisystem disorder. There has been little attention for orthopaedic disorders; scoliosis seems the most significant orthopaedic problem. The purpose was to report the prevalence, characteristics and treatment options of scoliosis in 22q11DS.
Methods: A total of 1067 patients from two large 22q-centers (mean age 11.8y,0.8-49y, 431 M,636 F) were included. One cohort has recently started a prospective screening. A retrospectively analysis (partially of prospectively collected data) was performed by reviewing clinical reports, using questionnaires and assessing available X-rays.
Results: Scoliosis was found in 18.9% (F:M 61vs.42%). The curve distribution varied: right thoracic (RT) combined with left lumbar (LL) (27%), RT alone (17%), left thoracolumbar (LTL, 9%), LT (6%), followed by LT/RTL, RTL and LL. If scored according to the Lenke classification most curves resembled type 1 (32%), followed by type 3 and 6. A brace was applied in 7%, however 60% progressed into surgery. Surgery was required in n=27 (PSF n=21, GR n=5, VEPTR n= 1). 3 patients required 2 procedures because of progression despite earlier treatment. At least 2 more children are planned for surgery. Surgical complications were present in 12 cases (n=5 hypocalcaemia, n=2 excessive bleeding (one requiring 2-stage procedure), n=3 hardware failure, n=1 persistent wound leakage, n=1 infection).
Conclusion: Scoliosis is very common in 22q11DS, affecting almost 20%. Moreover, a majority has not gone through their growth spurt yet and are at risk for scoliosis. Also, the retrospective analysis of 1 cohort may have caused an underestimation (proven by a higher prevalence in prospectively screened cohort). Surgery was required in 12.5%. It appears that brace treatment might be less effective. It might also be suggested that more aggressive fusion is recommended to prevent postoperative decompensation. We believe that awareness of 22q11DS and its features (among all also c-spine anomalies), comorbidities, syndrome related per- and postoperative complications (bleeding, hypocalcemia, immune deficiency) is important for every orthopaedic surgeon. An extensive preoperative work-up minimizing surgical risks should be standard.

159. LONG-TERM EFFECTS OF EIGHT WEEKS OF SPINAL STABILIZATION EXERCISES IN ADOLESCENTS WITH IDIOPATHIC SCOLIOSIS AND LOW BACK PAIN

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Summary: The outcomes of supervised spinal stabilization exercises compared to unsupervised spinal stabilization exercises in patients with adolescent idiopathic scoliosis (AIS) and low back pain (LBP) were examined at two different times. Outcomes significantly differed between groups immediately after 8 weeks of spinal stabilization exercises compared to 6 months of follow-up. However, the 6-month follow-up results still favored supervised spinal stabilization exercises.
Introduction: Many patients with AIS develop LBP and are often treated with spinal stabilization exercises. No studies have evaluated the long-term effects of spinal stabilization exercises for managing LBP in AIS. The purpose of this randomized control trial was to evaluate the effects of 8 weeks of weekly physical therapy (PT) compared to one-time treatment in patients with AIS and LBP at 6 months of follow-up.
Methods: Thirty-four participants completed 8 weeks of PT intervention (spinal stabilization exercises) after randomization into a supervised or unsupervised group. The supervised group received weekly PT for 8 weeks. The unsupervised group received a one-time treatment and an 8-week home exercise program. Thirty-two participants (16 in each group) were re-evaluated at 6 months of follow-up. Four outcome measures were compared: Numeric Pain Rating Scale (NPRS) scores for pain intensity, Patient-Specific Functional Scale (PSFS) scores for functional limitations, SRS-22 scores for quality-of-life (QOL), and Global Rating of Change (GROC) scores for patients' perceived improvement after PT. ANOVAs with repeated measures were performed for NPRS, PSFS, and SRS-22 scores. Mann-Whitney U tests were performed for GROC scores.
Results: There were no group differences in baseline demographics including age, gender, and curve magnitude and in baseline outcome measures. Both groups improved in all outcome measures. After 8 weeks of PT, the supervised group had significantly reduced NPRS and improved PSFS scores, but had no differences in SRS-22 and GROC scores compared to the unsupervised group. At 6 months of follow-up, the supervised group had significantly improved GROC scores, but had no differences in NPRS, PSFS, or SRS-22 scores from the unsupervised group.
Conclusion: Patients with AIS undergoing supervised PT for back pain initially respond better than unsupervised PT in pain intensity and functional limitations but not in QOL and perceived improvement immediately after PT. However, at 6 months of follow-up, there are no longer significant differences in pain intensity and functional limitations, but patients in the weekly supervised PT program perceive that they are significantly better after PT.

160. THE LUMBAR PELVIC ANGLE (LPA), THE LUMBAR COMPONENT OF THE FAN OF SPINOPELVIC ALIGNMENT, CORRELATES WITH HRQOL AND PI-LL MISMATCH AND PREDICTS GLOBAL ALIGNMENT

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USA

Summary: The pelvic incidence minus lumbar lordosis mismatch (PI-LL) is a useful preoperative planning tool and postoperative gauge of adequate correction in lumbar flatback. In patients with prior interbody fusion at L5-S1, the exact plane of the S1 endplate can be blurred, creating error in the assessment of PI-LL. This study introduces the lumbar pelvic angle (LPA), a novel measure of lumbopelvic alignment and demonstrates that LPA correlates with HRQOL and predicts global alignment and PI-LL mismatch.

Introduction: The T1 Pelvic angle (TPA), a measure of global spinopelvic alignment, correlates with HRQOL but it may not be measureable on all intraoperative x-rays. In patients with prior interbody fusion at L5-S1, the exact plane of the S1 endplate can be blurred, creating error in PI-LL measure. This study introduces the lumbar pelvic angle (LPA), a novel parameter of spinopelvic alignment which is more readily measured on intraoperative imaging. LPA, the lumbar component of the TPA, creates part of the fan of spinopelvic alignment (Figure 1).

Methods: Multicenter, prospective, analysis of ASD patients. Inclusion criteria: ASD, age>18, and any of the following: scoliosis Cobb angle >20 deg, SVA>5 cm, thoracic kyphosis>60 deg, and PT greater than 25 deg. Clinical measures of disability included ODI, SRS and SF36. Baseline and 2-yr follow-up radiographic and HRQL outcomes evaluated.

Results: 852 ASD patients (407 operative) were enrolled (mean age 53.7). Baseline LPA correlated with PI-LL (r=0.79), PT (r=0.78), TPA (r=0.82) and SVA (r=0.61) (all p<0.001).

PI-LL, LPA and TPA correlated with ODI (r=0.42/0.29/0.45), SF36 PCS (-0.43/-0.28/-.45) SRS (-0.354/-0.23/-.37) with all p<0.001. At 2 years follow up, LPA correlated with PI-LL (r=0.77), PT (r=0.78), TPA (r=0.83) and SVA (r=0.57) (all p<0.001). Categorizing the patients by increasing LPA (<7; 7-15; >15) revealed a significant and progressive increase in all HRQOL, PI-LL (-3.2/12.7/32.4) and TPA (9.7/20.1/34.60) with all p<0.001. Using linear regression analysis, moderate disability (ODI=40) corresponded to an LPA of 10.1, PI-LL of 12.6 and TPA of 20.6. Mild disability (ODI=20) corresponded to LPA of 7.2, PI-LL of 4.2 and TPA of 14.7.

Conclusion: LPA correlates with PI-LL and HRQOL in patients with ASD. It can be used as an intraoperative tool to gauge the adequacy of correction with a target LPA of less than 7.2. LPA predicts global alignment as it correlates with baseline and 2 year TPA and SVA. Along with the CTPA and TPA, LPA completes the fan of spinopelvic alignment.

161. ASSESSMENT OF IMPACT OF LONG-CASSETTE STANDING X-RAYS ON SURGICAL PLANNING FOR LUMBAR PATHOLOGY: AN INTERNATIONAL SURVEY OF SPINE SURGEONS

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USA

Summary: Assessment of long-cassette standing x-rays can have significant impact on surgical planning for lumbar pathology. Failure to account for global spinal alignment when addressing what may appear to be isolated lumbar pathology can have negative consequences. These data suggest that surgeons should maintain a relatively low threshold for obtaining long-cassette standing x-rays when contemplating surgical treatment for significant lumbar spine pathology.

Introduction: Surgical planning to address significant lumbar spine pathology, performed without appreciation of global spinal alignment, may have negative consequences. Our objective was to assess whether the extent of recommended surgery for lumbar pathology would significantly change with the addition of long-cassette standing x-rays.

Methods: This was an international on-line survey of spine surgeons. A series of 15 cases of lumbar spine pathology were presented with a brief clinical vignette and lumbar imaging (x-rays and MRI/CT). Surgeons were asked to select the most appropriate surgical plan, with 5 choices, ranging from least aggressive (decompression alone; 1 point) to the most aggressive (upper throracic to sacrum/ilium fusion +/- osteotomies/decompression/interbodies; 5 points). Cases were then re-ordered and presented with long-cassette standing x-rays and the same surgical planning question. Results were compared based on lumbar imaging only vs addition of long-cassette x-rays. 5 cases (control group) had normal global alignment and 10 cases (study group) had global malalignment.

Results: 316 surgeons completed the survey, predominantly (63%) from North America and Europe. Specialties included orthopedic surgery (65%) and neurosurgery (34%), 68% completed spine fellowship, and responders had a mean 13.4 yrs in practice that was a mean of 76% spine and included a mean of 123 fusions per yr. For study cases, extent of recommended surgery increased significantly with addition of long-cassette x-rays vs lumbar imaging only (p=0.002). For control cases with normal global alignment, no significant changes in surgery plans were identified with addition of long-cassette x-rays (p=0.280).

Conclusion: Long-cassette standing x-rays can have significant impact on surgical planning for lumbar pathology. Surgeons should maintain a relatively low threshold for obtaining long-cassette standing x-rays when contemplating surgical treatment for significant lumbar spine pathology.

162. POSTERIOR COLUMN RECONSTRUCTION IMPROVES FUSION RATES AT THE LEVEL OF THE OSTEOTOMY IN PEDICLE SUBTRACTION OSTEOTOMIES

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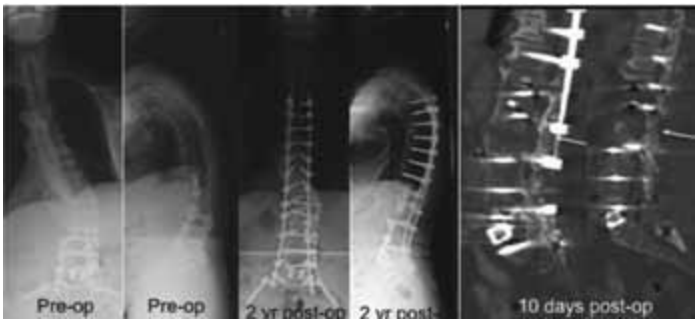
Canada

Summary: 81 consecutive adult patients (mean age 50.7 years, range 19-77) underwent Pedicle Subtraction Osteotomy (PSO) with structural restoration of the posterior column without interbody support. The pseudarthrosis rate at the osteotomy level was 2.9% at a mean of 45 (27-147) months. The revision rate was high in this group with an 13.2% pseudarthrosis at other levels, and 8.8% rate of revision for adjacent segment failure. Restoration of the posterior column is associated with a high fusion rate at the osteotomy level.
Introduction: PSOs have been associated with significant correction of fixed spinal deformities. Resection of the posterior elements to achieve the required decompression can leave a posterior column defect that can lead to pseudarthrosis and early implant failure. While some authors have advised the use of cages or some other form of anterior column support to promote fusion at the osteotomy site, we feel reestablishing the integrity of the posterior column at this region to be a key factor in promoting local fusion.
Methods: 82 consecutive adult PSOs (68 patients) with greater than 2 year f/u were retrospectively reviewed. The inferior facets if the proximal level were reduced to the superior facets of the distal level. If that was not possible, a structural piece of bone graft either from the resection or a local rib was slotted in the posterior defect to reestablish continual structural posterior bone across the lateral margins of the resection. No interbody cages were used at the level of the osteotomy. Local bone graft/ ribs were used for graft without any adjuvant agents, proteins or allograft. Fusions were assessed with radiographs in all cases, and with CT in symptomatic patients or those with broken or loose implants.
Results: There were 40 lumbar , one sacral and 41 thoracic PSOs with a mean f/u 45 (27-147) months. There was 2 definite cases of pseudarthrosis at the osteotomy site (2.9%). There were two cases of unilateral broken rods adjacent to cross-links in the area, however, neither of these cases required revisions and CT scans at 116 and 122 months post-op showed fusion at all levels without any loss of correction. There were 9 (13.2%) revisions for pseudarthrosis at other levels, revisions for proximal (n=4) and distal (n=2) failure, 4 cases of revisions for infection, 5 (7.3%) cases of removal of loose or malpositioned implants, and 2 (2.9%) peri-operative deaths (mean 6 months).
Conclusion: Restoring the structural integrity of the posterior column in PSOs is associated with a greater than 95% fusion rate at the level of the osteotomy. The addition of interbody support was not required for fusion at the osteotomy level. Adjacent segment failure and pseudarthrosis at other levels were the main reason for revision in long-term follow-up.



163. EFFICIENCY IN ADULT SPINAL DEFORMITY (ASD) SURGERY: A MULTICENTER COMPARISON OF RESOURCE USE

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USA

Summary: Decision makers and payers are placing increasing scrutiny on the costs and outcomes associated with complex spine surgery. In order to justify higher cost practice patterns, there must be evidence of additional patient benefit; however, little is currently known regarding the variation in resources used and associated outcomes in complex spine surgeries.
Introduction: Efficiency in surgical resource use is critical to high value health care. Our study examines multi-center variability in patient-level surgical resource use, including implants, biologics, and length of stay, alongside health-related quality-of-life (HRQoL) improvements following ASD surgery.
Methods: Retrospective analysis of a multi-center prospective database of consecutive ASD patients. HRQoL outcomes were calculated from the ODI, SRS-22 and SF-36 domain scores. Changes in HRQoL were estimated as the difference between baseline and 2-year values. Patient-level surgical resources included blood use, bone morphogenetic protein (BMP) volume (ccs), length of stay (LOS), and implants. Patients were classified by mild, moderate or severe sagittal modifier and analyzed across centers. Statistical analysis was performed using ANOVA and regression analysis.
Results: Baseline and 2-year HRQoL data were available for 226 surgical ASD patients, with an average age of 56 (18 - 84) who were predominantly female (N=189, 84%). Significant differences were found in the average 2-year change in HRQoL across centers, however this difference becomes insignificant after controlling for patients within the same major modifier groups ($p>.05$). Significant differences were found across centers in average resources used per surgery ($p<0.05$), with only LOS not reaching significance ($p>0.05$). Significant differences were found in average BMP and screw use across all modifier groups. Table 1 summarizes the results of ANOVA by center, overall and per modifier group for HRQoL and resource use. After accounting for clinical, demographic, and regional characteristics at the patient level, variation among centers persisted in both screw use and total BMP volume with no corresponding statistical differences in HRQoL outcomes.

Conclusion: The use of additional surgical resources does not appear to impact 2-year HRQoL outcomes following surgery for ASD. In order to improve efficiency in ASD surgery, standardization of physician practice patterns and resource use could help curb costs without negatively impacting patient HRQoL.

164. COMPARISON OF RELIABILITY OF THE SRS-SCHWAB CLASSIFICATION BETWEEN IDIOPATHIC AND DEGENERATIVE SCOLIOSIS IN ADULTS

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China

Summary: With the 82 non-premarked cases, the new SRS-Schwab system for adult IS (idiopathic scoliosis) and DS (degenerative scoliosis) patients achieved excellent intra- and inter-observer agreement, but the definition of thoracic or lumbar curves in IS group and PI minus LL modifier in DS group appears to need improvement.
Introduction: Schwab et al. reported excellent inter- and intra-observer reliability for classifying adult spinal deformity (ASD) based on the curve type and three modifiers. However, there is lack of comparison of reliability analysis with this new system for classifying ASD patients with different etiologies. The objective of the current study was to compare the inter- and intra-observer agreement of the new SRS-Schwab system for classifying adult IS (idiopathic scoliosis) and DS (degenerative scoliosis) patients using non-premarked cases.
Methods: A total of 82 adult scoliosis patients (Group A: 40 IS; Group B: 42 DS) were included in this study, which ranged from January 2010 to January 2012. Long-cassette standing posterior-anterior and lateral radiographs of the spine and the pelvis were obtained in the fist-on-clavicle position. All cases were classified according to the new SRS-Schwab classification by 4 observers. After a two-week interval, the same classification was independently repeated by each observer with the cases in a different randomly assigned order. Kappa coefficient was calculated to test the inter- and intra-observer agreement of this new SRS-Schwab classification. Data were compared using X2 analysis.
Results: In IS group, there were 11 male and 29 female (20-49yrs, mean age 29.2yrs), while there were 10 male and 32 female (40-71yrs, mean age 58.1yrs) in DS group. For overall classification, the mean inter-observer Kappa was 0.79 and intra-observer Kappa was 0.85 in IS group. Meanwhile the inter- and intra-observer Kappa of the DS group were 0.71 and 0.81. Disagreements occurred often when differentiating type T curves from type L curves in IS group (mean inter-observer Kappa was 0.77 in IS group vs. 0.82 in DS group) and when determining the PI minus LL modifier in DS group (mean inter-observer Kappa was 0.69 in DS group vs. 0.75 in IS group).
Conclusion: The new SRS-Schwab system for adult IS and DS patients could achieve similarly excellent intra- and inter-observer reliability. However, the definition of thoracic or lumbar curves in IS group and PI minus LL modifier in DS group were easily leads to confusion.

165. A REPORT OF 52 CASES OF THREE-COLUMN OSTEOTOMIES OF THE UPPER THORACIC SPINE AND CERVICOTHORACIC JUNCTION: COMPLICATIONS, OUTCOMES AND DIFFERENTIAL IMPACT ON SPINAL PELVIC PARAMETERS, CERVICAL SAGITTAL ALIGNMENT AND GENERAL HEALTH STATUS

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Summary: Evidence regarding 3-column osteotomies (3CO: PSO, VCR) of the upper thoracic (UT) spine and cervicothoracic junction (CTJ) are limited. A retrospective analysis was conducted on 52 patients that underwent UT or lower cervical (LC) 3COs. LC 3COs produce greater correction of C2-C7 SVA with shorter operative time. UT 3COs did not show significant radiographic changes in cervical or spinopelvic parameters. However, there were less medical complications, shorter stay, and small improvements in general health status PCS.
Introduction: 3-column osteotomies (3CO: PSO, VCR) are most commonly performed at or below the mid thoracic apex to lower lumbar spine. Evidence regarding 3COs of the upper thoracic spine and cervicothoracic junction (CTJ) are limited. This study details and compares complications, radiographic, and clinical outcomes of lower cervical and upper thoracic 3COs.
Methods: A retrospective analysis was conducted on patients (pts) that underwent either a lower cervical (LC: C6 or C7) or upper thoracic (UT: T1-T5) 3CO (VCR or PSO) for proximal junction kyphosis, fixed cervical sagittal deformity, or posttraumatic kyphosis. Operative, radiographic, health-related-quality-of-life (HRQOL), and complications were recorded.
Results: 52 pts (60±18yrs) met criteria (LC:16, UT:36) with 25 PSO and 27 VCR and mean follow-up 15months. Average estimated blood loss and number of fusion levels were similar. LC Operative time was significantly shorter than UT. The lower cervical osteotomy group had longer ave ICU and hospital stays ($p>0.05$). Average preop radiographic parameters were similar between LC and UT except C2C7 SVA (4.4±1.5vs3.7±1.4cm,$p=0.0022$). No other significant changes in radiographic parameters were observed($p>0.05$ for all). LC 3CO provided greater correction of cervical SVA ($p=0.04$) and UT 3CO had larger decrease in T1 slop ($p=0.01$). LC had significantly lower SF12 PCS than UT (30.4±9.6vs 38.3±9.9,$p=0.02$) that was not significant postop (33.5 ± 9.3vs41.4 ± 11.7,$p>0.05$). LC and UT reop rates were similar (25vs19%,$p>0.05$). Complications included (LCvsUT): intra-op(1vs2), tracheotomy(5vs6), pseudoarthrosis(3vs6), infection(1vs2), postop rod fracture(0vs3).
Conclusion: 3COs at the CTJ and UT spine restore regional sagittal alignment. LC 3COs produce greater correction of C2-C7 SVA with shorter operative time. UT 3COs did not show significant radiographic changes in cervical or spinopelvic parameters. However, there were less medical complications, shorter stay, and small improvements in general health status PCS.

166. ANALYSIS OF DEGLUTITION AFTER OCCIPITOCERVICAL ARTHRODESIS FOR CERVICAL DEFORMITY IN RHEUMATOID ARTHRITIS

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Japan

Summary: Preoperative impairment of deglution may be closely related with postoperative dysphagia after occipitocervical arthrodesis for RA induced cervical deformity.
Introduction: We sometimes encounter patients with dysphagia or respiratory impairment after occipitocervical arthrodesis for rheumatoid arthritis (RA)-induced cervical deformity. The importance of the occipito-C2 or mandibular-C2 angle to avoid these side effects has been reported previously. We investigated deglutition function before and after O-C fusion collaborating with the departments of otorhinolaryngology and rehabilitation.
Methods: The study included six patients with RA-induced upper cervical deformity who underwent occipito-C3 arthrodesis. All patients underwent both deglutition contrasting and endoscopy before and after surgery. We examined the relationship between imaging studies and deglutition examinations.
Results: Preoperatively, three patients showed impairment of deglutition. In two patients, contrast medium mistakenly entered the larynx resulting in dysmotility of the epiglottis, and it was impossible to completely close the airway of the respiratory tract. Food residue was found in the larynx in one patient on performing deglutition endoscopy. After surgery, two patients showed dysphagia, and they had shown impairment of deglutition preoperatively. Imaging examinations showed that the O-C2 angle had reduced by 10 degrees in one patient, but the other patient showed no marked difference in the O-C2 angle.
Conclusion: To the best of our knowledge, this is the first report to examine deglutition function before and after O-C3 arthrodesis in patients with RA-induced cervical deformity. The present study demonstrated that the O-C2 angle pre- and postoperatively, and preoperative impairment of deglutition were closely related with postoperative dysphagia.

167. HIGH INCIDENCE OF CERVICAL DEFORMITY AND INSTABILITY REQUIRES SURVEILLANCE IN LOEYS-DIETZ SYNDROME

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Summary: We characterized cervical spine abnormalities in 80 patients with Loeys-Dietz syndrome (LDS), including treatment and complications. Cervical instability (CI) due to vertebral anomalies or focal kyphosis was common.
Introduction: LDS is a connective tissue disorder with vascular and musculoskeletal abnormalities.
Methods: Clinical and imaging data of 80 LDS patients were reviewed. Mean age was 17y (range 3m-75y).
Results: Atlas anomalies: 25 patients (31%) had atlas anomalies: anterior arch defects in 19 (24%), posterior arch defects in 13 (16%), and hypoplasia in 4 (5%). 4 patients with atlas anomalies had atlanto-axial instability requiring surgery.
Axis anomalies: 53 patients (66%) had axis malformation: elongation in 43 (54%), dorsal angulation in 12 (15%), and spondylolysis in 3 (4%). All patients with C2 spondylolysis had subaxial instability requiring surgery.
Subaxial anomalies: 10 patients (13%) had hypoplastic subaxial vertebrae (C3 mode=8), leading to focal kyphosis in 8 and subaxial instability in 9.
CI and Malalignment: Focal kyphosis was present in 12 patients (15%). CI was present in 13 patients (16%); 9 were symptomatic and 6 had cord compression. Of the patients with CI, 8 (10%) had atlanto-axial instability, and 9 (11%) had subaxial instability (Fig 1). 11 patients with CI had vertebral anomalies; 8 had focal kyphosis.
Treatment and Complications: Treatment for CI included surgical fusion in 8 patients and halo application in 1. Mean age at surgery was 4.2y (range 3m-11y). All patients requiring surgery were symptomatic and had vertebral anomalies. Postoperative complications included pseudarthrosis in 5 patients, failure of fixation in 5, junctional kyphosis in 2, and development of occipital-cervical instability in 1, requiring 13 re-operations.
Conclusion: Cervical midline defects are common in LDS, particularly anomalies of C1-C3. CI, particularly subaxial instability, is common, often due to vertebral anomalies or focal kyphosis. Patients requiring surgery often present in early childhood, though periodic surveillance is recommended. This is the first study to report the high frequency of bony anomalies and CI in a large cohort of LDS patients.

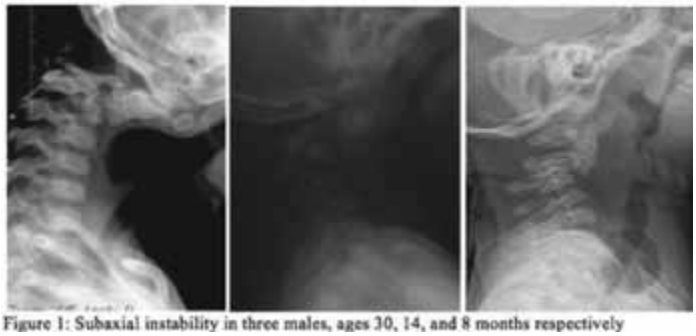

Figure 1: Subaxial instability in three males, ages 30, 14, and 8 months respectively

168. IMPACT OF ETHNICITY ON ADULT SPINAL DEFORMITY (ASD) SURGICAL OUTCOMES: AN ANALYSIS OF JAPANESE AND NORTH AMERICAN DATABASES

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USA

Summary: Research of sagittal malalignment in ASD and its treatment has continued to evolve and grow internationally. Based on an increase in global efforts to better analyze and predict surgical outcomes, we compared outcomes and radiographic correction between two countries (USA and Japan) with high rates of adult deformity surgery to help define the effect of ethnic variation. When thresholds of disability by population were applied, Japanese patients had greater post-operative disability at 2 years and greater spino-pelvic deformity.
Introduction: ASD research and treatment has continued to evolve and grow globally. International studies are now frequently presented

at the SRS but surgeons are unsure of the data comparisons and global relevance of conclusions across ethnicities. We compared HRQOL and radiographs between two countries (USA and Japan) to help define the effect of geographic variation.
Methods: Retrospective, multicenter case series of 337 operative ASD patients with baseline radiographs and ODI from 11 sites across USA (n=235) and Japan (JPN, n=102). Patients were compared pre- and post-operatively in ODI, ODI need for improvement (ODIni, using age/ethnic normative values), and radiographs. Regression was used to define thresholds for disability: USA ODI 41.9, JPN ODI 33.7.
Results: Differences in age (USA 55yrs, JPN 65yrs, $p<0.001$) and primary cases (USA 59%, JPN 98%, $p<0.001$) existed at baseline (BL), but not gender (USA 84%, JPN 84%). BL ODIni was significantly higher in JPN, without a difference in BL ODI (Table). JPN was significantly more deformed at BL (Table). At 2-yr follow-up, both cohorts improved significantly ($p<0.05$), however JPN had significantly higher ODIni without a difference in 2-yr ODI (Table). Both cohorts improved significantly radiographically ($p<0.05$) however, JPN was more malaligned (Table). Applying thresholds of deformity, 46% USA (n=54) were disabled compared to 60% JPN (n=36; p=0.014).
Conclusion: Despite having a greater deformity at BL, there were no significant differences in BL ODI. While both groups improved in ODI and alignment, JPN cohort still had higher offset from the normative age/ethnicity matched values and more spino-pelvic malalignment at 2 yrs—for the same ODI, JPN patients may be masking a greater disability than represented by the score. When population-specific thresholds of disability were applied, JPN patients had a large percentage over the threshold, revealing that 60% were still with lower scores at 2 yrs. The ethnicity of a patient should be considered when interpreting ODI and comparing surgical outcomes for ASD using standard metrics.

169. PROGNOSIS FOR INTRAOPERATIVE SPINAL CORD INJURY IN SEVERE SPINAL DEFORMITY SURGERY IN THE DEVELOPING WORLD

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USA

Summary: This study examines the relationship between Neurophysiological Intraoperative Monitoring (NIOM) events and post-operative neurological function and recovery in the developing world. In a series of 33 patients with identifiable intraoperative NIOM events, six of these had post-operative neurologic deficits. The triggering event in all six patients was related to osteotomy, and four of these patients had persistent deficit at 6-weeks.
Introduction: The risk of NIOM events in severe spinal deformity correction is relatively high. However, the persistence of post-operative deficits in this group is unknown. This study examines the relationship between NIOM events and post-operative neurologic deficits at early follow-up.
Methods: A prospectively collected database was reviewed for all spinal deformity surgery performed by a single site in a West African hospital during a 12-month period. Operative reports and neuromonitoring data were reviewed. The surgical and systemic triggers of significant NIOM events, neurologic status upon procedure completion, and final neurologic status at 6-week follow-up. A significant NIOM event was defined as a 50% or greater decrease from baseline in the amplitude of tibial nerve SSEP, or 75% decrease in the MEP amplitude recorded from the lower extremity muscle with the largest baseline response.
Results: 88 patients met inclusion criteria. The average age was 14 years (3-28), and male:female ratio was 43:45. Diagnoses included idiopathic scoliosis, (20), congenital scoliosis (9), congenital kyphosis (7), congenital kyphoscoliosis (11), idiopathic kyphoscoliosis (5), early-onset scoliosis (6), post-infectious kyphosis (15), and other (15). The average kyphosis was 108° (54-176°); the average scoliosis was 100° (48-177°).
8% (7/88) of patients had new neurological deficits post-operatively. In 6 of these 7 patients, the cause appeared related to osteotomy; in one patient, the cause was not determined. All 7 patients had NIOM changes. By closure, no patient had absence of MEP bilaterally, but 5 patients, lower extremity MEPs remained absent unilaterally.
Only one case was aborted.
No patient had complete loss of neurological function in either lower extremity postoperatively. At six-week followup all patients had either fully recovered, or had preserved motor function bilaterally with the ability to walk (ASIA D or better).
Conclusion: Despite the relative high incidence of intra-operative NIOM events, only 4 of 34 patients had persistent residual post-operative neurological deficit at 6-week follow-up. Our findings support the view that incidence of persistent neurologic injury at early follow-up is low with the use of intra-operative monitoring.

170. PERIOPERATIVE COMPLICATIONS OF TOTAL EN BLOC SPONDYLECTOMY: ADVERSE EFFECTS OF PRE-OPERATIVE IRRADIATION

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Summary: The perioperative complication rate associated with total en bloc spondylectomy for spinal metastasis was significantly higher in patients receiving preoperative irradiation (77.8%) than in those not receiving preoperative irradiation (18.8%). The incidence of complications, such as intraoperative dural injuries, postoperative CSF leakage, wound dehiscence, and pleural effusions, was significantly higher in patients receiving preoperative irradiation.
Introduction: Compared with other spinal surgeries, total en bloc spondylectomy (TES) is associated with a higher complication rate because it is technically demanding and involves patients compromised by cancer. Specifically, perioperative complications are more likely to occur in patients receiving preoperative irradiation. In this study, we examined the perioperative complications associated with TES in patients receiving preoperative irradiation.
Methods: Seventy-seven patients underwent TES between May 2010 and April 2013. We performed a retrospective review of prospectively collected data for 50 patients with metastatic tumors of the thoracic spine, excluding patients with primary spinal tumors, lumbar

spinal metastasis, and combined anterior and posterior approach TES. Patients were divided into 2 groups: those with preoperative irradiation (RT-TES group, 18 patients) and those without preoperative irradiation (TES group, 32 patients). The following perioperative complications, occurring within 2 months of surgery, were compared between groups: intraoperative dural injuries, epidural hematomas, deep surgical-site infections, postoperative cerebrospinal fluid leakage, wound dehiscence, pleural effusions, and neurological deficits.

Results: Significant differences in patient characteristics were not observed between the RT-TES and TES groups. Perioperative TES complications occurred in 20/50 patients (40.0%). The complication rate in the RT-TES group was 77.8% (14 out of 18), or threefold higher, than the 18.8% (6 out of 32) in the TES group ($P < 0.01$). The incidence of complications, such as intraoperative dural injuries, postoperative CSF leakage, wound dehiscence, and pleural effusions, was significantly higher in the RT-TES group ($P < 0.01$).

Conclusion: The perioperative complication rate associated with TES for spinal metastasis was significantly higher in patients receiving preoperative irradiation than in those not receiving preoperative irradiation.

171. ACCURACY OF AUTOMATED ONSITE GENEXPERT PCR TESTING FOR SPINAL TUBERCULOSIS

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Summary: Prospective study of the use of on site GeneXpert PCR testing for diagnostic confirmation of spinal tuberculosis. 71 samples were tested from surgical specimens with a 96% sensitivity and results available by day 2 as opposed to an average of 35 days for the culture. This allows immediate clinical decision making as regards medical management.

Introduction: A new, rapid diagnostic method, the GeneXpert Assay, is an automated sample preparation and real-time PCR instrument. For pulmonary TB, this test has become the gold standard and is a faster alternative to the current testing method, which is sputum, microscopy and culture. Yet, its validation for musculoskeletal TB and diagnostic skeletal samples is still pending.
The aim of this study was to assess the accuracy of an automated PCR sample preparation (GeneXpert assay) for spinal TB.

Methods: A prospective clinical validation study on the diagnostic accuracy of GeneXpert was performed. Tissue samples of enrolled patients with suspected musculoskeletal TB were subjected to on-site automated PCR analysis (GeneXpert assay). The diagnostic performance of a GeneXpert assay was compared to standard tissue culture regarding days to availability of results and accuracy of the test.

Results: Seventy-one spine samples from 69 patients (2 re-biopsies) were included in the study. The GeneXpert showed a high sensitivity of 95.6% compared to the gold standard (cultures) 82.2% in spinal TB. The test results were available by day 2 for the GeneXpert test, compared to an average of 35 days for cultures. The multidrug resistance rate was 5.8% and all cases were diagnosed accurately with the GeneXpert test.

Conclusion: GeneXpert PCR testing of TB dramatically reduced the delay to diagnosis as well as identified drug with a high sensitivity and specificity. This conveys a huge advantage to the clinical management of these patients.

172. ANTERIOR POSTERIOR VERSUS POSTERIOR-ONLY CORRECTION IN ADULT SPINAL DEFORMITY MATCHED CURVES: SIMILAR CORRECTION WITH MORE INTRA-OPERATIVE, BUT FEWER LATE IMPLANT COMPLICATIONS

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USA

Summary: Deformity matched cohort of 54 ASD patients who either underwent either an Anterior/Posterior (AP) or Posterior Only (PO) surgical correction. Baseline demographics are similar, except for baseline health related quality of life measures (HRQOL). Surgical correction for each group is similar, and yields significant improvement in HRQOL at 2 years. Intra-operative complications are higher for AP group, however at 2 years reoperation for rod fractures are higher in the PO group.

Introduction: Multiple options exist for the surgical correction of adult spinal deformity. The choice of these surgical procedures is often based upon surgeon preference, patient profile and curve pattern.

Methods: Prospective, multicenter database. Inclusion criteria age>18, adult spinal deformity, no prior fusion surgery, >4 levels fused, fusion to sacrum, complete radiographic and HRQOL outcomes, min 2yr follow-up. Health related quality of life measures Oswestry Disability Index (ODI), SF36, and SRS-22 were determined for each patient for baseline, one and two years. Anterior/Posterior (AP) surgery was propensity matched to posterior Only (PO) based on baseline SVA, PI-LL mismatch and PT by using linear regression.

Results: 54 patients met inclusion criteria and were matched; AP (27) and PO (27). Baseline demographics were similar for age, BMI, co-morbidity, SVA (76 vs 62mm), PT (24 vs 23), LL (31 vs 40) and PI-LL (19 vs 17); p>0.05. However baseline HRQOL measures were all better for the AP group. At 1 and 2 years HRQL improved statistically for each group, and there was no longer any statistical difference between groups. Radiographic improvement, 1yr and 2yr were similar except for 2 yr PI-LL which was lower for AP (-0.4 vs 7.1; p=.044). Total OR time was greater for AP (528 vs 416min; p=.003), but had similar EBL and hospital stay. More Smith-Peterson Ostotomies, and longer fusion in AP group (4.2 vs 1.9 per pt; p=.005, and 11.9 vs 9.7 levles; p=.015), but similar PSO rate. BMP use was more often in AP group (81% vs 48%; p=.01). Minor intra operative complications occurred more often in the AP group: (63% vs 4%; p=0). Revision operations were more common in the PO group (8 vs 4) due to more late rod fractures (3 vs 0).

Conclusion: Anterior/Posterior versus Posterior only matched curves have similar radiographic and HRQL improvement. AP was associated

with more intra-operative complications, however PO led to more implant related post-operative complications including revision surgery for rod fracture.

173. RADIOGRAPHIC PARAMETERS ASSOCIATED WITH REVISION FOR PROXIMAL JUNCTIONAL KYPHOSIS

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USA

Summary: Between 2003 and 2011, 204 patients who developed proximal junctional kyphosis (PJK) after long spinal fusions were identified. Inadequate correction of lumbo-pelvic mismatch and increasing sagittal imbalance were significantly associated with the need for revision. No differences were observed based on upper instrumented vertebra (UIV).
Introduction: Determining the need for revision surgery in cases of PJK presents a challenging clinical problem. Multiple clinical and radiographic parameters are considered when arriving at the decision for re-operation. We propose to examine which radiographic parameters are most closely associated with proceeding to revision surgery, and whether these differ based on the UIV.
Methods: All patients undergoing fusion from the thoracic spine to the pelvis in a single institution between 2003 and 2011 were reviewed. Inclusion criteria were age over 18, fusion extending from the thoracic spine to the pelvis and radiographs adequate for analysis. Measurement of proximal junctional angle (PJA), sagittal balance and pelvic parameters were performed on pre-operative, post-operative and follow-up long, standing x-rays.
Results: Of 433 patients meeting the inclusion criteria, 204 developed PJK (PJA > 10°), 44 of whom went on to revision surgery. PJA and progression of kyphosis in patients undergoing revision (27°, +15° progression) were not statistically different from patients not requiring surgery at the time of final follow-up (24°, +11° progression; p = 0.08 and p = 0.053). Progression of sagittal vertical axis (SVA) and final SVA were significantly higher in patients undergoing re-operation (+41 and 99 mm) than in those not requiring revision (+9 and 45 mm; p = 0.01). Pre-operative lumbo-pelvic mismatch was statistically similar in both groups (mean 18°), while patients undergoing revision had significantly less correction at the time of initial surgery (-7.6°) compared with those not requiring additional surgery (-13.6°, p = 0.047). Multivariate analysis investigating the association of re-operation with UIV failed to reveal any significant results.
Conclusion: In the final decision governing revision of spinal fusions for PJK, the degree and progression of kyphosis appears less relevant than overall spinal alignment and sagittal balance.

174. A PROSPECTIVE RANDOMIZED TRIAL ON ANTERIOR CERVICAL DISCECTOMY AND FUSION WITH ANTERIOR PLATING AND STAND-ALONE CAGE: INTERIM ANALYSIS OF THE DIFFERENCE IN THE CANAL ENCROACHMENT BY FUSION MASS

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Republic of Korea

Summary: We have been conducting a prospective randomized study comparing cage with plate in anterior cervical discectomy and fusion. During the analysis, we noticed a difference in canal encroachment by fusion mass between the two groups. There was a high likelihood of spinal canal encroachment by fusion mass in the cage group possibly making its use alone a disadvantage in narrow spinal canals.
Introduction: We have been conducting a prospective randomized study comparing cage with plate in anterior cervical discectomy and fusion (www.clinicaltrials.gov, NCT01011569). Our previous interim analysis showed autologous bone graft with plating advantageous over the stand-alone cage for segmental lordosis. During the analysis, we noticed a difference in canal encroachment by fusion mass between the two groups. Because a narrow cervical spinal canal is an important risk factor in the development of cervical spondylotic myelopathy, the potential unexpected risk of spinal cord compression necessitated another interim analysis to investigate whether there was a difference in canal encroachment by fusion mass between the two groups.
Methods: Patients had a minimum 2-year follow-up. Neck disability index, visual analog scale and lateral radiographs including bone fusion patterns were evaluated.
Results: Twenty-nine (M:F = 13:16, mean age; 50.7 years) and 21 patients (M:F = 14:7, mean age; 56.2 years) were in the cage and plate group, respectively. Both groups had the same clinical outcomes, improving after surgery. Fusion began at 2.1 months and 1.3 months and finished at 7.1 months and 3.5 months in 26 (89.6%) and 19 (90.5%) patients in the cage and plate group, respectively. Encroachment into the spinal canal by fusion mass showed a notable difference in the fusion patterns; 22 (75.9%) in cage group vs 3 (14.3%) in plate group (p <0.05).
Conclusion: There was a high likelihood of spinal canal encroachment by fusion mass in the cage group possibly making its use alone a disadvantage in narrow spinal canals.

175. RADIOGRAPHIC CHARACTERISTICS OF BONY SEPTUM OF SPLIT SPINAL CORD MALFORMATION IN PATIENTS PRESENTING WITH CONGENITAL SCOLIOSIS: A RETROSPECTIVE STUDY OF 40 CASES

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Summary: Split spinal cord malformation (SSCM) and congenital scoliosis are all rare congenital spinal anomaly. But the coexistence of congenital scoliosis and split spinal cord malformation (SSCM) is often encountered in the congenital scoliosis corrective surgery. SSCM is definited that the spinal cord is divided by a rigid bony septum or fibrous septum into two parts and is classified into two types. The radiographic characteristics of the bony septum of SSCM are still unknown to us.

Introduction: The aim of this article is try to delineate the configuration and nature of the bony septum. The correlation between congenital scoliosis and SSCM is also discussed.
Methods: We retrospectively reviewed the records of 200 consecutive patients with congenital scoliosis and/or kyphosis who were treated in our hospital during the years 2006 to 2011, among them 65 patients associated with SSCM and were treated by corrective surgery. 40 Patients were classified as SSCM type I and followed up more than 2 years. These patients underwent operations and were retrospectively evaluated.
Results: The figuration, component, location, number, orientation of growth, division of vertebral canal and nature of bony septum are described. 38 of the 40 SSCM (95%) were type I(only has single bony septum). Only 2 cases were type II (has more than 1 bony septum) (5%) at different levels. 22 septum (55%) were mainly made of cortical bone, other 18 septum (45%) were mainly made of cancellous bone and cortical bone, The prominent central blood vessels were found in 19 cases (36%). 23 patients with bony septum mainly were derived from vertebral growth plate and the other 17patients growth direction were derived from neural arches. 37 bony septums (92.5%) divide the spinal canal nearly equally and 3 patients divide the spinal canal unequally. there were 3 bony septums located in the thoracic vertebral, 17 bony septums located in the thoracolumbar vertebral and 19 in the lumbar vertebral.
Conclusion: We assumed that there are two kinds of bony septum derived from in the SSCM patients: 1. the bony septum derived from neural arches and growth to the vertebral body. 2. the bony septum derived from the vertebral body and growth to the neural arches, and the growth plate is always derived from the disc place and not derived from the vertebral body directly. 3. There is always failure of segmentation in the vertebral body or lamina of vertebral arch. 4. Two kinds of bony septum might contribute to the progress of scoliosis and may tether the spinal cord. It is recommended that removal of the bony septum before corrective surgery on the spine.

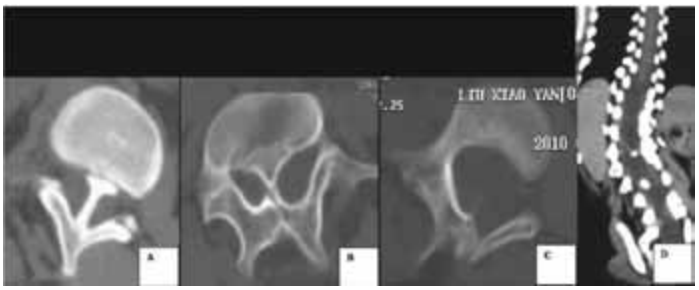

Fig A: bony septum derived from the neural arch direction, the two side spinal canal is equal. B: bony septum derived from the vertebral direction, the two side spinal canal is not equal. The left side is larger than the right side. C: bony septum derived from the neural arch direction and does not reached the vertebral body. D: there are two bony septums in the spinal canal.

176. RADIOGRAPHIC MARKERS OF DISC DEGENERATION FOLLOWING SURGERY FOR ADOLESCENT IDIOPATHIC SCOLIOSIS: A TEN-YEAR FOLLOW UP EVALUATION

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Summary: Radiographic markers of disc degeneration were assessed in a 10 year follow-up prospective study of operative adolescent idiopathic scoliosis. Radiographs were assessed at 4 follow-up time points (first erect, 2, 5, and 10 years) and a composite radiographic score was assigned for each. The earlier time points exhibited lower scores indicating less degeneration; however, longer follow-up revealed increasing signs of degeneration via moderate sclerosis, osteophytes and disc height loss. Investigation of the clinical implications of these findings is planned.
Introduction: The long term impact of spinal fusion on disc health in the unfused distal segments is unknown. Radiographic markers of disc degeneration (RMDD) have been shown to be an effective grading method. The purpose of this study was to assess disc degeneration in the distal mobile segments using these markers following surgery for adolescent idiopathic scoliosis (AIS).
Methods: Through an outcomes study of operative AIS, 6 radiographic parameters of disc degeneration were evaluated on plain posterior-anterior (PA) and lateral (LAT) radiographs in patients following surgical correction of scoliosis. The first-erect (FE), 2, 5 and 10 year follow-up x-rays were scored by a trained radiologist. A composite radiographic score (CRS) of 0-3 was assigned using the most advanced parameter of disc degeneration (0=least degeneration, 3=most degeneration). Changes in the frequency of scores over the post-operative time points were assessed using a Binomial comparison.
Results: Forty-four consecutive patients (mean age 24 years [range 19-28]) from 2 sites were included in this analysis with an average length of follow-up of 10 years (range 9-15). Surgical approach included 11 posterior and 33 anterior fusions. The lowest instrumented vertebrae was T12 in 15 patients, T11 in 8, L1 in 5, L2 in 4, L3 in 9 and L4 in 3. The frequency of the CRS for the PA and LAT films at each of the follow-ups showed progressive degeneration over time, with an increased rate of 2/3 scores exhibited at 10 years versus the earlier visits on the PA(p=0.01) and LAT (p=0.00)(figure 1). Contributing to the maximum CRS at 10 years are RMDD of moderate sclerosis (in 2-7% patients), osteophytes (in 2-14% patients) and disc height loss (10-20% loss in 53-61%, 20-30% loss in 16-21% and >30% loss in 5-7% of patients). None of the patients were smokers.
Conclusion: In this initial attempt to assess RMDD in the young adult AIS patient population, radiographic signs of degeneration were found which progressed over the post-op period. The 10 year follow-up time point showed significant changes via moderate sclerosis, osteophytes and disc height loss. The clinical implications of these findings and the potential continued changes at longer term follow-up are planned for further evaluation.

177. A NOVEL MEASUREMENT OF POST-OPERATIVE AXIAL PLANE ROTATION IN ADOLESCENT IDIOPATHIC SCOLIOSIS USING PLAIN RADIOGRAPHS

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Summary: We describe a novel technique which accurately measures axial rotation of pedicle screws in the post-operative spine. The method is validated by CT scan and has good/excellent inter- and intra-observer reliability.

Introduction: Prior methods of axial rotation measurement depend on an intact and visible spinous process, pedicle, and/or lateral borders of the spinal canal, rely on pre-defined vertebral shape parameters, or require oblique radiographs. Three-dimensional imaging is costlier and/or exposes the patient to additional radiation.

Methods: Patients were included who underwent computed tomography (CT) scan and scoliosis radiographs within sixty days of one another. Posterior to anterior length of the screw was measured on the lateral radiograph; medial to lateral length of the screw was measured on the PA radiograph, both parallel to the floor. Rod width was then measured on both radiographs at the nearest available level for reference. A correction factor δ was calculated to account for magnification differences.

$\delta = L_{Rod,\ Lateral} / L_{Rod,\ PA}$

Visible screw lengths were related using the trigonometric relationship described below to calculate axial rotation.

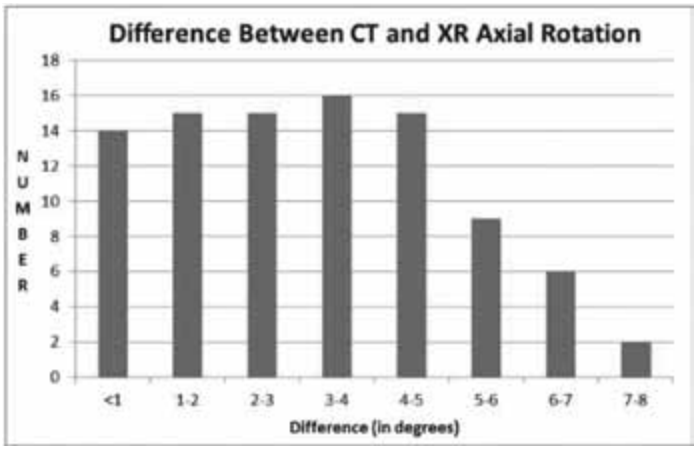
$\theta = \tan^{-1}[L_{Lateral} / (\delta \times L_{PA})]$

Axial rotation was measured on CT scan by a line drawn through the screw body and a line parallel to the floor.

Results: 3,552 instrumented spinal levels in 308 consecutive patients who underwent spinal fusion for AIS over a six-year period were reviewed. 95 spinal levels in nine patients met inclusion criteria. 93 screw tips were visible and distinguishable on both radiographs and CT scan. The average difference between plain radiographs and CT scan was 3.3° +/- 1.9°. 81.7% (76/93) of all pedicle screws measured by this technique were within 5° of the measured value on CT scan.

Intra- and inter-rater reliability were calculated using the intraclass correlation coefficient (ICC 2,1) with absolute agreement. Intrarater reliability for three raters was excellent (average ICC = 0.879); interrater reliability was also excellent (ICC = 0.900). A pedicle screw at the apical vertebra was present and measureable by this technique in 90.3% (272/308) of patients reviewed.

Conclusion: This novel technique accurately measures axial rotation of pedicle screws in the post-operative spine, is validated by CT scan, and has good/excellent inter- and intra-observer reliability. This method may provide an additional resource for future studies to estimate post-operative axial rotation.



Mesaurement discrepancy between CT and radiograph measurement.

178. WHY LUMBAR ARTIFICIAL DISC REPLACEMENTS (ADR) FAIL

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Summary: To determine why A.D.R.'s fail by examining results of 91 patients in F.D.A. studies performed at a single I.D.E. site with minimum two-year follow-up

Introduction: Surgery to treat low back pain (ADR or fusion) has a success rate reported in the literature that ranges from 50-70%. This paper analyses the success rate of ADRs in 91 consecutive patients from IDE trials performed at a single institution. It also scrutinizes the reasons why some patients did not reach the success criteria.

Methods: Consecutive patients (N=91) were evaluated. Failure was defined as less than 50% improvement in O.D.I. and V.A.S. or any additional surgery at index or adjacent spine motion segment. This criterion for success was more stringent than F.D.A. guidelines, which require only a 25% improvement in O.D.I. and V.A.S. for clinical success. Three A.D.R.'s were evaluated: Maverick™ (M) 25 patients, Charité™ (C) 31 patients, Kineflex ™(K) 35 patients. All procedures were one level performed at L4-5 or L5-S1. Facet pain was diagnosed by facet block and significant clinical improvement after facet rhizotomy.

Results: Overall clinical failure occurred in 26%, (24 of 91 patients) at 2 follow up. There was success rate difference among implant types. ADR patients are often either a clinical success at three-month follow-up (home run) or a possible failure (strike out). Only five patients failed after three months. One infection one year after A.D.R. and four patients developed additional pathology unrelated to their A.D.R. One patient went from failure to success after a facet rhizotomy one year after A.D.R.

Conclusion: Seventy-five percent of patients after ADR met strict clinical success after two-year follow-up. The clinical success verses failure rate did not change from their three-month follow-up in 85 of the 91 patients (93%). Home run verse strike out can be determined early. Failures occurred due to: facet pain, 46% of the time; implant complications in 25%; and additional unrelated pathology or disability/narcotic issues resulting in form filling not specific to their ADR in 29% of patients. Implant type appears to impact clinical success. These results indicate overall clinical success can be

improved most by patient selection and implant type. Patients with a B.M.I. over 34, multiple orthopedic and/or medical pathology, facet pain, or disability/narcotic issues have a higher failure rate with A.D.R.

179. HALO-GRAVITY TRACTION IMPROVES THORACIC KYPHOSIS CORRECTION FOR THOSE EARLY ONSET SCOLIOSIS PATIENTS UNDERGOING GROWING SPINE TECHNIQUES

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USA

Summary: The use of HGTx is a safe and effective technique in EOS and when used prior to placement of a growing spine construct demonstrates a statistically significant improvement in T5-T12 and overall thoracic kyphosis after growing construct insertion compared to those without HGT.

Introduction: Preoperative halo-gravity traction (HGTx) has been used to correct severe spinal deformity, but the benefits when used prior to placement of a growing spine construct are unknown. Thus, we compared radiographic parameters of patients who underwent placement of a growing construct with or without preoperative HGTx.

Methods: Review of a prospectively collected database. All patients ≤ 10 years of age who underwent placement of a growing spine construct. Patients treated with and without HGTx were matched 1:1 on preoperative main and proximal thoracic Cobb measurements. Postoperative radiographic results were compared within groups using paired t-tests and between groups using independent sample t-tests.

Results: 15 patients (8M, 7F) who underwent growing construct placement with preliminary HGTx were matched to 15 patients (4M, 11F) who did not have HGTx prior to placement of a growing construct. The 2 groups did not differ in any preoperative radiographic parameter. The mean measurement time was 2.4 months after growing construct placement and compared to baseline with or without HGTx. Both groups demonstrated significant improvements in proximal thoracic Cobb, main thoracic Cobb, thoracolumbar/lumbar Cobb, apical vertebral translation, and space available for the lung (Table 1). Patients who underwent preoperative HGTx demonstrated statistically significant improvements in T5-T12 kyphosis and total thoracic kyphosis while patients without HGTx did not (Table 1). Patients who underwent HGTx also experienced a greater overall amount of kyphosis correction (28.11° vs -1.36°, $p<0.01$) and a greater proportional improvement in thoracic kyphosis (47.69% vs -12.08%, $p<0.001$).

Conclusion: The use of preoperative HGTx for patients ≤ 10 years of age improves thoracic kyphosis correction in EOS for patients undergoing implantation of a growing spine construct.

180. RECONSTRUCTION OF WIDE LAMINECTOMY DEFECTS WITH FEMORAL STRUT ALLOGRAFT (FSA) FOLLOWING THREE-COLUMN OSTEOTEOMIES (3CO)

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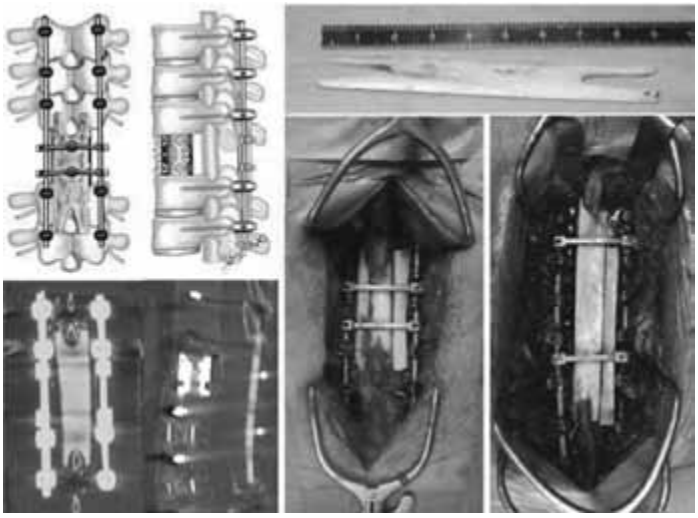
Summary: Femoral strut allografts (FSA) are effective in reconstructing wide laminectomy defects and help to prevent potential complications following three-column osteomies (3CO).

Introduction: Wide laminectomies needed for three-column osteotomies (3CO) leave huge posterior defects prone to serious complications. Postop epidural hematoma compression causing neurological deficit, dural sac adhesions and instability due to a huge posterior defect, loss of correction and pseudoarthrosis are potential complications. Reconstruction of these defects may prevent these potential complications.The aim of this study is to evaluate the efficacy of femoral strut allografts (FSA) that we use for the reconstruction of laminectomy defects.

Methods: 46 pts (25F,21M), with mean age 35 (5-83) years who had wide laminectomy defects due to 3CO and underwent reconstruction by FSA with more than 2 yrs f/up were included. During surgery a high speed burr was used to make a saddle-shaped cut at the both ends of strut graft for creation of H-shape (Fig.1). FSA was placed press-fit in between adjacent intact spinous processes over the laminectomy side. Cross-bar(s) were placed tightly over FSA to prevent its dislodgement. Local autografts were placed underneath both H ends to promote fusion. Preop, postop and f/up standing AP/L x-rays were reviewed and 3D CT scan was performed to evaluate the integration of FSA.

Results: Av f/up was 38,3 (27-65) months. Osteotomies were grade 3 in 5 pts, grade 4 in 3 pts, grade 5 in 35 pts and grade 6 resections in 3 pts according to Schwab's osteotomy classification. Av length of laminectomy defect was 57.67mm (range:24.56-118.05mm) and av length of FSA was 94.99mm (range:46.81-168.59mm). There were no significant correction losses in both coronal and sagittal plane corrections during f/up ($p>0.05$). There was no infection, breakage, migration, dislodgement or resorption of FSA. Complete incorporation/fusion of both ends of FSA was observed in 37 (80.4%), partial fusion of both ends was observed in 9 (19.5%) pts with 3D CT scan at the final f/up.

Conclusion: This study demostrated that FSA was effective in reconstruction of wide laminectomy defects after three-column osteotomy. Complete fusion of FSA in 80% of the cases also showed that FSA not only help to prevent potential complications of wide laminectomy defects but also provide posterior structural support and act as a second stabilizator preventing mechanical failures.



181. PROSPECTIVE, MULTICENTER ASSESSMENT OF NON-OPERATIVE TREATMENT OUTCOMES AND CONVERSION TO OPERATIVE TREATMENT FOR ADULT SPINAL DEFORMITY: MINIMUM TWO-YEAR FOLLOW UP

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USA

Summary: Of 225 adult spinal deformity (ASD) patients who elected for nonoperative (nonop) treatment, 19% converted to surgery at minimum 2-yr follow-up. Those who converted to surgery had greater baseline sagittal spinopelvic deformity and poorer HRQL scores. Surprisingly, appearance was a driver of operative (op) conversion. These data suggest that nonop care at best maintains pain and disability levels and patients with greater pain and disability tend to convert to op care.

Introduction: First-line treatment for ASD is typically nonop. Our objective was to assess outcomes of nonop care for ASD and compare those who converted to op vs those who remained nonop.

Methods: This is a multicenter, prospective analysis of consecutive ASD patients electing for nonop care. Inclusion criteria: age>18 yr, ASD and min 2-yr follow-up or conversion to op care. Efforts were made to maximize standard multimodality nonop care.

Results: Of 225 patients (mean age=53 yrs), 42 (19%) converted to op at a mean of 12.5 mos. At baseline, those who converted to op had greater BMI (27.3 vs 25.2, p=0.041), greater pelvic tilt (23° vs. 19°, p=0.043), greater pelvic incidence to lumbar lordosis mismatch (11° vs 4°, p=0.038), trend toward greater C7 SVA (70 vs 52 mm, p=0.075), greater ODI (37 vs 22, p<0.001), worse SF36 PCS (35 vs 44, p<0.001) and MCS (45 vs 51, p=0.012), worse SRS-22 (3.0 vs 3.6, p<0.001) and worse back (6.4 vs 4.4, p>0.001) and leg (4.4 vs 2.3, p<0.001) pain, but did not differ based on age (p=0.2), gender (p=0.3) or coronal Cobb angle (p=0.8). On multivariate analysis the only factors in the best-fit model were ODI (p=0.005) and SRS Appearance (p=0.032). Patients who converted to op had modest worsening of ODI (40 vs 37, p=0.085), SF36 PCS (33 vs 36; p=0.009) and back pain (7.1 vs 6.3, p=0.024) prior to surgery, but other outcomes and radiographic measures did not significantly change. Min 2-yr post-op follow-up was available for 27 who converted to op, and all HRQL measures improved significantly (p<0.007). Those remaining nonop had no clinically significant changes in HRQL during the observation period.

Conclusion: Of 225 ASD patients treated nonop, the 19% who converted to op had greater baseline sagittal spinopelvic deformity and poorer outcomes scores. Surprisingly, appearance was a driver of operative conversion. These data suggest that nonop care at best maintains levels of pain and disability and patients with greater pain and disability tend to convert to op care.

182. FOUR RODS PREVENT ROD BREAKAGE AND PSEUDARTHROSIS IN PEDICLE SUBTRACTION OSTEOTOMIES

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USA

Summary: Non-unions and rod breakages are well-known complications of pedicle subtraction osteotomies. Multiple rods appear to help in osteotomy closure and prevent rod breakages. This study demonstrates that the four rod technique is successful in preventing non-unions and rod breakages compared to just two rods.

Introduction: Pedicle Subtraction Osteotomies have been widely used to treat sagittal plane deformities. The purpose of this study was to assess two methods of posterior instrumentation (2 rods vs. 4 rods) used in the surgical technique when performing pedicle subtraction osteotomies.

Methods: A retrospective review of consecutive pedicle subtraction osteotomies was performed at two centers where the only major difference in the technique was the use of 2 rods vs. 4 rods. Center 1 using 4 rods had 29 pts and Center 2 using 2 rods had 20 pts that were analyzed. The clinical as well as the radiographic data was reviewed. Statistical methods used were two-sample t-tests and Fisher's Exact Test using R,version 2.13.0 (R Core Team, 2013).

Results: All cases at both centers were revision cases. The mean preoperative SVA (p=0.014), CSVL (P=0.004), and PI + TK + LL (P=0.033) were significantly larger for Center 1 than for Center 2. Similarly, the mean postoperative thoracic kyphosis (p=0.001), SVA (P=0.049), CSVL (P=0.042), and PI + TK + LL (P<0.001) were significantly larger for Center 1 than for Center 2. Changes from preoperative to postoperative radiographic measurements did not differ significantly including the PSO angle between institutions. A rate of pseudarthrosis of 5 out of 20 with 2 rods was significantly greater than 1 out of 29 with 4 rods (P = 0.035). Rod breakage was higher 5 out of 20 with 2 rods than 0 out of 29 with 4 rods (P = 0.008). The broken rods were Stainless (5.5 mm & 6.35 mm) and CoCr (5.5 mm, 6.0 mm & 6.0 mm). Three out of five patients from Center 2 with a pseudoarthrosis had BMP used. The patient with a pseudarthrosis from Center 1 had an infection and developed a pseudarthrosis after rod removal. Rates of other major and minor complications did not differ significantly.

Conclusion: Both techniques can be successfully used to correct sagittal plane deformity. Four rods are more successful in avoiding pseudarthrosis and rod breakage.

183. A MINIMALLY DISRUPTIVE MUSCLE SPARRING APPROACH IN MIS ITS EFFECT ON PATIENT OUTCOMES: A COMPARISION TO THE OPEN APPROACH

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USA

Summary: A Study compared the effects of a minimally disruptive muscle sparring approach for lumbar fusion to the classic open approach. The results revealed less blood loss,shorterOR times, reduced narcotic use,reduced hospitalization,sooner return to work,and improvements in outcome measurements in the MIS group compared to the open group. This was primarily attributed to the muscle sparring approach that limited the damage to the multifidus.
Introduction: Minimally Invasive spine surgery for lumbar fusion is an attractive concept with advantages for the surgeon, patient, and hospital. Questions arise as to the effect it really has on patient outcomes and its comparison to the open appoach. For this to be accepted it should have similar if not better outcomes to the classic approach in terms of fusion rates,shorter hospitalization,less blood loss,less muscle damage,more rapid recovery,and quicker return to work. The impetus centers on the need to minimize muscle damage and moreso damage to the multifidus that is seen in the classic open approach. The open approach strips the paraspinal muscles leading to increased blood loss, postoperative pain and loss of function
Methods: 200 patients with100 in the open(OG)and100 in the minimally disruptive(MIS) groups were compared.All were single level fusions with similar diagnosis,instrumentation,interbody implants and bone grafting. All were evaluated for OR time,Blood loss,Duration of Hospitalization,Narcotic use,Fusion rates,Return to work status and Outcomes via the ODI, SF36,BPS,andVAS.
Results: OG:OR time110min,Blood Loss300ml,Hospitalization3.3days, Narcotic use51hrs,Fusion rate:93%
MIS:OR time90min,Blood Loss75ml,Hospitalization1.5days,Narcotic use25hrs,Fusion rate: 95%
Return to Work:OG/MIS:one month15/30%,three months30/60%,six months72/94%,1year:82/97%2years80/97%
ODI:OG/MIS:preop52.5/54.1postop28.4/12.2
SF36:OG/MIS:preop27.6/27.1postop39.7/49.6
BPS:OG/MIS:preop16.4/17.1postop8.1/2.0
VAS:OG/MIS:preop8.8/9.3postop5.5/1.0
Conclusion: The Minimally Disruptive Muscle sparring approach for MIS offered a shorterOR time,less blood loss,shorter hospitalization,quicker entry into PT and leading to sooner return to work and continuation of work compared to the open approach. Improved outcomes were noted for the Minimally Disruptive MIS compared to the open attributing this to muscle sparring and trauma limiting damage to the multifidus the primary posterior dymnamic stabilizer. Most importantly,similar fusion rates were noted but significantly more patients returned to work sooner and continued to work,again atributed to the minimally disruptive muscle sparring of this approach and procedure.

184. PROSPECTIVE FDA IDE CLINICAL SAFETY TRIAL OF A SCOLIOSIS GROWTH MODULATION CLIP/SCREW DEVICE: ONE-YEAR RESULTS

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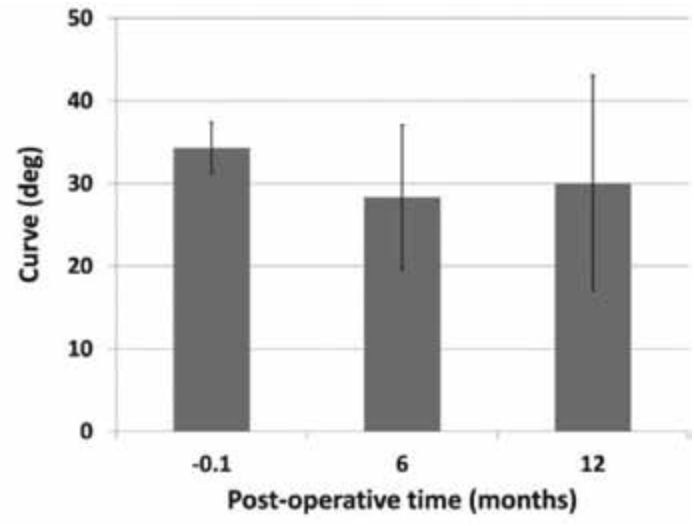
USA

Summary: Spinal growth modification using titanium clip/screw device was prospectively tested in an FDA IDE clinical safety trial in children with progressive scoliosis. Mean thoracic curve Cobb angles were 34° preoperatively and 30° one year after surgery.
Introduction: The purpose of this study was to determine 1-year results of a prospective, first human use, FDA Investigational Device Exemption (IDE) clinical safety trial of a titanium clip/screw device in children with late juvenile and early adolescent idiopathic scoliosis (www.clinicaltrials.gov Identifier: NCT01465295).
Methods: Six patients with progressive idiopathic scoliosis underwent endoscopic placement of a titanium clip/screw device (IRB approved). Inclusion criteria were Lenke 1A and 1B single thoracic curves, Cobb angle 25° to 40°, Cobb levels between T3-L1, age > 10 years, open triradiate cartilages, Risser stage 0, thoracic kyphosis < 40°, females pre-menarchal. Criteria were chosen to include only patients at high risk for progression to >50°.
Results: No device related adverse events occurred. A procedure-related mucous plug secondary to single lung ventilation in one patient resolved after bedside bronchoscopy. A chylous effusion in one resolved with pigtail catheter and nonfat diet. No device misplacement in spinal canal or disc space, no neuromonitoring changes or neurological deficits, and no device breakage or loosening was noted. Mean post-op hospital stay was <4 days. Surgical implantation time averaged 90 min (range 57-124). Mean blood loss was <75 ml. Mean major curve Cobb angle was 34° preoperatively and 30° at one year. In one patient, the thoracic curve increased 14°from pre-operative baseline. The greatest thoracic curve correction was 72%. Approval was granted for next 30 subjects.
Conclusion: At 1 year, mean curves did not increase from baseline after implantation of a titanium clip/screw implant in a small prospective cohort of very immature patients at extremely high risk of progression. In this initial safety study, blood loss was minimal, surgical times low, and no device failure or misplacement occurred. Curve changes were variable, but included proof of concept of growth modification in humans by this method.



185. ANTERIOR COLUMN REALIGNMENT (ACR): MINIMUM TWO-YEAR FOLLOW UP OF CLINICAL AND RADIOGRAPHIC OUTCOMES

Drew Brown, MD; Gregory M. Mundis, MD; Navid R. Arandi; Ali Bagheri, MD; Stacie Nguyen, MPH; Robert K. Eastlack, MD; Ramin Bagheri, MD; Behrooz A. Akbarnia, MD
USA

Summary: Anterior Column Realignment (ACR) is a novel minimally invasive technique using the lateral transpsoas approach for the treatment of adult sagittal plane deformity. At 2year follow-up, ACR demonstrated a maintenance of sagittal alignment and an improved pain profile.
Introduction: ACR is a novel technique using a lateral transpsoas approach with release of anterior longitudinal ligament for correction of adult sagittal plane deformity. This is the first 2 year outcome study using ACR as a minimally invasive alternative to pedicle subtraction osteotomy (PSO) in select patients.
Methods: Retrospective multi-center case-series of consecutive pts with clinical, radiographic, and HRQOL outcomes of pts who underwent ACR with a minimum 2 year follow up.
Results: 16 pts with a mean age of 62 yrs (35-75) and a mean follow-up of 37 months (22-89) were identified. 13 of 16 (81%) had previous spine surgery. All pts had an open posterior approach, 14/16 having a Ponte osteotomy and 2 with a PSO, in addition to ACR.
Radiographic: Motion segmental angle (MSA) was 4° preoperatively corrected to -23°, and maintained at -21° at latest follow-up. The mean lumbar lordosis (LL) was -19° preoperatively improved to -45° and maintained at -43° at latest follow-up. Pts with preoperative negative T1 spino-pelvic inclination (T1SPI) corrected from -7° to -4° and those with zero or positive T1SPI corrected from 6° to -1°at latest follow up. Significant changes occurred from pre- to post-op with pelvic tilt, sacral slope, thoracic kyphosis max, intradiscal angle (IDA), MSA, LL, and pelvic incidence- lumbar lordosis mismatch (PI-LL). A significant mean change was also found on pre-op to latest follow up for IDA, MSA, LL, and PI-LL mismatch (table 1).
Clinical: VAS, ODI, and SRS-22 were 6.9, 57.1, and 2.3 preoperatively and improved to 3.6, 38.3, and 3.0 respectively at latest follow-up.
9 pts (56%) had 11 complications. 7 pts (43.8%) had a major complication and 4 (25%) had a minor complication.
Conclusion: At 2 year follow up, ACR demonstrated maintenance of sagittal alignment and an improved pain profile. The small sample size and retrospective study design are the major limitations of the study. Complications analysis is confounded by an open posterior approach on all pts with concomitant use of osteotomies. Meticulous attention to detail during surgery and careful patient selection are key to the ACR technique.

186. TWO-LEVEL SPINAL OSTEOTOMY FOR SEVERE THORACOLUMBAR KYPHOSIS IN ANKYLOSING SPONDYLITIS: EXPERIENCE WITH 48 PATIENTS

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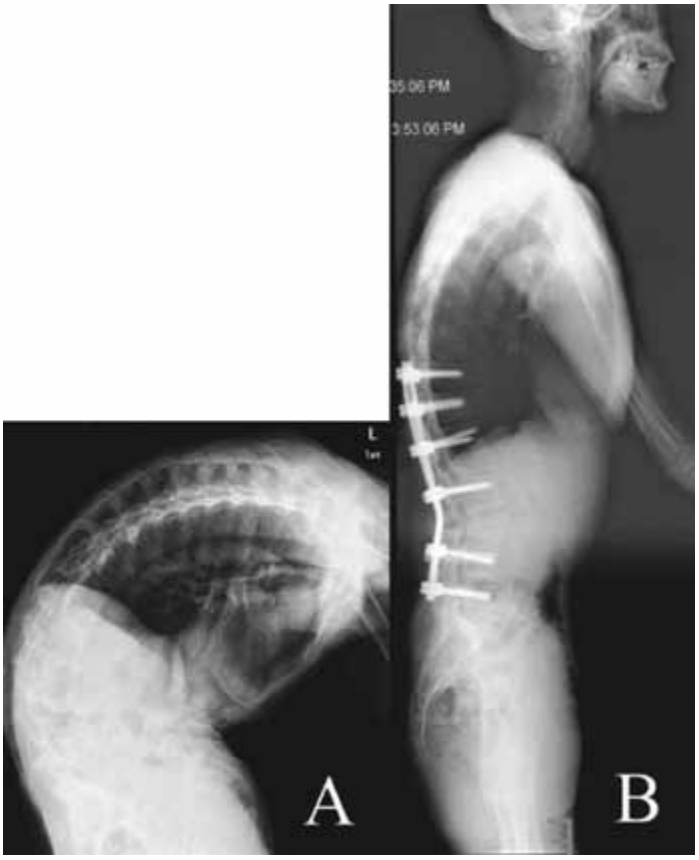
China

Summary: Only a few literatures reports two-level osteotomy in ankylosing spondylitis patient.
The purpose of this investigation was to document the preoperative plan, design, and
effects of single-stage interrupted two-level spinal osteotomy for correcting severe
thoracolumbar kyphotic deformities in ankylosing spondylitis.
Introduction: Transpedicular osteotomy in the lumbar spine is the major approach to correct kyphosis in ankylosing spondylitis. Most surgical procedures were performed at one level and only a few literatures reports two-level osteotomy in one patient.
Methods: From January 2003 to June 2011, we reviewed 48 patients suffering from AS with severe thoracolumbar kyphosis who underwent stage two-level spinal osteotomy in our hospital. The osteotomies were performed at T12 and L2 or L1 and L3, according to the apex of kyphosis. Preoperative and postoperative height, chin-brow vertical angle, sagittal balance, and the sagittal Cobb angle of the vertebral osteotomy segment were documented. Intraoperative, postoperative, and general
complications were recorded.
Results: The chin-brow vertical angle (CBVA) improved from 65.0±28.0° to 5.0±10.0° (P=0.000) and the sagittal imbalance distance improved from 26.9±10.4 cm
to 10.6±5.6 cm (P=0.000). The mean amount of correction was 24.9° at the superior site of the osteotomy and 38.1° at the inferior site of the osteotomy. Postoperatively, all patients could walk with horizontal vision and lie on their backs. No major acute complications such as death or complete paralysis occurred. Five patients suffered complications such as infections (n=1) and CSF leaks (n=4). Both ODI and SRS scores improved largely. Fusion at the osteotomy site was achieved in each patient and no implant failures were noted.
Conclusion: Single-stage two-level osteotomy can effectively and safely correct kyphotic deformities of the thoracolumbar spine caused by ankylosing spondylitis.



A AS kyphosis deformity. A: preoperative X-ray shows the apex of the kyphosis is located at L2/3 disc; B: two level spinal osteotomies were performed at L1 and L3. Postoperative X-ray shows that a harmonious lumbar lordosis was achieved and the whole alignment is very good.

187. OUTCOMES OF LUMBAR SPINE SURGERY IN PATIENTS WITH PARKINSON'S DISEASE

Branko Skovrlj, MD; Javier Guzman, BS; Samuel K. Cho, MD; John Caridi, MD
USA

Summary: PD patients undergoing lumbar surgery for degenerative conditions have increased LOS and costs when compared to patients without PD. Uninsured patients with PD, possibly due to advanced PD secondary to limited healthcare access, are nearly 9 times more likely to have a revision following the index surgery.

Introduction: Parkinson's disease (PD) is increasingly recognized as an important cause of spinal disorders requiring surgical correction. Spinal decompression and/or fusion can be complicated due to poor bone quality and severe muscular dysfunction in this patient population. The purpose of this study was to assess characteristics and outcomes of patients with PD undergoing lumbar spine surgery for degenerative conditions.

Methods: The National Inpatient Sample was examined from 2002 to 2011. Patients were included for study based on ICD-9-CM procedural codes for lumbar spine surgery and further substratified to degenerative diagnoses. Incidence and baseline patient characteristics were determined. Multivariable analysis including patient characteristics (e.g. gender, age, race, insurance type), hospital characteristics and major comorbidities was done to determine independent risk factors increasing incidence of lumbar fusion revision in PD patients.

Results: PD patients account for 0.8% of all degenerative lumbar procedures. At baseline, PD patients are older (70.4 versus 58.9, $p < .0001$) and are more likely to be male (58.6% male, $p < .0001$). Mean length of stay (LOS) was increased in PD patients undergoing lumbar fusion (5.1 days versus 4.0 days, $p < .0001$) and lumbar fusion revision (6.2 days versus 4.7 days, $p < .0001$). Costs were 8.0% ($p < .0001$) higher for lumbar fusion and 25.1% ($p < .0001$) higher for lumbar fusion revision in PD patients when compared to those without PD. Multivariable analysis indicates that osteoporosis, fluid/electrolyte disorders, blood loss anemia, Medicare, Medicaid and, in particular, no insurance (OR 8.8, $p < .0001$) are significant independent predictors of lumbar fusion revision in patients with PD.

Conclusion: Patients with PD undergoing lumbar spine surgery are a challenging population due to their poor bone quality and severe muscular dysfunction. PD patients with osteoporosis make these procedures increasingly difficult and should be managed with special attention to avoid revisions.

Patient characteristics and outcomes in patients with PD and no PD

Population	No PD	PD	p-value
Females	52.90%	41.40%	< .0001
Mean Age (years)	58.9	70.4	< .0001
Elixhauser Comorbidity Index	0.5	6.7	< .0001
Mean Costs ($USD)			
Lumbar Decompression	12,365	12,469	0.717
Lumbar Fusion	27,272	29,427	< .0001
Lumbar Fusion Revision	31,866	39,885	< .0001
All Lumbar Procedures	21,225	20,545	0.016
Mean Length of Stay (days)			
Lumbar Decompression	3.3	4.1	< .0001
Lumbar Fusion	4.0	5.1	< .0001
Lumbar Fusion Revision	4.7	6.2	< .0001
All Procedures	3.7	4.1	< .0001

Significant Independent Predictors of Lumbar Fusion Revision in PD patient population

Risk Factor	Odds Ratio	Lower 95 %CI	Higher 95% CI	P value
Osteoporosis	1.9	1.02	3.50	0.0418
Psychiatric	2	1.03	3.90	0.0412
Medicare	1.4	0.86	2.43	< .0001
Uninsured*	8.8	0.93	83.41	< .0001

Confidence Interval=CI, United States Dollars=USD, Parkinson's Disease=PD
*Reference for Insurance is private

188. LAMINOPLASTY VERSUS LAMINECTOMY AND FUSION TO TREAT CERVICAL SPONDYLOTIC MYELOPATHY: OUTCOMES OF THE PROSPECTIVE MULTICENTER AOSPINE INTERNATIONAL CSM STUDY

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Canada

Summary: We present an analysis of a prospective observational multicenter study examining outcomes of surgical treatment for CSM.
Introduction: Recent studies conducted in North America have demonstrated benefits of surgical treatment for symptomatic CSM. However, differences in pathology, comorbidities, treatment approaches and cultural response to treatment may affect the generalizability of these findings at the global level.
Methods: Patients receiving surgery for clinically symptomatic CSM were enrolled in a prospective multicenter, cohort study which is continuing to accrue subjects at 16 sites in Europe, Asia, North and South America. Subjects included were a part of a larger ongoing prospective observational study that has enrolled 492 subjects with CSM involving 16 clinical sites in Europe, Asia, North and South America. Of those, 108 received laminectomy and fusion; 66 received laminoplasty. The choice of surgical approach was at the discretion of the surgeon. Outcome measures were mJOA, the Nurick scale, NDI and the SF36 PCS and MCS Component Scores.
Results: Average age was 60.2 years (SD 10.8), 29.8% were female. Subjects threated with laminectomy and fusion had more levels operated (5.0 vs. 4.4, P<.01), shorter length of stay (7.7 vs. 15.7 days, P < .01) and, less severe neurologic impairment measured by mJOA (12.6 vs. 11.2, P < .01). There were no differences in age, and baseline NDI, SF36v2 PCS and SF36v2 MCS. At 12 month follow-up, there were no differences in neurologic and functional outcomes for laminoplasty compared to laminectomy and fusion; mJOA (3.0 and 2.3, respectively, P=0.15). Moreover, there were no differences in NDI (13.3 and 12.0, respectively, P=0.71), SF-36v2 PCS (8.5 and 7.7, respectively, P=0.66) and SF-36v2 MCS (7.9 and 6.9, respectively, P=0.56).
Conclusion: Patients undergoing laminectomy and fusion and laminoplasty surgery for CSM show similar improvements in generic and disease specific outcome measures allowing for baseline differences in clinical presentation between the two groups of patients. Longer term follow-up will be required to determine whether any differences in outcome between the two forms of treatment emerge.

189. SURGERY IN POTT'S DISEASE: EXPERIENCE OF 135 CASES

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Bangladesh

Summary: Tuberculosis of spine accounts a major form of bone TB in developing country like Bangladesh. Proper diagnosis before treating this condition is essential as vertebral body collapse due to TB may be misdiagnosed as compression fracture.For patients with thoracolumbar spinal tuberculosis anterior debridement, auto graft bone fusion, anterior or posterior fixation appears to be effective in arresting disease, correcting kyphotic deformity and maintaining correction until solid spinal fusion.
Introduction: Tuberculosis of the spine is the most common and dangerous form of TB infection accounting 50 to 60% of osseous tuberculosis. Although uncommon, spinal TB still occurs even in both developed and developing countries. The diagnosis of spinal tuberculosis is difficult and it commonly presents at an advanced stage. Delay in establishing diagnosis and management cause spinal cord compression and spinal deformity. Patients mostly present with lower limb weakness, Gibbus, pain, palpable mass and Kyphotic deformity in long standing cases.
Methods: 135 patients who had tuberculosis of the thoracic and lumbar spine with moderate to severe cord compression were studied. Variable degrees of neurological deficit with deformity were treated at NITOR and BSOH, DHAKA in the period from 2008 to December, 2013. Anterolateral decompression and autogenous strut bone grafting with simultaneous fixation by screws and rods were done. Posterior decompression, posterior interbody and posterolateral fusion by bone graft with stabilization by transpediculer screws and rods. Appropriate anti TB drugs were given to all patients for 18-24 months. The postoperative follow-up period was 12 months (range: 3 months to 21 months).
Results: 99 cases with neurological deficits recovered totally or partially. No neurological improvement had occurred in 16 cases with paraplegia. 13 cases were lost from follow-up. X-ray showing bony fusion was achieved in all cases for mean of 6 months (ranging 4-8 months). There was no recurrence. 7 cases developed bed sore post operatively.
Conclusion: For patients with thoracolumbar spinal tuberculosis anterior debridement, auto graft bone fusion, anterior or posterior fixation appears to be effective in arresting disease, correcting kyphotic deformity and maintaining correction until solid spinal fusion.

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201. THE EFFECT OF METAL DENSITY ON THORACIC AND LUMBAR CURVE CORONAL CORRECTION IN THORACIC ADOLESCENT IDIOPATHIC SCOLIOSIS

Paul Rushton; Saumyajit Basu, MD; Ashley A. Cole, DM, FRCS (Tr&Orth); Michael Grevitt, FRCS(Orth)
United Kingdom

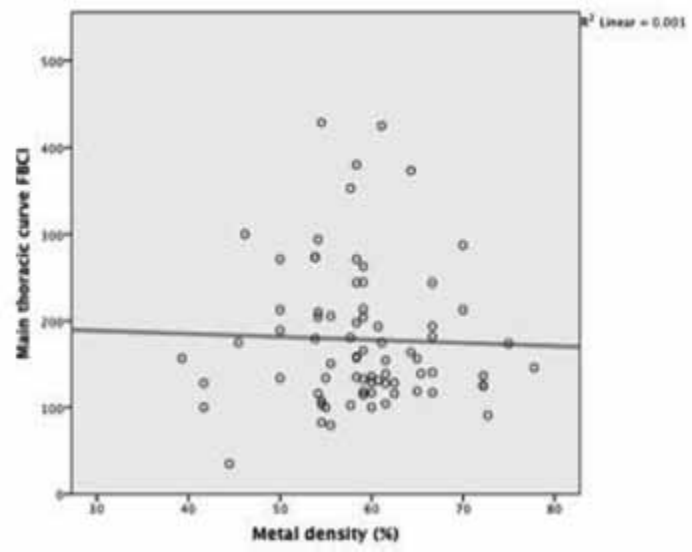
Summary: The influence of metal density on curve correction of adolescent idiopathic scoliosis remains controversial. We report 2 year outcomes of a multicentre international cohort of 77 patients with Lenke 1 or 2 curves who underwent single stage posterior only surgery. Metal density varied from 39-78% and did not correlate with main thoracic or lumbar curve fulcrum bending correction indices. Increasing metal density does not improve coronal curve correction in AIS.

Introduction: Pedicle screw constructs allow greater curve correction in AIS than hook or hybrid constructs. To date the ideal number of screws per level, or metal density, remains controversial. Current literature is contradictory and mainly composes small single surgeon case series that often fail to consider curve flexibility. This multicenter international study seeks to assess the influence of metal density on coronal curve correction using fulcrum bending correction index (FBCI).

Methods: Study design: Retrospective multicenter case series
Inclusion criteria: Lenke 1-2 AIS, curve flexibility assessed by fulcrum bending technique, single stage posterior only surgery, variable metal density up to 80%, >2 year follow up.
Outcome measures: Coronal main thoracic and lumbar curve correction, FBCI, metal density (number of instrumented pedicles vs total available).
Surgical technique: Standard technique used in all centres using extra hard titanium-aluminium-niobium alloy 6mm diameter rods (DePuy Synthes, Raynham PA) with reduction of the curvature via cantilever - segmental translation manoeuvres. Implant location and density was according to curve stiffness and intra- operative bone density. The majority of the implants were on the thoracic curve convexity.
Analysis: Pearson's correlation coefficients for metal density vs FBCI for main thoracic and lumbar curves.

Results: 77 patients, mean age 14 years underwent surgery by one of three surgeons at different centres. Mean preoperative main thoracic Cobb angle of 63° was corrected to 22° (65%) with FBCI of 178% (35-429). Mean preoperative lumbar curve of 39° was corrected to 14° (66%), FBCI of 88% (16-218). Metal density varied from 39-78%, mean 59%. Metal density did not correlate with main thoracic curve correction index ($r=-0.03$, $p=0.8$) or correction index for the largely uninstrumented lumbar curve ($r=-0.07$, $p=0.6$).

Conclusion: Increasing metal density does not improve coronal curve correction in AIS. As healthcare costs must be increasingly justified this should be considered by the treating surgeons.



Graph of main thoracic curve fulcrum bending correction index vs metal density.

203. IS BONE MINERAL DENSITY REDUCED IN CHILDREN WITH ADOLESCENT IDIOPATHIC SCOLIOSIS? AN AGE-MATCHED COMPARISON USING CT ATTENUATION

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USA

Summary: AIS is associated with reduced BMD. Past studies have used DXA scans to generate these data. CT attenuation, where available, is more specific and sensitive than DXA. This study evaluated the utility CT attenuation in elucidating differences in BMD between AIS patients and healthy controls.
Introduction: In AIS, up to 40% of patients have a reduced bone mineral density (BMD); this osteopenia affects the axial and appendicular skeleton. Dual x-ray absorptiometry (DXA) is the traditional method of quantifying BMD. CT attenuation can now be used to generate estimates of bone density; it can also potentially be derived from intra-operative imaging, providing the possibility of a rapid perioperative characterization of BMD. The aim of this study was thus to evaluate the utility of CT attenuation in elucidating differences in BMD in a cohort of patients with AIS compared to a healthy age matched cohort.
Methods: Patients aged 8-17 years who were otherwise well but presented emergently, and had a CT scan of their abdomen in the course of their presentation were used as normal controls. A parallel cohort of patients with AIS who had also had a CT scan that included imaging of their L1 vertebra was identified. Patients were matched by age with the controls. Their CT scans were reviewed, and a region of interest in the body of L1 highlighted. Values for mean CT attenuation in Hounsfield units were then derived and compared between groups.
Results: Of around 2000 potential controls and subjects screened, a total of 157 subjects were included in this study. All were female, with 134 controls and 23 AIS patients. Mean CT attenuation in the control group was 262 Hounsfield Units (HU) and 197.4HU in the AIS cohort. While controls were available from age 8-17 years, AIS study subjects ranged from 11 to 16years. Age matched analysis showed significant differences between the control and study group for all but one age group compared, with CT attenuation lower in the AIS cohorts.
Conclusion: This study demonstrates, using CT attenuation, the differences in estimates of BMD between AIS patients and matched controls. In line with the literature, patients with AIS were generally found to have lower values than age matched controls. CT attenuation has greater sensitivity and specificity than DXA, thereby providing a greater degree of certainty in the estimates obtained. Values for CT attenuation could potentially be derived from intra operative imaging, which may provide a rapid perioperative characterization of bone density, and thus help in operative planning.

	Control		AIS Patients		
Age	n	Mean CT attenuation	n	Mean CT attenuation	p value
8	8	256	0		
9	7	250	0		
10	8	230	0		
11	19	250	1	201	N/A
12	14	293	4	197.5	4.36E-05
13	12	242	8	227.13	0.403
14	15	278	5	201.2	0.00035
15	14	277	2	147	2.72E-07
16	13	275	3	210.67	0.00010
17	24	269	0		
Total/Mean	134	262	23	197.42	

204. EPIDURAL ANESTHESIA-ANALGESIA DURING SURGICAL CORRECTION OF SCOLIOSIS IN ADOLESCENTS

Anna Ezhevskaya, PhD; Sergey Mlyavykh, MD
Russian Federation

Summary: Serial double epidural anesthesia and analgesia in the surgical correction of scoliosis can be successfully applied both during and after surgery, as well as provide better pain relief, postoperative mobility and patient satisfaction.
Introduction: Surgical treatment of severe scoliosis is still the only method that can prevent the progression of vital disorders. At the same time, factors such as forced massive surgical trauma, duration of surgery, blood loss and the inevitable initial cardiopulmonary dysfunction determine the high operational and anesthetic risks. The purpose of the study was assessment of the efficacy of serial epidural analgesia and anesthesia in providing complex perioperative protection of patients.

Methods: The randomized study included 155 patients, aged from 12 to 25 years with severe scoliotic deformities. Duration of operations amounted to 385,8 ± 27,4 min (4 to 9 hours). All patients were divided into 2 groups. In the Group 1 (n=80) before each stage of the operation patients had epidural puncture consistently on two levels with 0,75% of ropivacaine and endotracheal anesthesia with sevoflurane (MAC 0.4-1%) during surgery. After surgery analgesia was performed by prolonged epidural analgesia by setting at the end of surgery two epidural catheters with ropivacaine, fentanil and epinephrine (Fig.1). Patients in the Group 2 (n=75) had general anesthesia with sevoflurane (MAC 1,2-2,2%) and fentanyl. After surgery patients un Group 2 had systemic administration of opioids by controlled analgesia.
Results: The study has revealed a statistically significant reduction in intraoperative blood loss in 50% in the Group 1. Also in the Group 1 postoperative pain was significantly less pronounced, patients were better satisfied, they had faster postoperative mobility compared with Group 2.
Plasma concentrations of cortisol and serum glucose from the beginning of the surgery were significantly increased in both groups. However, by the end of surgery and then during the postoperative period the cortisol and glucose were significantly lower in patients of Group 1.
Conclusion: Thus, serial epidural anesthesia and analgesia in surgical correction of scoliosis can be successfully used both during and after surgery, providing a reliable multi-level nociception, less blood loss, and surgical stress response modulation.

insertion of epidural catheters for postoperative analgesia

205. SHOULDER IMBALANCE AT MINIMUM ONE-YEAR FOLLOW UP IN 172 PATIENTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS: ATTEMPTED VALIDATION OF PRIOR RECOMMENDATIONS FOR UPPER INSTRUMENTED VERTEBRA SELECTION

Benjamin T. Bjerke-Kroll, MD, MS; Zoe B. Cheung, MS; Grant D. Shifflett, MD; Sravisht Iyer; Peter B. Derman, MD; Matthew E. Cunningham, MD, PhD
USA

Summary: Few validated systems exist for selection of upper instrumented vertebra (UIV) with regard to shoulder balance. Final shoulder balance of 172 consecutive patients treated with posterior spinal fusion (PSF) for adolescent idiopathic scoliosis (AIS) with minimum of 1-year follow-up is reviewed. Using three published methods for UIV selection, incidence of shoulder imbalance was paradoxically greater for patients with appropriate UIV selection by all methods. At this time, we are unable to identify UIV selection criteria to accurately predict post-operative shoulder balance.
Introduction: Post-operative shoulder balance is associated with patient satisfaction and self-image. The purpose of this study is to 1) perform a literature review of available validated systems for UIV selection with regard to post-operative shoulder balance 2) determine shoulder imbalance in a consecutive series of patients treated for AIS, and 3) apply UIV selection criteria retrospectively to assess correlation with shoulder balance measurements in AIS patients.
Methods: All patients age 10-18 who underwent PSF for AIS over a six-year period at a single institution were reviewed.
Shoulder imbalance was determined to be radiographic shoulder height (RSH) ≥ 15mm at latest radiographic follow-up. Other methods could not be applied uniformly, as appropriate landmarks were not visualized in all patients.
After a literature review, three methods for UIV selection were identified. Pre-operative radiographs were evaluated, and a recommended UIV was determined for each methodology. The recommended UIV for each method was then compared to the actual UIV instrumented.
Results: 308 consecutive patients were reviewed. 172 patients had appropriate radiographs at average 2.3 ± 1.1 year follow-up; all patients had visible radiographic markings for RSH. The overall incidence of radiographic shoulder imbalance was 15.2% (26/172). Using methods described by Errico, Ilharreborde, and Lenke, correct UIV selection resulted in shoulder imbalance in 21.9%, 14.9%, and 16.0% of patients, respectively; incorrect UIV selection resulted in shoulder imbalance in 10.2%, 15.4%, and 14.6% of patients, respectively. When Ilharreborde criteria were applied to only Lenke type 1 and 2 curves (as originally recommended), correct and incorrect UIV selection resulted in 16.4% and 13.9% shoulder imbalance, respectively.
Conclusion: Using three published methods for UIV selection, incidence of shoulder imbalance was paradoxically greater for patients with appropriate UIV selection by all methods. Only the Ilharreborde method, when applied to all Lenke curve types, resulted in a slight decreased incidence of shoulder imbalance. At this time, we are unable to identify UIV selection criteria to accurately predict post-operative shoulder balance. Further validated measures are needed in this area.

206. THE EVALUATION OF THE CURATIVE EFFECT OF PRE-OPERATIVE HALO-GRAVITY TRACTION IN SEVERE SCOLIOSIS

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Summary: our study showed a better correction in adolescent group than adult group.
Introduction: To assess the effect of pre-operative halo-gravity traction in severe scoliosis cases.

Methods: We retrospectively reviewed the cases of 20 consecutive patients who had treated with halo-gravity traction for severe scoliosis from March 2010 through March 2012. All 20 cases were divided into 2 groups according to age, named adult group and adolescent group. There were 7 males and 4 females in adult group with an average age of 23.3 years. And, there were 4 males and 5 females in adolescent group with an average age of 12.1 years. Preoperative X-rays of standing and bending positions were taken, as well as gravity traction position after been treated for 4-6 weeks.
Results: All 20 cases were treated with halo-gravity traction devices. Cases in adults group were tracted for 6.1 weeks on average. The average cobb angle of coronal plane major curve was corrected from 144.5° ± 14.8° before traction to 132.7° ± 11.2° after traction, with the average corrective rate of 7.8%. On bending films, the average cobb angle of major curve was 125.1° ± 15.6°, with the flexibility of 12.7 ± 8.2%. The average kyphotic angle was corrected from 135.4° ± 38.4° before traction to 112.1° ± 38.0° after traction, with the average corrective rate of 15.2 ± 20.0%. Cases in adolescents group were tracted for 3.0 weeks on average. The average cobb angle of coronal major curve was corrected from 131.8° ± 12.3° before traction to 98.1° ± 21.7° after traction, with the average corrective rate of 25.7 ± 13.2%. On bending films, the average Cobb angle of major curve was 102.8° ± 18.7°, with the flexibility of 21.7 ± 10.8%. The average kyphotic angle was corrected from 119.9° ± 28.9° before traction to 80.7° ± 33.1° after traction, with the average corrective rate of 34.4 ± 16.8%. No statistically significant difference were found in pre-op Cobb angle and flexibility of major curve and kyphotic angle between two groups. However, apparent improvement of major curve Cobb angle and kyphotic angle after traction were found in adolescent group when compared to adult group($P < 0.05$).
Conclusion: The corrective effect of pre-operative halo-gravity traction in severe scoliosis is valid according to this study, especially among adolescent cases.

207. HOW TETHERS LINK ROTATION AND DISPLACEMENT WHICH RESULTS IN VERTEBRAL BODY TILTING: A THEORETICAL FRAMEWORK FOR THE UNDERSTANDING OF ADOLESCENT SPINAL DEFORMITY

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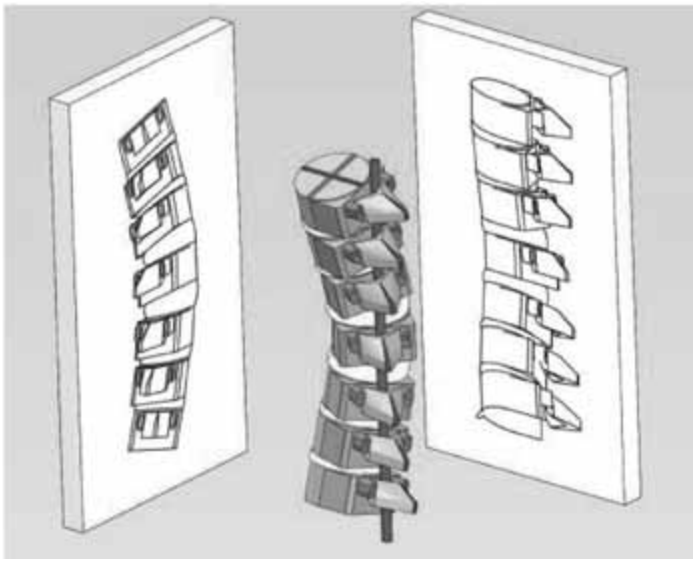
USA

Summary: Adolescent idiopathic scoliosis (AIS) has rotation, displacement, and tilting of the vertebral bodies. Using planar geometry, we found that in the presence of a tether any rotation requires displacement and vice-versa, and describe how vertebrae behave in the presence of various tethers. An anterior or posterior tether tilts laterally or side to side. Only a posterior tether produces a plane of maximum curvature which closely mimics AIS.
Introduction: In AIS the deformity consists of axial plane rotation linked with lateral bending or curvature. Various tethers during growth have been proposed, usually ignoring the effect of the tether on rotation. How rotation and curvature are mechanically linked remains elusive. The purpose of this study was to use simple geometric relationships to show how various tethers could link rotation to displacement.
Methods: Using engineering grade software models in 3 dimensions, 96 tethers with objects were drawn in 2 dimensions to demonstrate 45 degrees of rotation in 15 degree increments. Then the objects were rigidly constrained to allow only tilting in a plane tangent to a circle around the tether. Models of stacked and linked vertebral bodies with varied tether locations were displayed with additional orthogonal 2 dimensional images resembling conventional radiography.
Results: From these models, we show that for any object rotating around a tether, there must be displacement proportional to the rotation. The orientation of the object to the tether determines the direction of the displacement. The distance from the object to the tether controls the displacement per degree of rotation. A posterior tether produces rotation and displacement of vertebral bodies with maximum displacement close to the coronal plane while a lateral tether results in displacement near the sagittal plane.
Conclusion: Planar geometry shows how tethers link rotation with displacement. A posterior tether and only a posterior tether produces lateral tilt (measured by Cobb Angle), small posterior and large anterior displacements, proportional linkage between rotation and curvature, and planes of maximum curvature all very similar to AIS (figure 1). While this study does not prove the existence of any tether in AIS, if one exists its location must be posterior to the center of the vertebra.



Rotation with tilting to compensate for displacement around a posterior tether is shown. Any bending directly caused by the tether is ignored.

208. THE EFFECT OF SURGICAL CORRECTION FOR INCREASED COBB ANGLE AND SAGITTAL CONTOUR ON THORACIC VOLUME IN ADOLESCENT IDIOPATHIC SCOLIOSIS

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USA

Summary: This study examines the pre- and post-operative effect of sagittal contour and Cobb angle on thoracic volume in patients with adolescent idiopathic scoliosis (AIS), using 3D computer modeling to obtain volume measurements from 2D radiographs. At baseline,

increased Cobb angle with neutral or hypokyphotic sagittal contour was correlated with smaller thoracic volumes. Thoracic volume increased after surgical correction in all patients; those with smaller pre-operative volume and larger Cobb angle experienced greater post-operative change.

Introduction: Scoliosis detrimentally effects pulmonary function, as measured by pulmonary function tests (PFTs). Early results using computer modeling for thoracic volume has shown a correlation between decreased volume and severe pulmonary compromise as measured by PFTs. Thoracic volume changes based on varying Cobb angle and sagittal alignment are not well understood; additionally, changes before and after surgery are not well defined. This study examines the pre- and post-operative effect of sagittal contour and Cobb angle on thoracic volume in patients with adolescent idiopathic scoliosis (AIS), using 3D computer modeling to obtain volume measurements from 2D radiographs.

Methods: Coronal and sagittal radiographs of 9 adolescents with AIS enrolled in a multicenter database who had undergone corrective spinal fusion surgery were reviewed. All had Lenke type 1 curves with increasing coronal Cobb angles starting at 50°, and neutral or hypokyphotic sagittal alignment of T5-T12. Blender 2.63a™ software was used to construct pre- and post-operative 3D computational thoracic models by deforming the models to match the calibrated radiographs. Validation of this technique against CT has shown measurement differences of 3.8% ± 2.4%.

Results: Pre-operative modeling showed a moderate inverse correlation between thoracic volume and Cobb angle in samples with neutral sagittal contour ($r = -0.629$), a weak inverse correlation with hypokyphotic sagittal contour ($r = -0.458$), and no correlation with sagittal angle. Post-operatively, Cobb angle was significantly reduced ($p<0.001$) and thoracic volume significantly increased by a mean of 567 cc ($p<0.001$). Additionally, smaller baseline volumes showed greater postoperative change ($r = -0.86$) (Figure 1). There was a weak correlation between preoperative Cobb angle and postoperative change in volume ($r = 0.45$).

Conclusion: Despite the small sample size, preoperatively increased Cobb angle correlated with smaller thoracic volumes in patients with neutral or hypokyphotic sagittal contour. This provides pilot data suggesting the expected correlations. Postoperative models showed increased thoracic volume in all patients, with smaller preoperative volumes and increased Cobb angle associated with larger postoperative change.

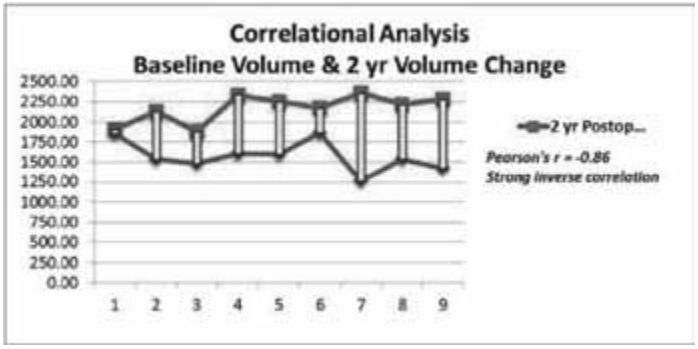

Figure 1: Correlational analysis of thoracic volume change between baseline and 2 years post-op. There is a strong inverse correlation between the baseline computed thoracic volume and the change in thoracic volume at the 2 year follow-up radiographs. The smaller the baseline volume the greater the difference ($r = -0.86$).

209. IS THERE A BETTER DEROTATION MANEUVER IN POSTERIOR CORRECTION OF THORACIC ADOLESCENT IDIOPATHIC SCOLIOSIS?

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Summary: Retrospective review of 62 consecutive patients affected by AIS (Lenke type 1 or 2) treated by posterior fusion with pedicle screw-only instrumentation. Three groups identified: Pre-Rod (direct derotation procedure done before inserting rods), Single-Rod (derotation done after concave rod insertion) Double-Rod (after both rods). The Pre-Rods insertion cases showed a significantly better final correction of apical vertebral rotation (61.9% vs 55.8% and 50.1%) and a greater final correction of main thoracic curve.

Introduction: Different manoeuvres can be adopted for direct derotation in posterior correction of thoracic adolescent idiopathic scoliosis (AIS). Aim of the study is to evaluate the better manoeuvre in AIS posterior surgery.

Methods: 62 consecutive patients affected by AIS (Lenke type 1 or 2), were treated by posterior fusion with pedicle screw-only instrumentation, between 2007 and 2009 at one single institution. Three groups were identified: a Pre-Rod group with the direct derotation procedure done before inserting rods (Pre-R group; n=22 patients), a Single-Rod group with the derotation done after concave rod insertion (Single R group; n=20) and a Double-Rod. group after both rods inserted (Double R group; n=20). There were no statistical differences in the 3 groups, in terms of age, Risser's sign, curve patterns, Cobb main thoracic (MT) curve magnitude and flexibility, extension of fusion, sagittal pre-operative contour and rotation angle (RAsag) of the apical vertebra, measured with axial CT on pre-op and last follow-up control.

Results: (Average FU 3.6 years, range 2.8 to 4.6). The Pre-Rods insertion cases showed a significantly better final correction of apical vertebral rotation (Pre-R 61.9% Single-R 55.8% Double-R 50.1%; $p<0.05$) and a greater final correction of MT curve (63.4% vs 61.1% and 59.1%; ns) with similar maintenance of initial correction (-1.71° vs -1.78° and -1.73; ns).

The T5-T12 kyphosis angle was similar before surgery (Pre-R 16.9° vs Single-R 17.5° and Double-R 17.2°): it was reduced at final follow-up in Single-R and Double-R cases in comparison with Pre-R patients that presented instead a little increase (19.8° vs 12.5° and 13.5°;ns). Lumbar lordosis was similar before surgery (-42.9° vs -41° and -42.1°) and at final follow-up (-45.1° vs -44.9° and -43.2°; ns). At the latest follow-up, SRS-30 and SF-36 findings were similar between the three groups.

Conclusion: The direct derotation procedure resulted more effective both concerning correction of apical vertebral rotation and magnitude of MT curve, when applied to the spine before both rods insertion. The

hypokyphotic effect of derotation procedure, registered in Single-R and Double-R groups, was avoided doing derotation before rods insertion.

210. THORACIC DEFORMITY IN AIS: AN INVESTIGATION OF ANATOMICAL GEOMETRIC AND POSITIONAL DIFFERENCES BETWEEN CONVEX AND CONCAVE RIBS

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Summary: CT scan analysis of convex and concave ribs supports the hypothesis that the global thoracic deformity observed in AIS is mostly a positional deformity of the ribs, not a structural deformity of individual ribs. This suggests that alternatives to thoracoplasty should be considered that address the true pathoanatomy of the rib hump, improving thoracic appearance, volume, and function.

Introduction: Currently, rib cage structure and dimensions have been studied extensively in skeletally normal adults. However, these analyses have not been applied towards investigating differences between concave and convex ribs in AIS. Thorax deformity in scoliosis is assumed to be an acute rib deformity secondary to spine rotation, commonly treated with thoracoplasty. As an alternative, we hypothesize that the rib hump in scoliosis is the result of a complex downward translocation of relatively normal ribs at the costovertebral articulations, potentially reversible by thoracic enlargement procedures. The specific aims of this study are to (1) to characterize the thoracoanatomy and (2) to assess compare geometric and positional features of convex and concave ribs.

Methods: Chest CT scans from 13 AIS subjects (mean age = 14±1.5 years; mean cobb angle = 56±17 degrees; curve apex at T7-T9) were reconstructed using Mimics (Materialise Inc., Belgium). The point cloud data for all the rib pairs were input to a custom MATLAB (The MathWorks Inc., Natick, MA) code to compute (1) geometric parameters: rib length, rib curvature at 10%-90%, and enclosed area and (2) positional parameters: lateral rib angle and frontal rib angle. Kruskal-Wallis One-Way ANOVA and Levene Test were used to assess differences in median and variance between rib measurements. All population statistics were calculated using MATLAB with a significance level of $p \leq 0.05$, with Bonferroni correction factor.

Results: For all rib pairs - the rib length, rib curvature at 10%-90% of rib length, enclosed area, lateral angle, and frontal angle were analyzed. No significant differences ($p \geq 0.05$) were observed in rib length, rib curvature, or enclosed area at all levels. Positional differences between convex and concave ribs were found in lateral and frontal angles at T8-T11, roughly at the apex of the lateral curve ($p \leq 0.05$).

Conclusion: Our results suppose the hypothesis that the global thoracic deformity observed in AIS is mostly a positional deformity of the ribs, not a geometric (i.e.) structural deformity. Our results suggest that alternatives to thoracoplasty should be considered to address the true pathoanatomy of the deformity, improving thoracic appearance, volume, and function.

211. THE USE OF PONTE OSTEOTOMIES (PO) IN AIS: ARE THEY SAFE?

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USA

Summary: This prospectively-collected, cohort of AIS patients who had PSF with screws with 2 year follow up compared safety of posterior column osteotomies to a control group. The osteotomy group (63% of patients) exhibited more blood loss, but no increase in transfusion requirements, other complications or increased operative time. Thus, potential complications should not deter the surgeon from using PO if helpful for correction.

Introduction: Little published data exists regarding the risks and complications associated with PO in patients with AIS. This study reviewed prospective cohorts of patients to determine the rate and nature of complications associated with PO in moderate AIS (<65°).

Methods: A prospectively collected, multicenter database (min 2 year F/U: 75%) was reviewed to identify consecutive patients with >80% pedicle screw posterior-only procedures for AIS with preop major curve magnitudes < 65°; Group I - PO, Group II - no PO (nPO). The number of PO performed relative to number of segments fused (P/F ratio) was calculated. Demographic, surgical, complication, and radiographic data (See Table) were compared preop and 2 years postop.

Results: A total of 695 patients met inclusion criteria, and 441/695 (63.4%) had PO. The median number of osteotomies in Group I was 4 (Mean P/F: 31 ± 24%) per patient. The EBL and cell saver (CS) transfusion per segment fused was higher in the PO group (PO: EBL/Level Fused: 91 ± 39 cc vs, nPO: 85 ± 34 cc, $p<0.05$). However, CS and PRBC transfusion volumes were similar in both groups. Operative time in the nPO group and PO group per level fused were similar (PO: 32 ± 17 min, nPO: 30 ± 17 min; $p=0.3$). There were no differences in rates of minor (PO: 13.1% vs. nPO: 13.8%; $p=0.7$) or major complications. Two patients with pseudarthrosis were noted in nPO group and 1 patient in PO group. There was no statistically significant difference in the rate of intra-operative neuro-monitoring (IONM) alerts (PO: 4.3 % vs. nPO 2.1%, $p= 0.13$). There was one delayed (presented >24 hrs) cord level deficit in the PO group, which completely resolved. There were two root level motor deficits in the PO group and one in the nPO group. The PO group had one re-operation for screw malposition.

Conclusion: We evaluated 695 patients and found that the PO group exhibited slightly more blood loss (EBL) per segment fused; however, transfusion volumes were similar. No differences in operative time, IONM alerts, major or minor complications, or reoperations were noted. Thus, potential complications should not deter the surgeon from using PO if helpful for correction.

212. UNIPLANAR VERSUS FIXED PEDICLE SCREWS IN THE RESTORATION OF THORACIC KYPHOSIS IN THE TREATMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS)

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USA

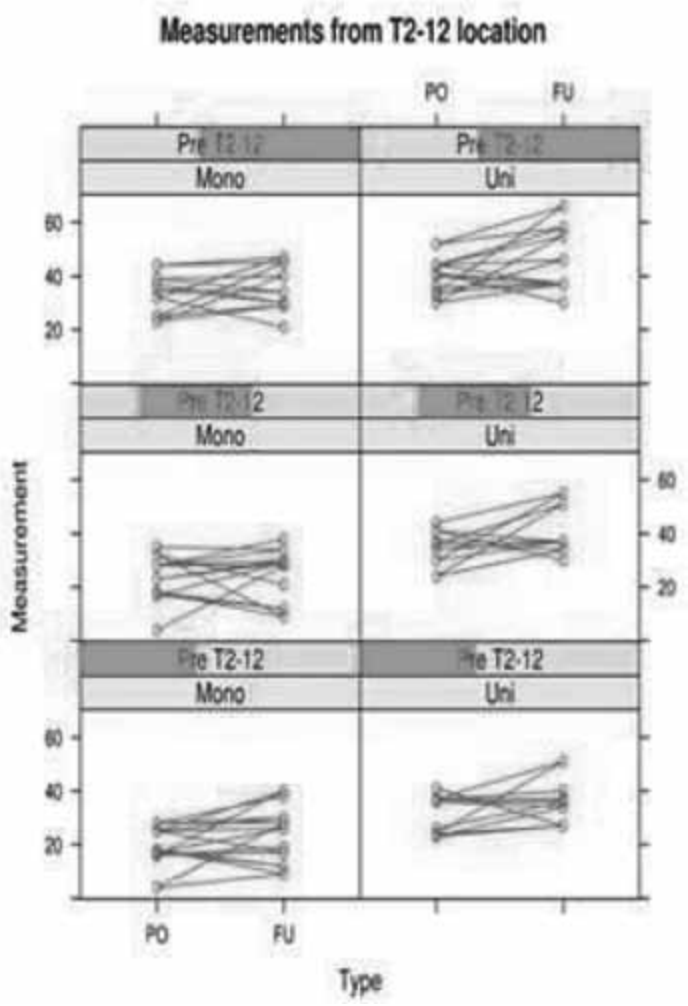
Summary: During AIS surgery, the restoration of the sagittal alignment is often suboptimal, in contrast to the impressive coronal correction. The use of uniplanar screws provides an advantage in the thoracic kyphosis restoration.

Introduction: The aim of surgical treatment of scoliosis is to obtain fusion of the spinal column, balanced in the coronal & sagittal planes. Great success has been attained with coronal correction; however, the sagittal profile has received less attention, resulting in little restoration of sagittal plane alignment. The purpose of this study was to compare uniplanar & fixed pedicle screws in the restoration of the thoracic sagittal alignment in the treatment of AIS.

Methods: The sagittal profile of two groups of patients undergoing posterior spinal fusion(PSF) for AIS was compared. One group had uniplanar screws (n=16) as bone anchors, and the second group had fixed screws (n=20). Consecutive patients with AIS treated by PSF during 2004-06 with fixed screws; & those treated in 2008 with uniplanar screws were included in the study. Data included patient demographics, medical conditions, curve type, Risser stage, coronal & sagittal curve magnitude, curve flexibility, fusion levels, type & location of instrumentation, curve magnitude at the initial post-operative visit & at final follow-up. A p-value < 0.05 was considered significant.

Results: Both groups were comparable demographically, medically, in relation to the curve characteristics & the surgical treatment. Higher curvatures pre-operatively were related to higher curvatures post-operatively and at follow-up. The post-correction T2-T12 curvature measurements were on average higher by 10 degrees using the uniplanar than the fixed screws. This difference was seen by the model as steady, both across levels of pre-operative T2-T12 measurement & the time of measurement.

Conclusion: In patients undergoing PSF for AIS, uniplanar screws achieved superior restoration of the sagittal thoracic alignment than fixed screws. This advantage was maintained in the postoperative follow-up period. The ability of the uniplanar screws to adapt to variable sagittal orientation appears to contribute to the better outcome.



Postoperative Kyphosis measurements from the T2-T12.

213. RETROSPECTIVE, FIVE-CENTER ANALYSIS OF 3,270 PEDICLE SCREWS PLACED WITH ROBOTIC GUIDANCE IN ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS)

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USA

Summary: Retrospective chart review of 223 patients with AIS in 5 centers, totaling 3,270 robotic-guided pedicle screws demonstrated accuracy rates >99% from T1 to S1, averaging nearly 17 screws per case. Fluoroscopy use was limited to 1.58 seconds per screw (about half a minute per case). The results demonstrate high reproducibility of robotic-guided instrumentation in scoliotic spines, relying on very low levels of exposure to intra-operative fluoroscopic radiation.

Introduction: Despite proximity of neurologic and vascular structures, pedicle screw placement in AIS is usually safe. Yet it is challenging due to the high frequency of anatomical constraints and the goal of optimal implant placement required for for adequate screw purchase to withstand corrective forces. Robotic-guidance of pedicle screw placement addresses these issues. This is a report of the combined experience of 5 centers with 223 patients.

Methods: A retrospective analysis of medical records from 2007 to 2013 for pedicle screw accuracy, robotic metrics, and intra-operative fluoroscopic radiation exposure, measured in seconds.
Results: Charts of 223 patients (76% female) were reviewed, average age was 14.4 (range 7-21) and BMI 21.1. A total of 3,768 screws were reviewed (average 16.9/patient), of which 3,270 screws (average 14.7/patient) were executed using robotic-guidance, and 3,245 (99.24%) were judged accurate (95% CI: 98.94-99.53%). Fluoroscopy was used for 30.8±17.9 seconds/patient. Average exposure per screw was 1.58±1.2 seconds of fluoroscopy, with the average per center ranging between 1.12 and 3.73 seconds/screw.
Conclusion: Over 99% accuracy of 3,270 robotic-guided screws, with fluoroscopy limited to 1.58 seconds per screw (about half a minute per case), demonstrates high reproducibility of robotic-guided instrumentation in AIS.

214. ESTIMATION OF THE PERSONALIZED 3D POSITION OF THE CENTER OF MASS IN ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS)

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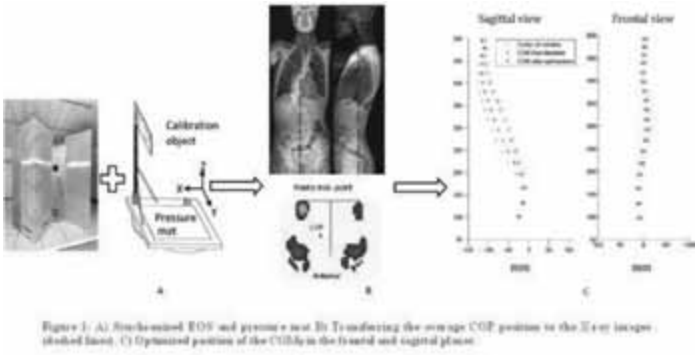
USA

Summary: The position of the COM is subject to change in AIS which in turn impact their postural balance. A hybrid method was used to estimate the 3D position of the COM at the level of each vertebra. This experimental/computational method was able to calculate the COM position using the synchronized center of pressure position and X-ray images with an error smaller than 10e-6.
Introduction: One important goal in surgical correction of AIS is to attain the natural postural balance by shifting the trunk center of mass (COM) to the normal position with respect to the hips axis. Greater correction can be obtained by manipulating the spinal deformities at the level of each vertebra. Defining the position of the center of mass at the level of each vertebra (COMV) improves the surgical planning and consequently the spinal correction. Despite its importance, there is no consensus in estimation of the personalized 3D position of the COMV in AIS.
Methods: Phase I) 21 AIS with different curve types and severity were selected. 30 seconds of the center of pressure (COP) oscillation was recorded with a force plates in the standing pose. The COP oscillation was double integrated to estimate the 2D position of the COM. A regression analysis formulated the correlation between the COP and the COM in the cohort. Phase II) A pressure mat was placed in the EOS radiography system and synchronized bi-planar X-rays and COP position were recorded for 9 AIS. The position of the COP was transferred to the COM position (COMregression) using the regression equation from the first phase. The distance between the COMregression and the net position of the COMV from literature was minimized in a nonlinear optimization process. This optimization process resulted in the optimized positions of the COMV for each subject.
Results: The optimization method minimized the distance between the net position of the COMV and COMregression to 10e-6 m. The optimized net position of the COMV was 26% and 15% closer to the center of the femoral heads in the sagittal and frontal planes respectively.
Conclusion: The 3D Position of the COMV was determined through a non-invasive method in the clinical setup. The personalized position of the COMV permits to quantitatively assess patients' postural balance pre- and post-operatively.



215. IS A MINI-INVASIVE APPROACH FOR ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) A REAL ALTERNATIVE?

Ignacio Sanpera, MD, PhD; Jesús F. Burgos, PhD; Helena Gómez-Santo; Eduardo Hevia, MD; Jose I. Maruenda; Carlos Barrios, MD, PhD
Spain

Summary: The results of a novel mini-invasive technique in AIS are discussed. The results were encouraging as a noticeable decrease in blood loss was achieved and despite using a limited exposure, this did not result in an increase in complications. However a number of concerning issues were found, such an increase surgical time or the no changes in the analgesia needs.
Introduction: Mini-invasive surgery is a hot topic in spine surgery. The search of approaches associated with less tissue damage, lesser complications and faster recovery is centering many of the actual research resources. AIS may not remain outside, but are we ready for it?
Methods: A novel mini-invasive approach using a single long median posterior incision and lateral via to the transverse process, articular facets and the pedicle leaving undisturbed the insertion of the paravertebral muscle, was developed in a cadaver model.
The approach was tested in a prospective comparative study with 2 AIS groups (Lenke 1 A curves):
- Group 1 (G1): study group (n=10), treated by a mini-invasive approach
- Group 2 (G2): Control group (n=10), operated by conventional posterior surgery.
Both groups were comparable for age, curve magnitude and characteristics.
Routine neumonitoring and radiological control were used in both groups.
The following parameters were evaluated: Surgical time; total blood loss; analgesic requirements. Immediate and late clinical and radiological results were recorded. And CT-scan was used to ascertain screw position.
Results: Mean follow-up 36 months.
Blood loss was significantly decreased in G1 ($p<0.001$) but at the expense of a increased surgical time ($p<0.001$).

Screw placement did not show significant differences between groups, but a trend towards better results in G1.
No significant differences were found; in the clinical and radiological results both at short and mid-term. Nor was found in the incidence of complications.
Conclusion: Mini invasive surgery should be an option in AIS, but some issues should be resolved (surgical time, curve's characteristics, hardware density), before it becomes a real alternative.

216. FACTORS INFLUENCING THE RESOLUTION OF THE LOWEST INSTRUMENTED VERTEBRA TILT AND ADJACENT SEGMENT DISEASE IN ADULT SCOLIOSIS SURGERY

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Germany

Summary: Adult scoliosis (AS) is characterized by increased rigidity and a lower rate of spontaneous correction of unfused fractional curves. This study targeted the prediction of postoperative evolution of the lowest instrumented vertebra (LIV) in AS with long fusions not ending at the sacrum. Factors most suitable for LIV selection were preop LIV-tilt on full-spine radiographs *and* the LIV-tilt on bendings/traction-films. The prediction model showed a high accuracy and accounted for 64% of the variance observed.
Introduction: In AS surgery sig. wedging of LIV increases the risk of adjacent segment disease (ASD) and revision surgery.The objectives of our study were to identify parameters most valuable for planning LIV and prediction of LIV-tilt resolution in patients with AS and long fusions ending at the lumbar spine.
Methods: 295 patients with adult scoliosis and fusion ending proximal to S1 resembled the study sample.A symptomatic ASD distal to the LIV was defined by necessitating treatment or distal extension of fusion during the postoperative course. Vertebral tilt of the LIV (LIV-tilt) and wedging of the LIV subadjacent disc angle in the coronal plane (LIVDA-coronal) and sagittal plane (LIVDA-sagittal) were assessed. LIV-tilt was assessed on preop radiographs, bending radiographs and traction-films. The difference between the LIV-Tilt on bendings vs. traction-films was not sig. (13.8±9.1°/13.4±7.8°,p<0.5). The smallest value of LIV-tilt on bendings vs. traction-films was defined as the 'Bending-LIV-tilt'. Stepwise mutlivariate regressions analyses were performed to identify predictors for LIV-TO and ASD.
Results: Mean age of 295 patients was 46 years, mean F/U was 41 months. 261 patients were females. 55% of pts had fusion ending at L4 or L5, 67% of pts had pedicle screw constructs, implant density was 64%. 27 pts (9%) had distal ASD requiring surgery. Posterior fusion length was 9.3±3.1 levels. According to the SRS-classification 35% had single-thoracic, 33% lumbar, and 32% double major curves. Radiographic results are summarized in table 1. Preop LIV-tilt was 18.8±9.4°, postop 9.5±6.7°, and at F/U 9.6±6.4° (p<.001).The occurence of ASD correlated with the magnitude of Bending-LIV-tilt (p=.02), preop and postop LIVDA-sagittal (p=.02/p=.01), postop and F/U lumbar lordosis (p=.06/=.03), and postop lumbar curve (p=.04). In the prediction model, Bending-LIV-tilt (p<.001) and preop LIV-tilt (p<.001) remained best input variables. The prediction equation was as follows: Postop LIV-Tilt= 0.95+ (0.32*Bending-LIV-tilt) + (0.22*preop LIV-tilt). The model achieved a high accuracy (multiple R2=0.64).
Conclusion: In AS, a balanced LIV-tilt is important to avoid accelerated ASD.The postop LIV-tilt is predicted best by the combination of preop LIV-tilt and Bending-LIV-tilt.

217. COMPARISON OF SURGICAL TREATMENT IN MAJOR THORACOLUMBAR/LUMBAR ADULT SCOLIOSIS: COMBINED ANTERO/POSTERIOR VERSUS POSTERIOR-ONLY TREATMENT

Heiko Koller, MD; Juliane Zenner, MD; Michael Mayer, MD, PhD; Oliver Meier, MD
Germany

Summary: A study with 37 matched pairs (n=74 patients) comparing patients with anterior release (+Rel-Group) to patients with posterior-only surgery (-Rel-Group) for correction of thoracolumbar/lumbar curves in adult scoliosis (AS) was performed.There were no significant differences regarding correction of lumbar curve (LC), thoracic curve (TC), lumbar lordosis (LL) or thoracolumbar kyphosis at T10-L2 (TLK). Perioperative revisions were more frequent in the -Rel-Group, while the number of late revisions was similar.
Introduction: For treatment of TL/L curves in AS some argue that the anterior release saves distal fusion levels, improves correction of LC, TLK and LL. Advocates of the posterior approach assert that with pedicle screws (PS) posterior correction is equivalent, complications are reduced and morbidity of the anterior approach is avoided.
The debate indicated a matched-pairs study comparing pts that underwent anterior release prior to posterior fusion (+Rel-Group) to pts with posterior-only correction (-Rel-Group).
Methods: A database with 448 AS pts formed the basis for this matched-pairs study. Inclusion criteria were a major TL/L curve, 2yrs F/U, ≥4 posterior fusion levels, only PS-constructs, fusion ending at L4-S1, ≥3 levels of anterior release in the +Rel-Group, LC of 20-80°, LC-flexibility data. Matching criteria were a similar LC (±<10°) and LC-flexibility (±<10%).
Results: 37 matched pairs could be established (n=74 pts). The +Rel-Group and -Rel-Group were comparable for ASA score (ø2.2 vs 2.4), F/U (ø40 vs 37 mo), body mass index (ø27.4 vs 27.1), posterior fusion levels (ø6.7 vs 6.1 levels). The only sig. difference existed for screw density (80±23% vs 90±13%,p=.02) which on average indicates 1 pedicle screw less per patient in the +Rel-Group, and for the number of pts with fusion to the sacrum (51% vs 76%,p=.01). Comparing the +Rel- vs the -Rel-Group (table 1) there were no sig. differences (p>.05) for preop LC, LC-flexibility, preop TC, TC-flexibility, postop and follow-up TC, postop LC and LC-correction (58±19% vs 59±15%), postop LC of instrumented levels (17±11° vs 13±9°), follow-up LC and LC-correction (56±24% vs 61±18%). However, LC of instrumented levels at F/U was sig. different (18±11° vs 12±8°,p=.02). LL at all time points, and preop TLK (10±13° vs 11±14°) were not sig. different. However, postop TLK was sig. different (10±9° vs 2±11°,p=.004), while there was no sig. difference at F/U (9±14° vs 7±11°). Periop. complications requiring revision were more frequent in the -Rel-Group (0% vs 16%,p=.01), while the incidence of late revisions was not sig. different (32% vs 41%).

Conclusion: A matched-pairs study served evidence that for LC 20-80° with mean LC-flexibility of 26% and anterior-release did not improve correction of the LC, TLK and LL.

218. CLINICAL CORRELATION OF SRS-SCHWAB CLASSIFICATION WITH HRQOL MEASURES IN A PROSPECTIVE NON-US COHORT OF ASD PATIENTS

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Summary: The clinical correlation of the SRS-Schwab ASD classification modifiers with different HRQOL measures was assessed in 98 consecutive patients from a non-US cohort. A statistical significant variation in mean score across all modifiers for VAS back pain and SF36 PCS score was found. Each modifier differed in the ability to show significant variation for the other measures. Although the SRS-Schwab modifiers were able to classify patients according to clinical important measures not all measures are equally sensitive to the classification.

Introduction: The SRS-Schwab adult spinal deformity (ASD) classification system is regarded as an important communication tool for spine surgeons as it summarizes the complex pathology of ASD with four coronal curve types and three sagittal modifiers. The cutoff values separating level 0 from + have been calculated to predict severe disability defined by an ODI score of more than 40. The aim of the present study was to assess the clinical correlation of the sagittal modifiers with HRQOL measures in a prospective, consecutive non-US cohort of ASD patients.

Methods: Between March and August 2013 a total of 112 ASD patients > 18 years having sufficient long standing X-rays taken at our out-patient clinic filled out VAS scores for back pain, ODI, SRS22r, EQ5D and SF36v.1 questionnaires. Six patients were adult AIS patients, 7 had deformity surgery performed within 3 months and one had sagittal images impossible to classify. 14 patients were excluded in all. For each sagittal modifier the variation of score means across levels 0, + and ++ was assessed with one way ANOVA. Mean differences between individual levels were not tested because of insufficient power from our material.

Results: 98 patients were included with a median age of 64 years (range 18-85), 64% were female, and 48 patients had a history of previous deformity surgery. Distribution of the SRS-Schwab classification was as follows: Curve Type N(73%), L(14%), D(11%) and T(2%); PI-LL 0(53%), +(15%) and ++(32%); PT 0(35%), +(41%) and ++(24%); SVA 0(35%), +(37%) and ++(28%). We found a significant variation for VAS scores and SF36 physical component summary (PCS) scores across levels of all modifiers. Furthermore, significant variation was found for SRS22r total score across PI-LL and PT levels, EQ5D across PI-LL and SVA levels, SF36 mental component summary across PI-LL levels and ODI across SVA levels.

Conclusion: Although we were only able to show significant variation of ODI means across levels of SVA, we showed that the SRS-Schwab classification modifiers are able to classify patients according to VAS for back pain and SF36 PCS scores in a consecutive non-US cohort of ASD patients.

219. THE RADIOGRAPHIC ANALYSIS OF THE INDIRECT DECOMPRESSION AFTER ANTERIOR LUMBAR INTERBODY FUSION (ALIF) OR DIRECT LATERAL INTERBODY FUSION (DLIF)

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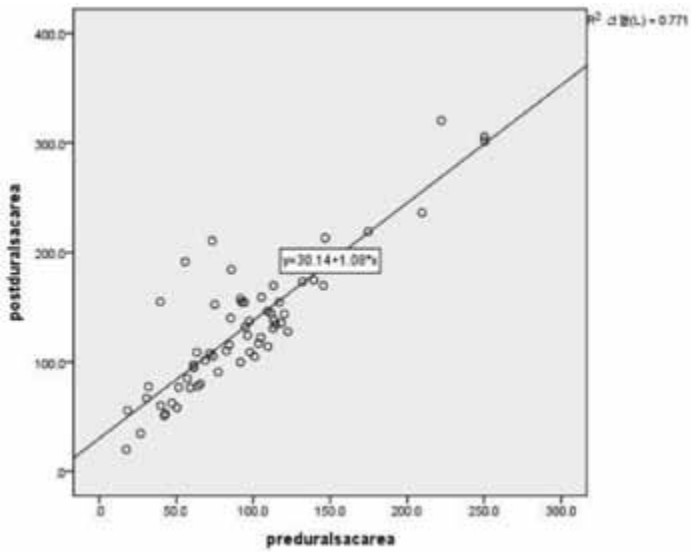
Summary: After anterior lumbar interbody fusion or direct lateral interbody fusion for the treatment of lumbar stenosis, there were significant improvement postoperatively in terms of disc height, segmental angle, CSA of dural sac, AP diameter of dural sac in mid-sagittal MR plane, the area of foramen when ALIF or DLIF was performed. Central stenosis with dural sac CSA of less than 65mm2 may require additional posterior decompression

Introduction: To evaluate the radiolographic outcome of the indirect decompression after anterior lumbar interbody fusion or direct lateral interbody fusion for the treatment of lumbar stenosis

Methods: From Februray 2011 to November 2013, 33 patients (68 levels) with lumbar spinal stenosis underwent anterior lumbar interbody fusion (ALIF) or direct lateral interbody fusion (DLIF). All patients undertook the MRI preoperatively and before discharge postoperatively. These parameters were compared preoperatively and postoperatively using plane radiographs and MRI images: disc height (anterior/posterior/mean), segmental angle, cross-sectional area (CSA) of dural sac, antero-posterior (AP) diameter of dural sac in mid-sagittal MR plane, the area of foramen.

Results: All parameters were significantly increased postoperatively ($p<0.001$, paired t-test) : disc height (anterior/ posterior/ mean) from 9.3/5.6/7.4mm to 19.3/12.5/15.8mm, segmental angle from 6.6° to 13.8°, CSA of dural sac from 94.7mm2 to 132.0mm2, AP diameter of dural sac in mid-sagittal MR plane from 9.2mm to 11.8mm, the area of foramen from 56.1mm2 to 117.0mm2. There was no significant difference in the change of the CSA of dural sac between ALIF and DLIF group ($p=0.542$, independent t-test). However, the postoperative disc height and postoperative segmental angle differed significantly between ALIF and DLIF group (17.3mm vs. 15.0mm, $p=0.002$; 19.9° vs. 10.5°, $p<0.001$). There were 19 levels that could not reach 100mm2 of dural sac CSA after surgery. Their mean CSA of dural sac was 49.3mm2 preoperatively and 69.3mm2 postoperatively. The postoperative CSA of dural sac can be estimated by linear regression model using the preoperative CSA of dural sac ($Y=30.14 + 1.08X$, $R2=0.771$). Using this equation, the preoperative dural sac CSA

Conclusion: There were significant improvement postoperatively in terms of disc height, segmental angle, CSA of dural sac, AP diameter of dural sac in mid-sagittal MR plane, the area of foramen when ALIF or DLIF was performed. Central stenosis with dural sac CSA of less than 65mm2 may require additional posterior decompression



220. DOES MINIMALLY INVASIVE PEDICLE SCREW PLACEMENT PREVENT REOPERATION FOR DISTAL JUNCTIONAL FAILURE WHEN FUSION IS TO L5? A TWO-YEAR FOLLOW UP STUDY

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USA

Summary: Options for the distal instrumented vertebra (DIV) in adult deformity surgery include stopping at L 5 or above versus extending to the sacrum and/or pelvis. Little data is available regarding the DIV in MIS cases. We compared two cohorts of MIS patients with DIV at/above L5 versus S1 +/- pelvis. The data reviewed showed no significant differences in return to surgery rates between those patients whose fusions stopped at or above L 5 compared to those extended to the sacrum.

Introduction: Surgeons performing long segment fusions for scoliosis face the decision of where to stop the distal segment. Options are to stop above L 5, at L 5, or extending to S1 and/or pelvis. This study evaluates the re-operative rate between cases stopped at or above L 5, and those below L5 in minimally invasive (MIS) and hybrid cases (HYB).

Methods: 81 patients were retrospectively reviewed and the most distal fusion level was identified. 39 patients' distal instrumented vertebra (DIV) was at L 5 or above and 42 were below L5. Return to surgery rates were evaluated. Comparison groups included: All patients' DIV at L 5 vs sacrum; All patients undergoing circumferential MIS with perc screws stopping at L5 vs sacrum, 3) All patients undergoing HYB technique (MIS interbody with open posterior screw fixation) stopping at L5 vs sacrum. Mann Whitney U test was used for comparisons, and correlations were assessed using Chi-squared.

Results: All patients had min 2 year follow up. Differences in baseline deformity and two year outcomes are in Table 1. Among the 39 patients whose DIV stopped at L 5 or above 15.4% had a re-operation vs. 31% of the below L5 group (p = 0.08). Among HYB patients 17.6% had a re-operation vs. 35 % whose fusion extended to the sacrum (p= 0.2). Among MIS patients 13.7% of fusions stopped at L 5 required a re-operation vs27.3% of those whose fusions were extended to the sacrum (p = 0.27).

Conclusion: The decision of where to stop a distal fusion and instrumentation can be a perplexing problem. In the situation where the L5/S1 disc appears relatively normal on MRI, one might consider stopping the fusion above that level to preserve more motion segments for the patient. However, it could also be argued that the increased stress on that level created by multiple fused segments immediately above would likely lead to rapid degeneration of that level, and an early return to surgery. The data reviewed above showed no significant differences in return to surgery rates between those patients whose MIS or HYBRID fusions stopped at or above L 5 compared to those extended to the sacrum in cohorts with similar preop SVA.

221. COMPARATIVE BIOMECHANICAL STUDY OF LUMBO-SACROPELVIC FIXATION USING LOW PROFILE ILIAC SCREWS VERSUS S2 ALAR ILIAC SCREWS

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Japan

Summary: We have developed a new technique for lumbo-sacropelvic fixation through anatomic iliac bone trajectory without the adjunctive need for offset connector. In the finite element models (FEM), our low-profile S1-iliac (LSI) method effectively helped to disperse the stress on the sacrum to the iliac bone, and increased lumbosacral stability as a caudal anchor for posterior arthrodesis.

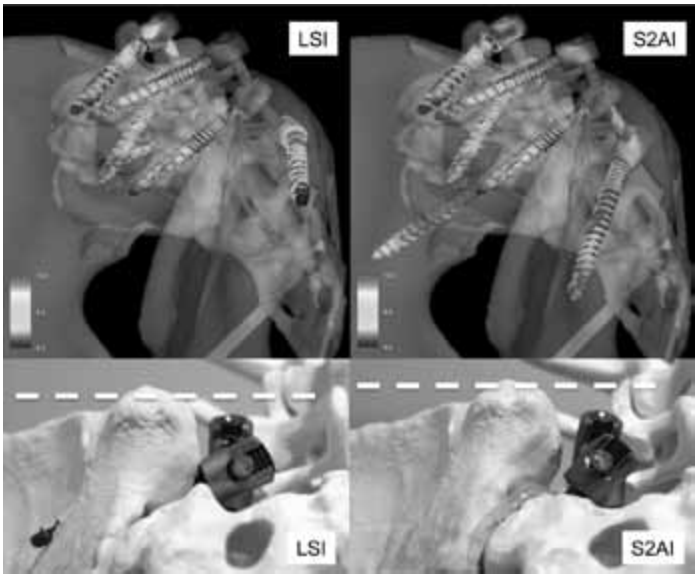
Introduction: With the growing significance of complete lumbosacral fusion in deformity surgery, multiple techniques including S2 alar-iliac (S2AI) screws have been used in a variety of clinical settings. We performed a biomechanical evaluation of LSI technique using iliac screw inserted bicortically from medial border of the posterior superior iliac spine at its junction with the sacrum.

Methods: Using MDCT images from patients with lumbar disease, we extracted mechanically equivalent and heterogeneous lumbar and pelvic motor units with the set of ligaments comprising the sacroiliac joint (SIJ). After establishing the LSI or S2AI instrumentation in the three-dimensional FEM for 6Nm of bending moment, we analyzed the equivalent stress and strain on the screw insertion trajectory, range of motion, and the instantaneous axis of rotation (IAR).

Results: By adding an iliac screw to the L5-S1 pedicle screw fixation, the Drucker-Prager stress on the S1 pedicle under flexion moment was dispersed to 47.5% for the LSI and 50.5% for the S2AI, while L5/S1 range of motion decreased to 83.0% for the LSI and 77.3% for the S2AI. Minimum principle strain on the sacrum revealed that the S2AI had 1.93 times more than the LSI. The location of IAR of the SIJ under flexion moment had moved posteroinferiorly in the LSI compared to the S2AI.

Conclusion: LSI method is biomechanically as stable as the S2AI constructs in all loading modes. Meanwhile, as the S2AI method bypasses the ala sacralis of lesser bone density and focuses the stress across the SIJ, strain is created in the sacrum distal to the

fixed region, potentially creating a higher risk for sacral insufficiency fractures among patients with osteoporosis.



Stress-distribution on implant after simulation of L5–Sacroiliac fixation under 400N compressive follower load plus 6N -m bending moment

222. DOES THE USE OF MINIMALLY INVASIVE PEDICLE SCREW FIXATION LOWER THE RATE OF PJK?

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USA

Summary: Disruption of the paraspinal muscles and joints may contribute to proximal junctional kyphosis (PJK) and proximal junctional failure (PJF) requiring reoperation. Minimally invasive (MIS) pedicle screw fixation has been theorized to lower the PJK rate by reducing paraspinal soft tissue injury. In this propensity matched analysis with minimum 2 year follow-up, MIS pedicle screw placement was associated with similar rates of PJK compared to open pedicle screw fixation, but there was a trend toward less PJF in MIS cases.

Introduction: Disruption of the paraspinal muscles and joints may contribute to PJK. Use of minimally invasive (MIS) pedicle screw fixation has been theorized to lower the PJK rate by reducing paraspinal soft tissue injury. The purpose of this study was to compare rates of PJK and reoperations for PJF in a propensity matched patient cohorts who had posterior minimally invasive (MIS) versus open pedicle screw placement to correct moderate degrees of adult deformity.

Methods: Two multi-center databases were queried. Inclusion criteria for the databases were age >18 yrs and one of the following criteria: coronal scoliosis ≥20°, SVA >5cm, PT >25°, or thoracic kyphosis >60°. Patients were categorized into 3 groups by surgical approach. The MIS group were those who had lateral interbody fusion (LIF) and/or MIS TLIF with posterior percutaneous instrumentation. Hybrid (HYB) group were those who had LIF followed by open posterior instrumentation. Open (OPEN) group were those who had a traditional posterior exposure for screw placement +/- osteotomies. Patients were propensity matched for SVA, PI-LL mismatch, and levels fused. 114 patients were included with 38 in each group. All patients had 2 year minimum follow-up. PJK was defined as proximal junctional angle >10° and change post-op >10°.

Results: Mean age was 60.8(MIS), 62.4(HYB), and 53.5(OPEN)yrs (p=0.018). Pre-op SVA and PI-LL were similar and remained so at 2 year follow-up (Table 1). Mean levels fused were 4.7(MIS), 5.4(HYB), 6.8(OPEN) (p=0.002). Radiographic PJK rates were similar. However, 0(0%) cases in MIS vs 6(15.8%) in HYB (p=0.01) and vs 3(7.9%) in OPEN (p=0.07) required re-operation. Mean PJK angle in these patients were 21.3° for HYB and 23.1° for OPEN.

Conclusion: In this comparative study, MIS pedicle screw fixation resulted in a similar rate of radiographic PJK in patients who were propensity matched for SVA and PI-LL mismatch (pre-op SVA<5cm, PI-LL of 10-20 degrees) and levels fused. There was a trend toward MIS cases requiring less reoperation for PJK.

223. DO MIS DEFORMITY INTERVENTIONS RESULT IN SIMILAR REDUCTIONS OF DISABILITY WHEN COMPARED WITH TRADITIONAL OPEN SPINAL DEFORMITY CORRECTION AT ONE AND TWO YEARS? A PROPENSITY MATCHED COHORT ANALYSIS

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USA

Summary: Adult spinal deformity (ASD) can result in severe disability. Corrective interventions often entail significant perioperative morbidity. Less invasive surgical techniques may result in decreased perioperative morbidity, but concern persists regarding long term benefit in terms of decreased disability. At 1 and 2 years after surgery in this study, patients treated with MIS deformity procedures demonstrated similar disability outcomes when compared with matched open patients. Patients treated with MIS techniques can achieve similar decreases in disability with less invasive techniques.

Introduction: Corrective surgery for adult spinal deformity (ADS) provides long term benefits but often at the cost of significant perioperative morbidity. The use of minimally invasive surgery (MIS) for correction of ADS has been theorized to lower the perioperative morbidity when compared to traditional open surgical approaches. However, there is concern that patients treated with MIS techniques will not achieve the same level of clinical improvement as those treated with traditional open surgery approaches. This study compared patients treated with MIS (MIS lateral or transforaminal interbody fusion (LIF or TLIF) with percutaneous pedicle screw fixation), hybrid techniques (HYB) (MIS LIF or TLIF in combination with open posterior pedicle screw fixation), and open techniques to assess ODI at 1 and 2 years.

Methods: All cases were reviewed retrospectively. Inclusion criteria included: age>18yr, ASD, min 2yr follow-up. Patients treated for adult spinal deformity using either less invasive or open surgical approaches were propensity matched by preop SVA, baseline ODI, and by number of fused levels. Patients' results were compared at 1 and 2 years postop.
Results: 40 patients were propensity matched into each group for a total number of 120. Mean number of levels fused and SVA was HYB = 5.9, 37.7mm, MIS = 3.7, 30.7mm, OPEN = 6.0, 47.5 mm. At baseline, ODI was: HYB=69.6, MIS=49.7, Open=49.6. At postop 1 year patients reported significantly improved ODI ($P<0.01$ when compared to baseline) (HYB=37.3, MIS=26.8, Open=35.6) (between groups $P>0.05$). At 2 years the patients maintained improvement in disability (HYB=37.5, SVA 43.6, MIS 28.0, SVA 34.5, and Open 30.6, SVA 33.5).
Conclusion: Patients treated with MIS techniques can achieve similar reductions in disability to those treated with open deformity surgery. When matched by SVA, number of levels fused, and baseline ODI there was no statistically significant difference in disability at 1 and 2 years after surgery.

224. CLINICAL AND RADIOGRAPHIC OUTCOME OF ANTERIOR LUMBAR INTERBODY FUSION (ALIF) USING A LOW-COST CONSTRUCT WITH FEMORAL ALLOGRAFT AND LARGE FRAGMENT SCREWS

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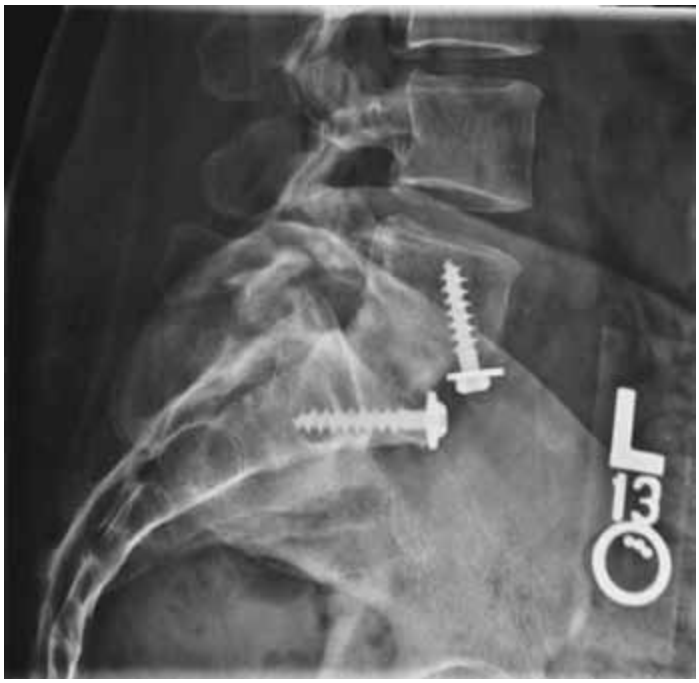
USA

Summary: Anterior lumbar interbody fusion using a low cost construct with femoral allograft secured with two 6.5 mm cancellous screws and washers to prevent anterior extrusion of the graft has a high union rate with minimal complications.
Introduction: Performing ALIF improves construct stability and decreases the incidence of non-unions at the lumbosacral junction in long posterior fusion constructs. At our institution, ALIFs are performed with a custom cut femoral ring allograft that is held in place with two 6.5 mm cancellous screws with washers. The outcomes of this technique have not been described in the literature. The purpose of this study is to evaluate the clinical and radiographic outcomes in patients who underwent an ALIF using this technique.
Methods: A retrospective chart review was performed on all patients who underwent an ALIF from 2000-2012. After preparing the disc space through an anterior approach, the allograft is custom cut from a cadaveric femoral shaft. The allograft is then packed with demineralized bone matrix and secured with two 6.5 mm cancellous screws with washers, placed obliquely into the proximal and distal vertebral bodies. Cost data for the construct were reviewed.
Results: A total of 75 patients fit the inclusion criteria, 22 males and 53 females. Mean age was 53 years (23-83). Mean postoperative follow-up was 37 months; 73% of patients achieved 2 years of follow-up. 50 patients underwent one level fusion, 14 had 2 levels fused and 11 patients had ≥ 3 levels fused. Mean EBL for a 1 level fusion, was 337 mL (± 257 mL). Mean operative time was 168 minutes. 3 of 75 patients had radiographic non-union, only 1 required revision. Intraoperative complications included, 1 case of a splenic laceration during a 7 level fusion and 1 case of a retained sponge. The cost of a 5 cm femoral shaft was $654, the cost of two 6.5 mm cancellous screws and washers was $67 and $57 respectively, resulting in a total construct cost of $778.
Conclusion: This ALIF technique provides comparable fusion rates at 96%, and is a viable alternative to other ALIF techniques for anterior column support in long posterior fusion constructs to the sacrum. Compared to other expensive ALIF constructs described in the literature, this technique can be performed with minimal implant cost.



ALIF of L5-S1 using a femoral ring allograft with two 6.5 mm cancellous screws with washers.

225. STUDY OF LUMBAR MULTIFIDUS MUSCLES IN PATIENTS WITH CHRONIC LOW BACK PAIN AND IN DEGENERATIVE SCOLIOSIS HUMAN: A BLINDED RANDOMIZED CONTROLLED TRIAL

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China

Summary: Several studies have described the histological and morphological changes to the PVM in patients with chronic low back pain and lumbar radiculopathy.
Introduction: A prospective observational study. A blinded randomized controlled trial. To evaluate the paravertebral muscle (PVM) degeneration in patients with Degenerative Scoliosis human , using 3.0T MRI.
Methods: 297 patients with low back pain(LBP group) and 300 control patients without low back pain(Healthy volunteers,HV group) were examined. The purpose was to avoid any bias generating from the researchers and participants who know the adopted treatment. The method we use is : Patients were randomly assigned to be taken to different treatments (conservative treatment and surgery). Another doctor of the clinic (who doesn't know the patient's treatment) is a researcher for the evaluation and follow-up. Doctors confirm that patients could not see the different treatment from the wound.

Because researchers and patients were masked, this study is a double blind clinical study. The cross-sectional area (CSA) and percentage of fat infiltration area (%FIA) of the bilateral multifidus and longissimus muscles at the L1-S1 levels were measured using T2-weighted axial magnetic resonance imaging and computer software. A multifidus muscle biopsy and histological evaluation were performed in some patients.
Results: In the LBP group, the CSA of the multifidus muscle was significantly smaller and the %FIA of both muscles was significantly higher on the concave side than on the convex side at all levels ($P < 0.0001$ for each). These differences were also found in the longissimus muscles at the L3-L4,L4-L5 and L5-S1 levels ($P < 0.05$ for each). Histologically, the multifidus muscle exhibited reductions in the muscle fiber size and number of nuclei on the concave side. In the LSS group, the total CSA and %FIA did not differ significantly between the left and right sides. However, in patients with unilateral radiculopathy, the CSA of the multifidus muscle was significantly smaller ($P < 0.05$) and the %FIA of both muscles was significantly higher ($P < 0.05$) on the symptomatic side, especially at 1 level below.
Conclusion: This observational study with 3.0T magnetic resonance imaging and histology showed that muscle degeneration was more common on the concave side in patients with LBP. Radiculopathy and spinal deformity may contribute to the PVM degeneration.

226. FOUR-ROD CONSTRUCTS DECREASE THE ROD FRACTURE RATE AFTER PEDICLE SUBTRACTION OSTEOTOMIES

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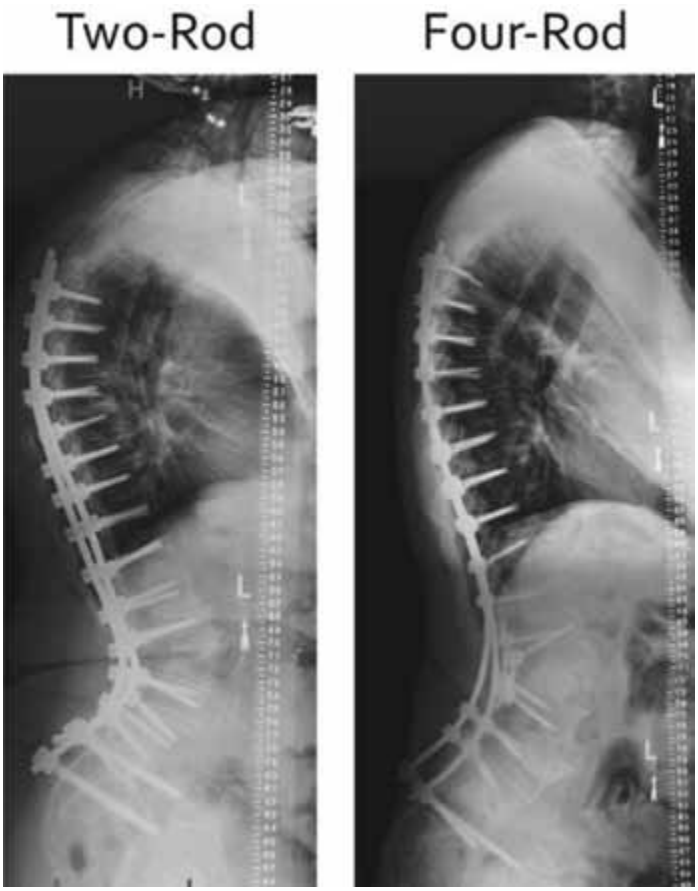
USA

Summary: Pedicle subtraction osteotomies (PSOs) provide large angular corrections over a single segment. This high stress can lead to rod fracture and subsequent revision surgery. Augmentation of traditional two-rod constructs with short-segment rods from one level above the PSO to one level below (i.e. a four-rod construct) decreases rod fracture and revision surgery rates compared to a standard two-rod construct.
Introduction: Pedicle subtraction osteotomies (PSOs) provide large corrections of positive sagittal balance. Rod fractures are an increasingly recognized complication associated with these large deformity corrections. We hypothesize that the addition of short-segment rods to the standard long rods for PSO stabilization decreases the rate of rod fracture and revision surgery.
Methods: A consecutive single-center review was performed of adult spinal deformity patients who underwent a lumbar PSO between 2007-2012. PSOs stabilized by a standard two-rod construct or a novel four-rod construct (short-segment fixation from the level above the PSO to the level below in addition to standard two-rod fixation) were included. All patients had a minimum of 1-year clinical and radiographic follow-up. Radiographic parameters assessed included: sagittal vertical axis (SVA), pelvic tilt (PT), and pelvic incidence (PI). Imaging and clinical records were assessed to determine construct type, presence of instrumentation failure and revision rate. Patients were divided into 2 groups based the type of construct (two-rod vs. four-rod).
Results: 66 patients met inclusion criteria: two-rod (n=48), four-rod (n=22). The two-rod group had a higher rate of rod fracture (48% vs. 0%, $p<0.05$) and revision surgery (40% vs. 8%, $p<0.05$). Average time to rod fracture was 14.5 months (SD ±9) with 56% and 87% of fractures occurring within 1-year and 2-year follow-up respectively No differences between the two groups were found in preoperative or postoperative deformity characteristics (i.e. SVA, PT, PI, maintenance of correction).
Conclusion: PSOs stabilized by four-rod constructs have decreased rates of rod fracture and revision surgery compared to standard two-rod constructs.



227. COMPARISON OF PEDICLE SUBTRACTION AND SMITH-PETERSEN OSTEOTOMIES IN CORRECTING THORACIC KYPHOSIS WHEN CLOSED WITH A CENTRAL HOOK AND ROD CONSTRUCT

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Canada

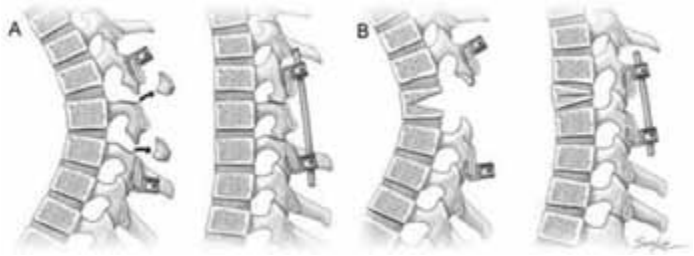
Summary: Osteotomies in the thoracic spine for kyphosis are more challenging due to the risk to the spinal cord and the difficulty in closing the osteotomies. This study shows that closing thoracic level PSOs and SPOs can be performed safely and effectively with the use of a central hook-rod construct in the setting of neuromonitoring.
Introduction: The outcomes of hook and rod instrumentation in osteotomies for the correction of kyphosis at the lumbar region of the

spine has been described. Little literature exists on the outcomes at the thoracic level.

Methods: The radiographs and clinical scores of 38 patients who underwent pedicle subtraction osteotomy (PSO) or Smith-Petersen osteotomy (SPO) in the thoracic spine with the osteotomies closed using a central rod were retrospectively reviewed. Measurements included osteotomy angle, thoracic kyphosis (T2-T12) and maximum kyphosis. Peri-operative and long-term complications were reviewed.

Results: 38 patients underwent thoracic level osteotomies. There were 8 males and 30 females with a mean age of 51.9 (18-76) at the time of surgery. The mean construct length was 13.2 levels (4-25). Kyphosis correction was equal in the two groups. In the PSO group, a mean of 24.7° (4-47°) correction was obtained through the osteotomies compared to 24.0° (9-65°) in the SPO group. Correction per osteotomy was 23.7° (4-47°) in the PSO group compared to 11.8° (2.8-46.0°) in the SPO group. No difference in the amount of correction achieved at the different regions of the thoracic spine was observed with either type of osteotomy with central rod closure.

Conclusion: SPO and PSO osteotomies performed in the thoracic spine provide safe and effective means of achieving correction for fixed sagittal kyphosis when closed with a central hook construct. Preserving the inferior facet of the proximal level prevents over shortening by limiting osteotomy closure to one level. The central rod provides powerful compression forces and the risk of over shortening with possible neurological compromise can be a potential complication with this method. There were no significant differences in the correction obtained when comparing the upper, middle and lower thoracic region osteotomies. These procedures are cord-level osteotomies and are associated with some risk. An experienced surgical, neuromonitoring and anesthesiology team are required for safe completion.



Schematic of SPO (A) and a PSO (B) closed with a central rod

229. INTER-CENTER VARIABILITY IN TREATMENT AND SURGICAL OUTCOMES OF SAGITTAL ADULT SPINAL DEFORMITY (ASD) SURGERY: A RETROSPECTIVE ANALYSIS FROM FIVE SURGICAL CENTERS

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Summary: This study investigates the inter-center variability of intra-operative treatment and outcomes of the surgical correction of adult spinal deformity (ASD) for patients with moderate and severe sagittal deformity. Significant inter-center variability was found in demographics, intra-operative procedures, and surgical outcomes (revisions, complications, and failures) for the overall study population, and for cohorts of moderate (MSM) and severe sagittal modifiers (SSM).

Introduction: Complex spinal osteotomies are often employed to treat sagittal spinopelvic malalignment. This study assesses variability in patient characteristics, surgical procedures and outcomes of spine surgery for patients with moderate and severe sagittal deformity, across 5 surgical centers.

Methods: Retrospective review of prospectively collected data of 132 patients who underwent surgical correction for sagittal ASD. Inter-center variability in demographics, intra-operative procedures, length of hospital stay (LOS) and surgical outcomes were determined for the overall population and for MSM and SSM subgroups.

Results: Overall group analysis revealed significant inter-center variability in patient characteristics, intra-operative procedures, and surgical outcomes (Table). Sub-analyses of MSM cohort revealed variability in age, years with spine problems, and rate of prior spine surgeries ($p<0.05$). MSM also differed across sites in percentage of same-day surgeries, decompressions, osteotomies, interbody fusions, antifibrinolytic use and LOS ($p<0.05$). MSM showed variability in post-operative complications and percentage of failed procedures ($p<0.05$). Sub-analyses of SSM cohort revealed inter-center differences in age, Charlson score, and rate of prior spine surgeries ($p<0.05$). SSM had variability in percentage of same-day surgeries, decompressions, interbody fusions, antifibrinolytic use, and operative time (all $p<0.05$). SSM showed inter-center variability in post-op complication rates and percentage of patients who returned to the operating room ($p<0.05$). No variability was found in revision rates overall or for MSM or SSM cohorts.

Conclusion: Surgical correction of sagittal ASD is complex with varying techniques and outcomes. There was significant inter-center variability in patient characteristics, intra-operative treatment, and surgical outcomes. When stratifying patients by severity of sagittal deformity, many differences remained, suggesting a lack of uniformity in surgical procedures across sites for patients with similar radiographic profiles.

		Overall (n=132)		Moderate Sagittal Modifier (n=83) Patient must meet at least one of the below criteria and no severe criteria: 20° < PT ≤ 30° 40 mm < SVA ≤ 95 mm 10 < PI-LL ≤ 20		Severe Sagittal Modifier (n=78) Patient must meet at least one of the below criteria: PT > 30° SVA > 95 mm PI-LL > 20	
		Range across sites	p-value	Range across sites	p-value	Range across sites	p-value
Demographics	Age (yrs)	33.8-63.8	<0.001	48.9-63.8	0.027	47.8-66.8	<0.001
	BMI (kg/m²)	24.8-29.9	0.001	25.3-30.7	0.094	26.2-31.0	0.148
	Charlson Comorbidity Score	0.3-2.2	<0.001	0.7-2.1	0.328	0.4-2.2	<0.001
	Prior spine problems (yrs)	4.0-4.8	0.005	3.8-4.8	0.038	4.2-4.8	0.356
	Prior spine surgery (%)	21-78%	0.001	22-78%	0.047	20-78%	0.033
Procedure	Same-Day Surgery (%)	14-88%	<0.001	17-89%	0.001	10-89%	<0.001
	Decompression (%)	31-92%	<0.001	35-100%	0.001	29-100%	<0.001
	Osteotomy (%)	35-77%	0.008	33-78%	0.002	43-79%	0.269
	IBF (%)	12-96%	<0.001	33-100%	0.022	6-100%	<0.001
	Operative time (min.)	344.8-454.8	<0.001	316.0-462.0	0.242	334.7-492.3	<0.001
	Antifibrinolytics used (%)	0-96%	<0.001	0-94%	<0.001	0-100%	<0.001
	EBL (cc)	62-100%	<0.001	38-100%	0.001	84-100%	<0.001
	Length of Stay (days)	6.39-9.11	0.317	8.22-10.73	0.018	6.7-8.9	0.730
Outcomes	Intra-op complications (%)	0-31%	0.028	0-38%	0.107	0-22%	0.111
	Post-op complications (%)	4-48%	0.004	0-59%	0.030	0-44%	0.023
	Revision (%)	4-23%	0.379	0-28%	0.353	0-16%	0.112
	Return to OR (%)	12-48%	0.034	8-56%	0.074	0-44%	0.024
	Failure (%)	0-33%	0.001	0-44%	0.002	0-28%	0.162

230. GLOBAL TILT: A SINGLE PARAMETER INCORPORATING THE SPINAL AND PELVIC SAGITTAL PARAMETERS AND LEAST AFFECTED BY PATIENT POSITIONING

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France

Summary: Global Tilt (GT). GT, the angle between the line from C7 to the center of S1 endplate and the line from the center of femoral heads to the center of S1 endplate, incorporates spinal alignment and pelvic compensation in a single angular measure. this angle is less affected by patient positioning than PT and SVA

Introduction: Parameters currently used for the evaluation of sagittal balance measure only the pelvic or spinal compensations with the exception of Global Tilt (GT). GT, the angle between the line from C7 to the center of S1 endplate and the line from the center of femoral heads to the center of S1 endplate, incorporates both in a single angular measure (Fig 1)

Aim: To analyze the changes in PT, SVA and GT in a cohort of patients with adult spinal deformity (ASD) in two different standing positions. The hypothesis is that GT would be the least sensitive to positional change .

Methods: A cohort of 22 patients with sagittal malalignment was identified from a multicentric database of ASD.. Inclusion criteria were age >30 years and SVA >40 mm and/or PT >20o. All patients had full spine EOS radiographs in positions 1 and 2 (P1 and 2); in which the patient was asked to stand and put hands on shoulders without any effort, or, to make an effort to be as straight as possible respectively. PT, SVA and GT were measured in both and changes with positioning was calculated and compared using students t test with significance level at $p<0.05$.

Results: It was seen that SVA had decreased and PT increased for all cases in P2 whereas the changes in GT were in either direction. The average increase in PT was 7.1° (± 5.4) or 30.8% (±24.9); decrease in SVA was 45.1 mm (±25.6) or 60.0% (±44.2) while the change in GT was 4.4° (±3.3) or 12.6% (±9.3). GT exhibited the smallest change although all were statically significant (Fig 1).

Discussion: .GT appears to be less affected by position compared to SVA and PT. This is very logical because since GT contains both spinal balance and pelvic compensations, it is not affected by their changes in opposing directions. Changes in GT are within the measurement error range but otherwise may be explained by other factors such as the flexibility of spinal column itself.

Conclusion: GT appears to be the most reliable single sagittal plane parameter in ASD. It is the least affected by patient position and incorporates both the pelvic and the spinal alignment within one measure.

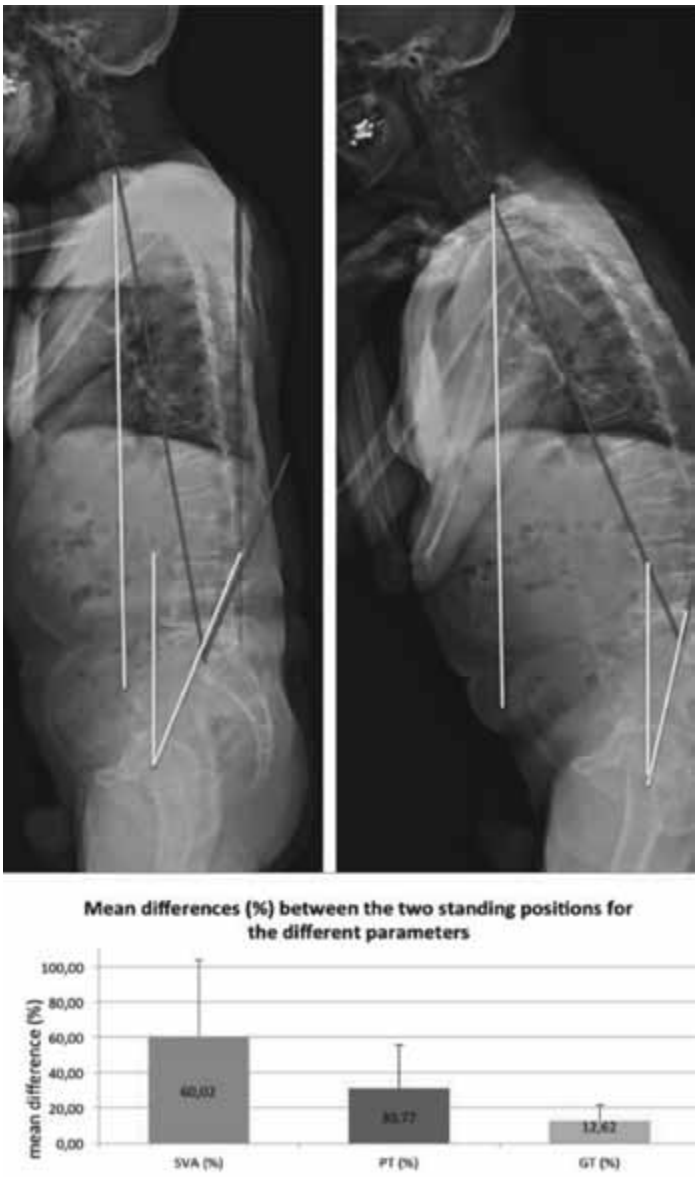

Fig 1
Position 2 and 1: changes of SVA (yello line) and PT (green line) is more important than GT (blue line) changes
The table shows mean value and SD of SVA,PT and GT in the cohort

231. ADULT DEGENERATIVE SCOLIOSIS: MID-TERM RESULTS OF DYNAMIC STABILIZATION WITHOUT FUSION IN ELDERLY PATIENTS: IS IT EFFECTIVE?

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Summary: 57 consecutive patients affected by de novo lumbar scoliosis surgically treated by posterior dynamic instrumentation were reviewed. At a mean follow up of 6.7 years clinical results improved with statistical significance. Major complications occurred in 2 cases, requiring revision surgery. Low average values of operative duration (170 min) and blood loss (560 cc) were observed. These

results showed that dynamic fixation is effective in the treatment of degenerative lumbar scoliosis in elderly patients.

Introduction: Posterolateral fusion with pedicle screw instrumentation represents the most widely accepted technique for degenerative lumbar scoliosis: however, a high incidence of complications has been reported in many studies. In elderly patients without sagittal imbalance, dynamic stabilization without fusion could represent an option to avoid these adverse events.

Methods: 57 consecutive patients treated by pedicle screw-based dynamic stabilization without fusion were reviwed. All patients had degenerative lumbar de novo scoliosis (average Cobb angle 17.2°), without sagittal imbalance, associated in 52 cases (91%) with lumbar stenosis. 24 patients (42%) also presented with degenerative spondylolisthesis. 19 patients (33%) had previously undergone lumbar decompressive surgery.

Results: At a mean follow-up of 6.7 years (range, 5.1 to 7.2), clinical results improved with statistical significance. Mean ODI score: preoperative 51.6, postoperative 27.2 , follow up 27.7; mean RMDQ score: preoperative 12.4 of 24, postoperative 6.0, follow-up 6.3; mean leg pain VAS score: preoperative 67.5, postoperative 40.1, follow up 41; mean back pain VAS: preoperative 66.7, postoperative 33.1, follow up 33. Scoliosis Cobb angle was 17.2° (range, 12° to 38°) before surgery and 11.3° (range, 4° to 26°) at last follow-up ($p< 0.05$). Apical vertebra lateral listhesis (AVLL) was 1.2 cm (range, 0.2 to 2.0 cm) before surgery and 0.8 cm (range, 0.3 to 1.2 cm) at last follow-up ($p<0.05$). Six patients (10%) had minor complications, which resolved after medical treatment. Two patients (4%) had major complications that required revision surgery. In 1 case (2%) a misplaced screw on L5. Another patient (2%) developed a junctional disc disease, that required extension of fixation from L5 to S1. No screw loosening or breakage was observed at follow-up. Furthermore, low average values of operative duration (170 min) and blood loss (560 cc) were observed.

Conclusion: In elderly patients with mild degenerative lumbar scoliosis without sagittal imbalance, pedicle screw-based dynamic stabilization can be effectively used, because less invasive with short operative duration, moderate blood loss and low adverse event rates.

232. GAIT ANALYSIS AFTER CORRECTIVE SURGERY FOR ADULT SPINAL DEFORMITY

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Japan

Summary: We investigated spinal sagittal balance while walking in patients who underwent corrective surgery for adult spinal deformity. The forward trunk tilt was found to be associated with lumbar kyphosis and backward pelvic tilt. Postoperative forward trunk tilt was improved when optimal correction of the spinal deformity was well achieved.

Introduction: Patients with adult spinal deformity(ASD) commonly present with forward trunk tilt when walking. We aimed to compare trunk tilt while walking before and after corrective surgery for ASD

Methods: We prospectively investigated 41 consecutive patients (mean age, 64 years; range, 22–81 years) who underwent corrective surgery for ASD from March 2011 to September 2012. The mean postoperative follow-up period was 26 (range, 15–33) months. Gait was analyzed before and 1 year after surgery, and the 4-m walking status was recorded with a video camera. We measured the angle of a line connecting the greater trochanter and the pinna to a plumb line in the side during gait (gait-trunk tilt angle). We investigated gait-trunk tilt angle(GTA) before and after corrective surgery. Patients were divided into two groups based on the postoperative GTA: Group A (28 patients; 0-10°) and Group B (13 patients, >10°). Differences in sagittal vertical axis (SVA), lumbar lordosis (LL), and pelvic tilt (PT) were examined in both groups.

Results: The mean preoperative GTA was 13° (range, -4-60°). The preoperative GTA negatively correlated with preoperative LL ($R=-0.45$, $P<0.01$) and preoperative PT ($R=0.55$, $P<0.01$). The mean postoperative GTA significantly improved to 8° (range, -5-33°; $P<0.01$). The postoperative GTA in Groups A and B improved from 8° to 4° and from 24° to 14°, respectively. The postoperative SVA in Groups A and B improved from 86 to 38 mm and from 149 to 115 mm, respectively. The postoperative SVA of Group A was significantly smaller than that of Group B ($P<0.01$). The postoperative LL in Groups A and B improved from 21° to 39° and from 17° to 28°, respectively. The postoperative LL of Group A was significantly larger than that of Group B ($P<0.01$). Patients with postoperative LL ≥40° and postoperative SVA <50 mm were significantly more in Group A ($P<0.01$ and $P<0.01$, respectively).

Conclusion: Gait analysis revealed that forward trunk tilt angle while walking is associated with lumbar kyphosis and backward pelvic tilt. Patients with improved LL after corrective surgery could walk with good sagittal balance. Our results suggest that postoperative forward trunk tilt was improved when optimal correction of the spinal deformity was well achieved.

233. HOW DOES SURGICAL CORRECTION OF SPINAL DEFORMITY AFFECT TOTAL BODY SAGITTAL ALIGNMENT?

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Republic of Korea

Summary: The effect of spinal deformity surgical correction on total body sagittal alignment (TBSA) is unknown. This study demonstrated that spinal deformity surgery significantly changes TBSA measured by 11 novel parameters. Postoperative change of TBSA is associated with the change in C7 sagittal vertical axis (SVA), C2 cervical SVA, and lumbar lordosis.

Introduction: Surgical correction for spinal deformity can result in changes to unfused spinal segments and also to total body sagittal alignment (TBSA). The purpose of this study was to evaluate the compensatory response of TBSA after spinal deformity correction and to analyze the correlation of these responses with postoperative changes in sagittal parameters.

Methods: A consecutive series of 147 spinal deformity patients (123 women/24 men; average age at surgery, 43.6 yrs) from a single

institution from October 2010 to September 2012 were evaluated using EOS® 2D/3D radio-imaging device (EOS Imaging, France). Twelve novel parameters to assess TBSA (Table 1) and 6 known spinal sagittal parameters (sagittal vertical axis (SVA), cervical SVA, cervical lordosis (CL), thoracic kyphosis (TK), thoracolumbar kyphosis (TLK), and lumbar lordosis (LL)) were measured at preop, 8 weeks postop and ultimate follow-up. Paired t tests and Pearson correlation coefficients were used for comparison between time points and the correlations between novel TBSA and known sagittal parameters, respectively.

Results: Head Sagittal Vertical Axis-Sacrum (HSVA-S, P=0.0003), HSVA-Head (P=0.0036), HSVA-Ankle (P=0.0023), Head Hip Sacrum angle (P=0.0001), Head Knee Sacrum angle (P=0.0009), Head Ankle Sacrum angle (P=0.0004) were all significantly decreased at ultimate follow-up except HSVA-Knee, (P=0.0959). Head Sacrum Femur angle (P=0.0004), Head Sacrum Mechanical Axis angle (P=0.0000), Head Sacrum Hip angle (P=0.0012), Sacrum Femur angle (P=0.0009), Sagittal Femur Tibia angle (P=0.0003) were significantly increased at ultimate follow-up. Compensatory response in 11 of the 12 novel parameters demonstrated significant positive or negative correlation with postoperative changes of SVA, CSVA, and LL (r = 0.405 to 0.948, P=0.000; r = -0.435 to -0.846, P=0.000), but not CL, TK or TLK.

Conclusion: Surgical correction for spinal deformity induces significant changes in TBSA as measured by 11 new parameters. Changes in SVA, CSVA, and LL postop correlate with improvement of TBSA. We recommend these novel TBSA measurements for complete assessment from the skull to the ankles.

234. NOVEL RADIOGRAPHIC PARAMETERS FOR THE ASSESSMENT OF TOTAL BODY SAGITTAL ALIGNMENT

Yong-Chan Kim, PhD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Jeffrey L. Gum, MD; Ryoji Tauchi, MD; Qiyi Li; Young-Woo Kim, MD; Seok-Woo Kim; Linda Koester, BS; Kathy Blanke, RN
Republic of Korea

Summary: We devised 13 novel radiographic parameters to assess total body sagittal alignment (TBSA). Twelve out of 13 novel radiographic parameters (except Perpendicular Sacrum-Femur angle) were found to significantly correlate with C7 sagittal vertical axis (SVA), C2 cervical sagittal vertical axis (CSVA), and lumbar lordosis (LL) and showed good to excellent intra- and interobserver reliability. These novel radiographic parameters are valid and reliable radiographic measurements to assess TBSA and can be recommended for routine clinical and academic use.

Introduction: Accepted radiographic parameters of sagittal alignment have been limited to spinal and pelvic alignment. No radiographic parameters take into account total body sagittal alignment (TBSA) including the head, spine, pelvis, and lower extremities. Our goal was to devise novel radiographic parameters to allow assessment of TBSA and to validate their reliability.

Methods: 166 consecutive spinal deformity patients were evaluated using the EOS® 2D/3D radio-imaging device (EOS Imaging, France) and were measured at pre- and 2 months postoperative. We analyzed the correlation between 13 novel parameters (Table 1) and 6 currently accepted parameters: C7 sagittal vertical axis (SVA), C2 cervical sagittal vertical axis (CSVA), cervical lordosis (CL), thoracic kyphosis (TK), thoracolumbar kyphosis (TLK), and lumbar lordosis (LL). In addition, we randomly chose 30 of the 166 patients for intra- and interobserver reliability of each new parameter. All the novel parameters were measured on two separate occasions at least 1 week apart by 3 surgeons from different institutions and of different nationalities at various levels of training using a digital software measurement program (4680 data points).

Results: 12 of the 13 novel radiographic parameters (all but PSF) demonstrated significant linear correlation with at least one of the currently accepted parameters (SVA, CSVA, LL; r = -0.404 to -0.893, P=0.000). The ICC ranges for intra- and interobserver reliability of the12 novel parameters were ρ=0.708-0.999 and ρ=0.703-0.984, respectively. Intra- and interobserver reliability of preoperative measures (ρ=0.892-0.999 and ρ=0.810-0.984) were excellent and somewhat better than postoperative measurements (ρ=0.708-0.997 and ρ=0.703-0.972).

Conclusion: Of 13 novel radiographic parameters analyzed for the assessment of TBSA, 12 were found to be significantly correlated with currently accepted radiographic parameters and showed good to excellent intra- and interobserver reliability. The TBSA parameters will help us with pre- and postoperative analysis of our surgical patients.

235. BIOMECHANICAL FATIGUE LOADING EVALUATION OF A NOVEL FOUR-ROD TECHNIQUE TO PREVENT EARLY INSTRUMENTATION FAILURE IN LUMBAR PSO

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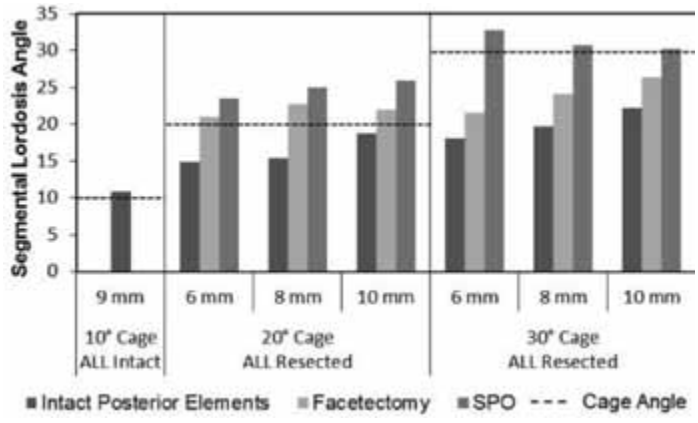
USA

Summary: The purpose of this study was to evaluate the fatigue performance of novel dual rod PSO stabilization constructs under mild to severe rod contours. The fatigue life of the dual rod constructs was significantly ($p<0.05$) higher than the single rod constructs. Dual rod constructs with equal contours were effective for mild corrections. Decreasing the contour in the short stacked rods dramatically increased fatigue life, even under severe corrections.

Introduction: Rod fracture is a significant issue in Lumbar pedicle subtraction osteotomy (PSO) [1]. A dual rod construct for PSO stabilization has been developed to mitigate clinical failures by deploying two sets of rods to encourage load share. One set is deployed to levels directly adjacent to the PSO and the second to the second level above and below (Figure 1a). The specific aims were to compare the fatigue performance between single and double rod techniques and investigate the performance according to contour angle of the short and long rods.

Methods: Six treatment groups were evaluated with sample size n=3: (1) 40/40 PSO, (2) 40 PSO, (3) 60/60 PSO, (4) 60 PSO, (5) 60/30 PSO, (6) 40/20 PSO. Rods were bent to the desired contour and fixed to UHMWPE blocks with pedicle screws. The construct was placed under a 400/40N at 4Hz to failure or run-out. Failure was defined as fracture and run-out as 1,000,000 cycles. Means testing was performed with a one-way ANOVA to determine significant differences in fatigue life between the constructs (α =0.05).

Results: All groups fractured at the rod bend. Only rods most adjacent to the PSO fractured. Fatigue life of the dual-rod constructs were significantly ($p<0.05$) higher than the single-rod constructs (Figure 1b). Fatigue life for the 40/40 and 60/60 constructs were 997851±3722 and 207700±33348 cycles, respectively. The 40 and 60 constructs lasted 214101±60821 and 125128±13890 cycles, respectively. All 60/30 and 40/20 constructs ran out.
Conclusion: Dual-rod constructs with a 40/40 contour showed a large increase in fatigue life while the 60/60 exhibited a minimal increase, suggesting that the dual rod, while much more resistant to fatigue failure, is also affected by increased rod contour. Decreasing the contour of the short stacked rods (60/30) significantly increases the fatigue life regardless of the severity of the correction.
References: 1. Smith JS et al: Assessment of Symptomatic Rod Fracture after Posterior Instrumented Fusion for Adult Spinal Deformity. Neurosurgery 7:862-868, 2012



Changes in segmental lordosis

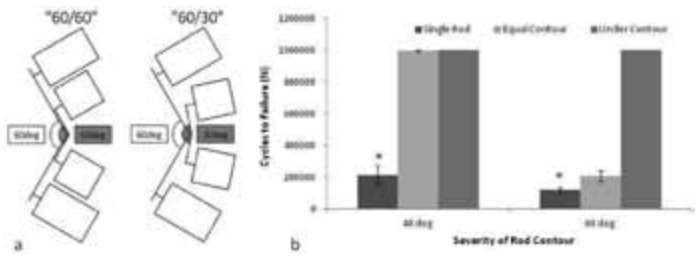


Figure 1. Pictorial representation and results of fatigue testing. Statistically significant differences within 40° and 60° groups are displayed with an asterisk.

236. RADIOGRAPHIC OUTCOMES FOLLOWING ANTERIOR COLUMN REALIGNMENT (ACR) WITH AND WITHOUT POSTERIOR OSTEOTOMIES

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USA

Summary: ACR was evaluated with respect to posterior-based osteotomies at the same level. ACR results in significant increase in intradiscal angle (IDA), which further increases with use of osteomies.
Introduction: Adult sagittal deformity has been effectively treated with a variety of surgical approaches. In this study we aimed to determine the role of posterior-based osteotomy in gaining additional segmental alignment change in conjunction with (ACR) through a lateral retroperitoneal transpsoas approach.
Methods: Multicenter retrospective review of consecutive patients treated with ACR at a minimum of one level through lateral retroperitoneal transpsoas approach. Radiographic parameters captured included intradiscal angle (IDA), lumbar lordosis (LL), T1 spinopelvic inclination (T1SPi), and pelvic tilt (PT), at pre-op, post-op (< 3 months), and at 1 year. Schwab modifiers were assigned based on the relevant parameters. ACR-level posterior osteotomies and cage angulation (CA) were recorded (20° vs. 30°). All patients underwent posterior spinal fixation, including at the ACR level.
Results: 56 patients were available for analysis. IDA changed significantly from pre-op to post-op, and the change was maintained at 1 year post-op (Table 1). Both 20 and 30 degree cages resulted in significant changes in IDA from pre-op to post-op, while non-ACR levels did not change. The use of osteotomy resulted in a significant increase in IDA when compared to no osteotomy. Increased CA did not result in increase in IDA achieved postoperatively. There were significant changes in LL, PT, and PI-LL from pre- to post-op, and the values were maintained at 1 year post-op.
Conclusion: ACR results in significant change in IDA postoperatively, and the amount of correction increases with the use of an osteotomy. In this population the use of more angulated intervertebral cages in ACR does not result in greater degrees of IDA correction, though this may be an effect of unbalanced application of osteotomies across cage sizes and small sample size. These changes are maintained from immediate to 1 year post-op. ACR can be utilized with or without osteotomy to correct segmental and global alignment.

238. LASER MODIFIED PEEK IMPLANTS AS AN ADJUNCT TO INTERBODY FUSION: A SHEEP MODEL

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USA

Summary: Advances in laser technology have been used to imprint surface mimetic patterns on PEEK implants that mirrors isotropic bone in an attempt to enhance fusion. In vitro cell culture analysis suggests laser surface etching enhances the deposition of mineralized matrix and attachment of bone. Three-month Micro-CT and histological data confirm these findings in a sheep model. Abundant mineralized matrix and bony attachments were found at the mimetic surface interface suggesting fusion in Group 1 in this sheep model.
Introduction: Advances in laser technology have been used to imprint surface mimetic patterns on PEEK implants that mirrors isotropic bone in an attempt to enhance fusion. In vitro cell culture analysis suggests laser surface etching enhances the deposition of matrix and preferentially encourages the attachment of bone. We evaluated the effect of mimetic patterning on PEEK cages on fusion in a sheep model.
Methods: PEEK implants were developed using advanced laser technology to produce a surface mimetic that was analogous to isotropic bone. Following IACUC approval, identical PEEK implants were implanted using an anterior approach and a C34 ACDF with plating was performed in 20 sheep. Sheep were divided into 4 groups. Group 1: mimetic patterning without autograft; Group 2: mimetic with

autograft; Group 3: no mimetic patterning with autograft; Group 4: no patterning without autograft. Sheep were analyzed at 3 and 6 months. At 3 months, all 20 sheep had radiographs and viable CT scans. Nine sheep were sacrificed at 3-months for micro-CT and histological analysis. At 6-months, the remaining 11 sheep were analyzed.
Results: Three-month data was available for analysis. Radiographs and viable CT scans of all 20 sheep at 3-months demonstrated the greatest radiographic evidence of fusion in Group 1 (Mimetic without autograft). Micro-CT and histological data were available in the 9 sheep that were sacrificed at 3-months. Only Group 1 demonstrated abundant mineralized matrix and bony attachments at the implant's mimetic surface interface suggesting fusion.
Conclusion: Surface mimetics on PEEK spinal implants that mirrors isotropic bone may enhance fusion. In vitro cell culture analysis suggests laser surface etching enhances the deposition of mineralized matrix and preferentially encourages the attachment of bone cells. Three-month Micro-CT and histological data confirm these in vitro findings in our in vivo sheep model. Abundant mineralized matrix and bony attachment was found at the mimetic surface interface suggesting fusion in Group 1 in this sheep model.

Mimetic Patterning on PEEK Cage

239. A BIOMECHANICAL COMPARISON BETWEEN CORTICAL SCREW-ROD CONSTRUCT VERSUS PEDICLE SCREW-ROD CONSTRUCT IN A TRANSFORAMINAL LUMBAR INTERBODY FUSION (TLIF) MODEL: A PORCINE ANIMAL STUDY MODEL

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Summary: This is a biomechanical study in 12 porcine lumbar spine motion segments comparing pedicle screw-rod (PS) and cortical screw-rod (CS) construct in a TLIF model. Non destructive testing was performed in flexion, extension, lateral flexion and axial rotation. There was no significant difference between the stiffness of CS and PS. Compared to intact spine, PS and CS showed significantly greater stiffness except in axial rotation. Bilateral cortical screw-rod fixation provided similar stability as pedicle screw-rod fixation in porcine TLIF model.
Introduction: Pedicle screw instrumentation has long been accepted as the workhorse for surgical stabilization in various lumbar degenerative disorders. The need for extensive exposure during pedicle screw insertion and poor pull out strength in osteoporotic bone has lead to the design of cortical screws. Although cortical bone purchase in theory will lead to an increased pull out strength, the biomechanical properties of cortical screw rod construct in a TLIF model has not been widely studied and accepted.The aim of this study is to compare construct stiffness of pedicle screw-rod (PS) and cortical screw-rod fixation (CS) with interbody support in the lumbar spine in a porcine animal model.
Methods: Six porcine lumbar spines (L2-L5) with an average age of 6 months were separated into 12 motion segments. Independent testing of each motion segment is carried out for the two groups. Group 1 consisted of bilateral pedicle screw-rod fixation (PS) with interbody support. Group 2 consisted of cortical screw-rod fixation (CS) with interbody support. Facetectomy and interlaminar decompression were performed for all specimens. The motion segments were then secured on a customized jig and non-destructive flexibility tests were performed using Instron material testing machine (Model 3365 and 5848) under load control at room temperature for all motions segments before and after instrumentations and decompression.
Results: Both the pedicle screw-rod and cortical screw-rod fixation with interbody cage constructs were significantly stiffer than intact spine in flexion, extension, right and left lateral flexion ($p < 0.05$) but not in axial rotation. Comparison between PS and CS is outlined in Table 1. When normalized to the intact spine the stiffness of PS and CS were not significantly different; flexion (1.41 ± 0.27, 1.55 ± 0.32), extension (1.98 ± 0.49, 2.25 ± 0.44), right lateral flexion (1.93 ± 0.57, 1.55 ± 0.30), left lateral flexion (2.00 ± 0.73, 2.16 ± 0.20), right axial rotation (0.99 ± 0.21, 0.83 ± 0.26), and left axial rotation (0.96 ± 0.22, 0.92 ± 0.25).
Conclusion: Bilateral cortical screw-rod fixation provided similar stability as pedicle screw-rod fixation in porcine lumbar spine TLIF model.

240. ACCURACY AND SAFETY OF FLOUROSCOPIC GUIDED PERCUTANEOUS PEDICLE SCREWS IN THORACIC AND LUMBAR SPINE: A REVIEW OF 2000 SCREWS

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Summary: This study involves computed tomography evaluation of 2000 percutaneous fluoroscopic guided pedicle screw to determine its accuracy and safety. 90.6% were inserted into the pedicle perfectly The overall perforation rate was 9.4% consists of 7.6% grade 1, 1.6% grade 2 and 0.3% grade 3 perforations. No clinical complications were encountered. The perforation rate was noted to be highest in T1, T4 and L5. In conclusion, percutaneous fluoroscopic guided pedicle screw technique is a safe technique.

Introduction: Percutaneous pedicle screws have become more popular due to expanding indications. However the knowledge regarding the accuracy and safety is still lacking in the English literature, especially the safety of this technique in the thoracic spine region. The aim of this study is to determine the accuracy and safety of fluoroscopic guided percutaneous pedicle screw technique.
Methods: 273 CT scans of patients who had spinal surgery from 2008 to 2012 using percutaneous pedicle screws were recruited to be evaluated. A total of 2000 percutaneous pedicle screws inserted using fluoroscopic guidance was analyzed. The direction and grade of pedicle perforations were assessed.
Results: Of the 2000 screws evaluated, 1813 pedicle screws (90.6%) were inserted into the pedicle perfectly. There were 187 screws with perforation with the overall perforation rate of 9.4%. There were 151 (7.6%) grade 1 perforations, 31 (1.6%) grade 2 perforations and 5 (0.3%) grade 3 perforations. All grade 3 screw perforations did not result in any complications and therefore these screws were left in-situ. The perforation rate was noted to be highest in T1, T4 and L5. The directions of perforations were: medial 31.4% (64), lateral 36.3% (74), anterior 25.5% (52), superior 2.9% (6) and inferior 3.9% (8). Out of the 64 screws with medial perforation, there were 89.1% (57) grade 1 perforations, 9.4% (6) grade 2 perforations and 1.6% (1) grade 3 perforations. All of the grade 2 and 3 medial perforations did not result in any neurological complication. For anterior perforations, there were 90.4% (47) grade 1 perforations, 5.8% (3) grade 2 perforations and 3.8% (2) grade 3 perforations. None of the grade 2 or 3 anterior perforations required any revision as it did not impinge on important anterior structures.
There were 1004 pedicle screws inserted into the right side with a perforation rate of 8.9% (89) whereas 996 screws were inserted into the left side with a perforation rate of 9.8% (98). There were no different in term of the rate and the grade of perforation between the right and left sided screws ($p>0.05$).
Conclusion: Fluoroscopic guided percutaneous pedicle screws fixation in thoracic and lumbar spine is safe and accurate.

241. NEUROANATOMICAL SAFE ZONE FOR TRANSPOAS LUMBAR APPROACH: A PORCINE STUDY

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Summary: Minimally invasive surgery of the lumbar spine has gained significant popularity. However, this technique is not without its own difficulties. The most notable complication associated with the lateral approach is the potential for injury to the lumbar plexus and genitofemoral nerve.
Introduction: The purpose of this study was to evaluate the relationship between lumbosacral plexus, its derivative nerves and EMG response in vivo. We hypothesized that the use of triggered EMG for nerve mapping is not accurate.
Methods: A standard left sided retroperitoneal approach was carried out to expose the psoas muscle in 8 pigs. Electrical stimulation was applied using both a ball-tip probe and a needle electrode. The lumbar nerves were identified; the EMG threshold values were measured to direct nerve stimulation (probe only) and then moving the stimulus away from the nerve in 2mm increments until 10mm. The stimulus threshold values in mA for the first visible response and the stimulus needed to elicit a 20 μV response were recorded. A standard serial dilation was accomplished via guide wire insertion through the level of the disc space. Post-op CT scans were obtained to evaluate for hematoma.
Results: Difference in EMG values with increasing distance was observed but this was not proportional for distance > 4mm from the nerve. An EMG response of <5 mA was observed in 19out of 24 tests when the probe was 0-4mm from the nerve. This is 79% true positive while 5 recordings were > 5mA for distance 0-4mm (21% false negative rate). At 0-6mm 7out of17 tests responded at >10mA, which is a false positive rate of 41%. No evidence psoas muscle compression to indicate postoperative hematoma.
Conclusion: The lack of proportionality of EMG response to distance suggests limitations in using EMG for nerve mapping. The nerve may be much closer than anticipated despite getting the "green light." Resultant neuropraxic injury may be secondary to unanticipated close proximity of the adjacent nerve. Postoperative hematoma is less likely to be the cause of nerve compression as compared to intraoperative injury caused by direct trauma or over-distraction injury.

242. SURGICAL OUTCOMES OF OCCIPITO-CERVICAL FUSION FOR RHEUMATOID CERVICAL SPINE: INFLUENCE OF METHOTREXATE AND BIOLOGICAL DRUGS

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Summary: Patients administered methotrexate and biological drugs had shorter fusion areas but similar surgical results to those of patients who were administered other drugs.
Introduction: This study investigated whether the administration of methotrexate (MTX) and biological drugs changes surgical occipito-cervical fusion results.
Methods: Twenty-three consecutive subjects with rheumatoid arthritis (RA; 5 men, 18 women; mean age, 64 ± 9 years) underwent occipito-cervical fusion of the cervical spine . Group A (n = 10) was given MTX and/or biological drugs, while Group B (n = 13) was given other drugs. Preoperative conditions, intraoperative conditions, postoperative results, and other factors were compared. Statistical significance was defined as $p < 0.05$. Mean follow-up was 54 ± 36 months.
Results: Surgical times differed significantly (Group A, 202 ± 76 min; Group B, 349 ± 50 min; $p = 0.017$), as did fusion areas (Group A, 3.7 ± 0.7 vertebrae; Group B, 5.8 ± 0.7 vertebrae; $p = 0.048$). There were no significant inter-group differences in intraoperative blood loss, preoperative RA treatment period, preoperative Steinbroker stage/class, or pre- or post-operative radiographic values (atlantoaxial interval and Ranawat values). Postoperative infection occurred in two Group A subjects only. Ranawat classifications were Class II, IIIA, IIIBa, and IIIBb in 4, 10, 8, and 1 subject preoperatively and in 1, 7, 9, and 6 subjects at final follow-up, respectively. Significant overall classification improvement was seen ($p = 0.013$) but without

significant inter-group difference. Similarly, Japanese Orthopaedic Association (JOA) scores improved significantly (p = 0.001) without significant inter-group differences. Postoperative atlantoaxial interval showed a significant negative and moderate correlation with JOA improvement at the final follow-up (Spearman correlation factor, -0.465; p = 0.025). Higher postoperative Ranawat values were correlated with significantly improved Ranawat classification at the final follow-up (Spearman correlation factor, 0.449; p = 0.032).
Conclusion: Mean fusion area was shorter in Group A; however, no significant inter-group difference in surgical outcomes was seen. The use of MTX and biological drugs might have prevented RA progression and enabled less invasive surgery, but postoperative infection occurred in that group only. Intraoperative correction was related to surgical outcome regardless of drug type.

243. C2 INSTRUMENTATION WITH THE STRONGEST FIXATION POWER FOR SPINAL STABILIZATION

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Summary: Theoretically, the stabilization method with both C2 PS and LS at a time is the strongest. Herein we report four cases of patients that were treated with both C2 PS and LS at a time. There were no adverse events by this method in this series. If the patients have a breakable bone by many different conditions, using both C2 PS and LS at a time might be one of the good choices.
Introduction: Several methods have been used to stabilize the cervical spine including the use of C2 pedicle, intralaminar, transarticular screws. In past literatures, biomechanical comparisons of C2 pedicle screws (PS) with C2 intralaminar screws (LS) were reported. The stabilization technique using C2 LS offered similar biomechanical stability to C2 PS excepting lateral bending. Theoretically, the stabilization method with both C2 PS and LS at a time is the strongest. Herein we report four cases of patients that were treated with both C2 PS and LS at a time.
Methods: Posterior instrumentation involving the C2 vertebra has been performed to eleven patients between April 2011 and October 2013. Four of eleven cases underwent stabilization surgery with both C2 PS and LS at a time. These screws were easily connected to the rod with a offset connector. Adequate bone graft was accomplished while there were many implants around the C2 vertebra. Neural and vascular injury resulting from incorrect screw placement were assessed by using computed tomography (CT). The evaluation of bone union was assessed by flexion-extension X-ray films.
Results: Stabilization surgery with both C2 PS and LS at a time had no intraoperative complication and no cases of neurological worsening or vascular injury from incorrect screw placement. There was no failure of instrumentation or screw loosening during the follow-up period in all patients.
Conclusion: When upper cervical spinal stabilization surgery with instrumentation is needed, these cases frequently have some inconvenient complications such as rheumatoid arthritis, hemodialysis, cerebral palsy, and severe osteoporosis. Theoretically, stabilization technique with both C2 PS and LS at a time can get the strongest power. Furthermore, there were no adverse events by this method in this series. If the patients have a breakable bone by many different conditions, using both C2 PS and LS at a time might be one of the good choices.

244. HIGH-VOLUME HOSPITALS AND SURGEONS EXPERIENCE FEWER EARLY REOPERATION EVENTS AFTER ADOLESCENT IDIOPATHIC SCOLIOSIS SURGERY

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Summary: Post-operative complications after posterior spinal fusion necessitating an early reoperation can be devastating for the patient, family, and physician. Previous studies have shown improved outcomes associated with higher volume surgeons and hospitals, but reoperation events have not yet been explored. Using relevant in-hospital patient records from the New York State Inpatient Database, we found fewer reoperation events among higher volume hospitals and surgeons for adolescent idiopathic scoliosis.
Introduction: Scoliosis surgery is associated with a significant learning curve. The need for early reoperation can be devastating for patient, family, and physician and adds significant cost. We aimed to assess reoperation risk in adolescent idiopathic scoliosis (AIS) by surgeon and hospital operative volume.
Methods: The 2008-2011 New York State Inpatient Database was queried using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes for patients with in-hospital stays including a spine arthrodesis for a diagnosis of idiopathic scoliosis age 10-21. Patient identifiers and revisit linkage variables were used to identify patients having multiple visits to the same or different hospitals for another spine surgery. Annual surgeon and hospital volumes were stratified into tertiles (low, medium, high) via identifier codes. The relative risk of reoperation after spine arthrodesis was calculated for relevant patient inpatient stays.
Results: Over 2008 to 2011, a total of 3,928 primary fusion operations for AIS were identified. The overall rate of reoperation after spine fusion for idiopathic scoliosis was 7.1%. Low volume surgeons performed less than 6 AIS fusions per year, medium performed less than 43, and high performed from 43 to 228 (see Table for Hospitals). Reoperation after a primary fusion for adolescent scoliosis showed reduced frequency among higher volume surgeons (14.1% for low, 5.1% for high, p<0.001, see Table for Hospitals). Irrigation and debridement was performed at a higher rate and infection or wound dehiscence was diagnosed more often at these re-hospitalizations (see Table). Low volume surgeons had a higher relative risk of re-operation for a diagnosis of wound dehiscence (RR 1.7, p<0.001). Each reoperation visit was associated with longer length of stay and increased hospital charges.
Conclusion: Early reoperation after spine fusion for idiopathic scoliosis are more likely in lower volume settings. Resources should be allocated accordingly to prevent these devastating events.

245. RESULTS OF REVISION SURGERY FOR PSEUDARTHROSIS FOLLOWING PEDICLE SUBTRACTION OSTEOTOMY FOR FIXED SAGITTAL IMBALANCE: MINIMUM FIVE-YEARS POST REVISION

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Summary: Although revision surgery for pseudarthrosis following spinal deformity surgery has been shown to be problematic, our results showed that revisions for pseudarthrosis after a PSO can provide acceptable radiographic and clinical outcomes at a minimum 5 years post-revision. It is imperative to use stronger instrumentation to provide more rigid stabilization and ample bone graft for complete fusion.
Introduction: To our knowledge, the results of revision surgery for pseudarthrosis following a primary pedicle subtraction osteotomy (PSO) have not been reported. The purpose of this study was to report our radiographic results and clinical outcomes at a minimum 5 years after revision surgery for pseudarthrosis following a PSO.
Methods: Eighteen consecutive patients with pseudarthrosis following pedicle subtraction osteotomy (16 women/2 men, average age at surgery, 49.8 years) treated with revision surgery at one institution were analyzed (average follow-up, 6.5 years; range, 5-12 years). Radiographic and clinical outcomes analysis was performed.
Results: Sagittal vertical axis (SVA) and lumbar lordosis (LL) improved significantly after revision surgery (SVA, P = 0.000; LL, P = 0.024) and were maintained until ultimate post-revision follow-up (SVA, P = 0.170; LL, P = 0.729). Proximal junctional angle (P = 0.828), thoracic kyphosis (P = 0.828), and PSO angle (P = 0.717) achieved by the primary surgery were also maintained until ultimate post-revision follow-up. We increased the number of rods and/or exchanged them to 6.35 mm diameter in all patients. There were significant improvements post-revision in Oswestry (ODI) scores (45 vs. 37.9, P = 0.041) and Scoliosis Research Society (SRS) pain subscale (2.6 vs. 3.1, P = 0.043), but not in the SRS total score or other subscales. Pelvic incidence (PI) >60° demonstrated a trend toward poorer post-revision ODI and SRS scores (P >0.05), but there were no significant differences between SVA > or < 110 mm.
Conclusion: Revision surgery for pseudarthrosis following pedicle subtraction osteotomy can provide acceptable radiographic and clinical outcomes at a minimum 5 years post-revision. Successful surgical outcomes may be achieved by using an increased number and size of rods across the pseudarthrosis site and ample bone graft for complete fusion. Absolute values of PI and SVA might not be critical for successful clinical outcomes of patients undergoing multiple revision surgeries.

246. RESULTS OF THE 2014 SRS GLOBAL DELPHI SURGEON SURVEY ON PJK/PJF: A REPORT ON SURGEON VIEW OF PREVENTION AND TREATMENT INDICATIONS, CLASSIFICATION AND GUIDELINES

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USA

Summary: Proximal Junctional Kyphosis (PJK) and Proximal Junctional Failure (PJF) are common problems in Adult Deformity Surgery. These conditions can lead to poor clinical outcomes, reoperations and decreased cost effectiveness of surgical intervention. Here we report the results of an SRS wide Delphi study of PJK and PJF practice patterns and preferences. Respondents in general support the need for development of a classification system (CS) (42%) and treatment guidelines (51%).
Introduction: Currently there are no agreed upon optimal prevention strategies or pre-op scoring systems to guide use of PJK prevention options. There are no general standards to guide decisions on when to proceed with revision surgery. Here we report the results of an SRS wide Delphi study of PJK and PJF practice patterns and preferences to assist in the development of an SRS treatment based classification by the adult deformity committee. Respondents in general support the need for development of a classification system and treatment guidelines.
Methods: An electronic survey regarding PJK/PJF was sent to 324 SRS members globally who treat adult scoliosis. Questions included importance of key factors influencing prevention and revision, prevention methods currently used.
Results: 115 surgeons from 26 countries completed the survey. 83% and 90% agree on the provided PJK/PJF definitions (PJK:UIV+2≥20deg, PJF:failure at top of instrumented fusion that needs revision). 42% and 51% reported that a CS and guidelines for prevention would be very helpful, and 57% of surgeons use a prevention strategy >60% of the time. 81% of surgeons used neurologic deficit as key factor for revision surgery, which was significantly higher than 20 other factors. Other significant factors included: severe focal pain (97%), subluxation fracture (93%), and a change in kyphosis >30deg (91%). 92% reported the impact of PJK on HRQOL as ≥moderately important. Of 19 prevention strategies, preop BMD testing and the use of extra thoracic kyphosis contour upper rod were used significantly more (76% and 80%, respectively).
Conclusion: A wide variety of PJK/PJF prevention strategies, and indications for revision surgery are being used by SRS surgeons. Many agree that the development of a CS and prevention and treatment guidelines for PJK/PJF would be beneficial. This survey provides important background information for the creation of a PJK/PJF CS that meets the needs of SRS membership and reflects their common clinical experience.

247. SPINAL CORD CONTUSIONS (SCC) DURING SPINAL DEFORMITY SURGERY

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Summary: Study of patients with intraoperative SCC. The neurophysiological intraoperative records were studied and related to the final outcome of the patients.: Incidental SCC during surgery is a relatively common event (3%) especially in complex surgery. When the injury manifest itself by isolated loss of MEP unilateral or bilaterally the neurological prognosis is excellent.

Introduction: Sudden loss of intraoperative neuromonitoring (INM) potentials may occur during the placement of spinal instrumentation and is often related to SCC. Scanty literature has dealt with this matter. The aim of this study was to establish the clinical and INM events associated with SCC and its related prognosis.

Methods: Multicentre retrospective study including 691 patients (2008-2013) that underwent surgery for all kinds of spinal deformity and were treated by a posterior approach, associated Smith-Petersen Osteotomies (SPO) were used in 90 occasions, pedicle subtraction osteotomy (PSO) in 30, 14 vertebrectomies (V) and Apical Vertebral Resection (AVR) in 9. In all patients intraoperative neuromonitoring (INM) with Motor Evoked Potentials (MEP) and Sensitive Evoked Potentials (SEP) was used.

Results: Out of the 691 patients, 23 (3%) had an event registered as SCC. The contusion was produced either during instruments placement (screw or sublaminar hook) or associated with a SPO (6), PSO (2) or an AVR (1).

The SCC was always associated by high blood pressure and changes in the INM.

All patients had a sharp loss of ipsilateral or bilateral MEPs noted. Of them 19 (82.6%) had preservation of SEP, all of them recover MEP during surgery (interval 4-40 minutes.). Four patients presented paretic changes on wakeup, which subsided during the following days (3-7 days).

Four (17.4%) loss MEP and SEP during INM, none recovered during surgery and all them presented a neurological deficits on wakening, 3 of them recover completely (3-12 months) while 1 had an incomplete recovery.

Conclusion: Incidental SCC during surgery is a relatively common event (3%) especially in complex surgery. When the injury manifest itself by isolated loss of MEP unilateral or bilaterally the neurological prognosis is excellent. However, when both MEP and SEP are loss they result in a serious neurological injury not always with complete recovery.

248. RESULTS OF REVISION SURGERY FOR PROXIMAL JUNCTIONAL KYPHOSIS FOLLOWING POSTERIOR INSTRUMENTATION: MINIMUM TWO-YEARS POST REVISION

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Summary: In this study, revision surgery for PJK provided acceptable radiographic and clinical outcomes at a minimum 2 years post-revision. Patients with pre-revision global spine alignment (GSA) ≥70° showed better ultimate outcome with surgery to treat PJK than those with GSA <70°. The fracture (F) group demonstrated a trend toward better clinical outcomes after revision surgery compared to the non-fracture (NF) group.

Introduction: We evaluated radiographic and clinical outcomes at minimum 2 years after revision surgery for proximal junctional kyphosis (PJK). In addition, we analyzed the results according to global spine alignment (GSA) and the cause of PJK.

Methods: Thirty-two consecutive patients with PJK following posterior instrumentation (25 women/7 men, avg age at surgery, 60.8 yrs) treated with revision surgery at 1 institution were analyzed (avg. follow-up, 4.5 yrs; range, 2-10 yrs). Radiographic and clinical outcomes analysis was performed. The causes for PJK revision were divided into fracture (F) and non-fracture (NF) groups. Global spine alignment (GSA), defined as thoracic kyphosis (TK) + lumbar lordosis (LL) + pelvic incidence, was evaluated as a predictor of outcomes following PJK revision.

Results: Measurements of PJK (P<0.001), TK (P=0.001), thoracolumbar kyphosis (TLK, P=0.001), and LL (P=0.016) improved significantly with revision surgery and were maintained until ultimate post-revision f/u (PJK, P=0.842; TK, P=0.893; TLK, P=0.984; LL, P=0.824). Sagittal vertical axis (SVA, P=0.018) acquired by revision surgery, however, was not maintained through ultimate f/u (P=0.044). There were significant improvements after revision in Oswestry scores (57.3 vs 40.8, P<0.001) and SRS total scores (50.9 vs 73.3, P<0.001) in all patients. In patients with GSA ≥ 70°, the ultimate PJK measurement was smaller than in patients with GSA < 70° (8.7° vs 18.2°, P=0.008). There were significant differences in the amount of post-revision changes at ultimate follow-up in SVA (29.0 vs -47.3, P=0.002), LL (-0.3 vs -16.2, P=0.001), Oswestry scores (-31.0 vs -7.8, P=0.004), SRS total score (29.0 vs 18.3, P=0.042), and SRS pain subscale (1.9 vs 0.4, P<0.001) between the F and NF groups respectively.

Conclusion: Revision surgery for PJK following posterior instrumentation can provide acceptable radiographic and clinical outcomes at a minimum 2 years post-revision. Patients with GSA ≥70° showed better ultimate outcomes in revision surgery for PJK compared to those with GSA <70°. Although the NF group showed more correction in LL and SVA than the F group, the improvement in clinical scores was greater in the F group.

249. SURGICAL SCOLIOSIS CORRECTION IN PATIENTS WITH SYRINGOMYELIA: A STUDY OF SURGICAL RESULTS IN ASSESSMENT OF SPINAL COLUMN LENGTH AND TRUNK HEIGHT CHANGES

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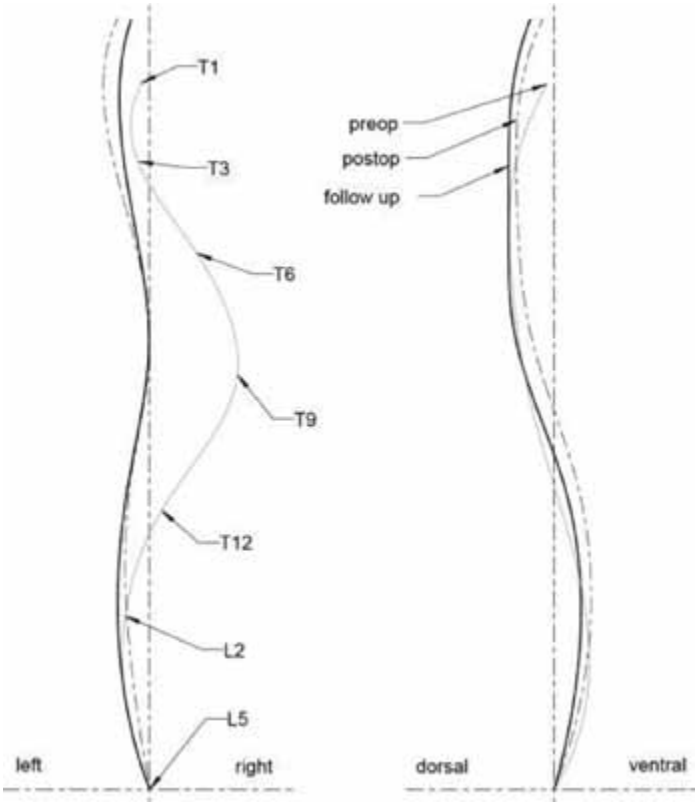
Summary: Analysis of 48 scoliosis patients with syringomyelia using 3D-analysis for changes of spinal column height (SLC) showed that SCL and trunk height (TC) changed by a total of 11mm and 37mm, respectively. Excessive correction was avoided. Our study adds evidence for a better understanding of spinal column and trunk height changes in scoliosis surgery. It is important to estimate the 3D-changes related to advanced corrective maneuvers, particularly in patients with spinal pathology like Syringomyelia (SM).

Introduction: Scoliosis surgery in patients with SM is associated with fraught regarding increased neurologic risk.In theory, resolving a scoliotic curve does not increase SCL while postop TH is increased by the straightened spine.In practice, over distraction of the spinal column can occur as a result of surgical maneuvers.Our objective was to analyze scoliosis correction in patients with SM in assessment of SCL and TH changes.

Methods: The sample included 48 patients with SM (17 congenital, 26 AIS, 5 neurom.). 23 were males. Avg. age was 18yrs and F/U 21 months. 63% had PSF, 37% had ASF.Fused levels were 10±4. Length of SM was 6±5 levels and affected the c-spine (17%), thoracic and TL-spine (60%). Morphology of the SM was holo-type and tubular in each 50%. 92% had a major thoracic/thoracolumbar curve. 9 patients had a preop neurologic deficits. On biplanar radiographs, scoliosis parameters, TH (T1-L5) and SCL (T1-L5) were measured as described: An identical coordinate system was used (fig.1). On lateral and AP radiographs landmarks were determined at T1 as cephalad, L5 as caudal border, and at apical and transitional vertebrae. The distance between landmarks and the neutral axes were measured and the avg. height (z-axis) used for calculation of 3D-curves (Pro/Engineer Wildfire 4). SCL was calculated by the length of the reconstructed 3D-curve.

Results: Radiographic results are summarized in table 1. Preop SCL was 352±43mm, postop 352±38mm and at F/U 353±35mm. The SCL decreased preop to postop by 0.4±17mm (p>.05) and increased postop to F/U by 1.4±12mm (p>.05). Trunk-height increased preop to postop by 37±22mm (p<.01) and decreased postop to F/U by 7.4±12mm (p<.01).There was no sig. correlation between SCL change and SM length, TC-/LC-correction or TH changes. Increase of SCL postop to F/U correlated with age of patients In perspective of overall only small SCL changes, statistics could not demonstrate predictors for neurologic worsening. However, individual analyses outlined the potential reasons in 2 patients with postop neurologic decline.

Conclusion: Analysis of SCL changes instead of only TH changes can improve understanding of the effects of correction maneuvers.This is of particular interest in scoliosis correction in patients with spinal pathology.



250. INTRA-OPERATIVE CARDIOPULMONARY ARREST IN PEDIATRIC PATIENTS UNDERGOING SPINAL DEFORMITY CORRECTION: ASSOCIATED FACTORS

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Summary: Increased estimated blood loss and proportion of blood volume lost were associated with increased risk for cardiopulmonary arrest. All occurred in diagnoses other than AIS or Scheuermann Kyphosis.

Introduction: The aim of our study was to report the rate of intra-operative cardiac arrest (ICA) in children undergoing spinal fusion for deformity correction and to assess associated factors.

Methods: Records of patients operated on at two pediatric hospitals between 2004 and 2014 were reviewed. Logistic regression models were used to analyze effect of patient age, gender, diagnosis, curve size, estimated blood loss (EBL), body mass index (BMI), and proportion of blood volume lost (EBL/BV) on cardiopulmonary arrest. Significance was set at P<0.05.

Results: 9 patients were identified. Diagnoses were Cerebral Palsy (4), Arthrogryposis (1), Connective 9 patients were identified. Diagnoses were Cerebral Palsy (4), Arthrogryposis (1), Connective Tissue Disorder (2), spinal cord tumor (1), IIS (1). There were none in AIS or SK. Hemoglobin was < 5 in three at the time of arrest. On univariate analysis, EBL (Odds ratio: 1.86, P=0.015) and EBL/BV (Odds ratio: 2.73, P<0.05) were found to be significant predictors of ICA. When adjusted for covariates in a multivariate model, none of the variables were found to be significant predictors of ICA. 8 of the 9

patients received cardiopulmonary resuscitation and one patient was re-intubated to sustain ventilation. 1 patient who developed ICA could not be resuscitated.
Conclusion: Intraoperative cardiopulmonary arrest is a rare complication occurring in <1% of children undergoing spinal fusion surgery. Patients with non-idiopathic scoliosis appear to be at highest risk of sustaining cardiopulmonary arrest. Total blood loss and proportion of blood volume lost were found to be significant predictors of developing cardiac arrest. Surgical teams should be cognizant of risk factors for this serious complication.

252. WHAT IS THE FATE OF ADULT AND PEDIATRIC SPINAL DEFORMITY RECONSTRUCTION AFTER PRIOR DEEP WOUND INFECTION?

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USA

Summary: In a cohort of 30 adult and pediatric patients undergoing spinal deformity reconstruction after deep wound infection, a high complication and recurrent infection rate was observed. However these patients demonstrated improved clinical and radiographic outcomes following their Post Infection Revision Surgery (PIRS).
Introduction: Deep wound infection after instrumented spine fusion is a significant complication resulting in substantial morbidity. The complications and outcomes of revision spinal deformity surgery in the setting of prior deep wound infections have not been reported.
Methods: A surgical database from 1985 to 2013 including adult and pediatric deformity patients was queried. Patients undergoing revision posterior spinal fusion ≥ 5 levels that had a prior deep infection and were clinically without signs of infection were included. The primary outcome measure was the occurrence of postop complications, specifically recurrent infection. Pre- and postop SRS-22R and ODI scores were also collected.
Results: 30 patients (12 males/18 females, 21 with min 2yr F/U (70%)) with a mean age of 31.7 yrs (range 3 to 76) and a BMI of 24.1 kg/m2 were identified as having a Post-Infection Revision Surgery (PIRS). These patients had a mean of 7.5 prior surgeries (range 2 to 26) with a mean of 11.5 levels fused. 27 patients (90%) had their instrumentation removed at a mean of 43.1 months prior to their PIRS. The most common diagnoses for PIRS were progressive deformity (60%) or fixed sagittal malalignment (30%). Pseudarthroses were common prior to revision, occurring in 21 patients (70%). A mean of 14.3 levels were fused for the PIRS with a mean EBL of 1491ml. A 3CO was performed in 19 patients (VCR = 14 (47%); PSO = 5 (17%)) primarily for sagittal realignment. A major complication occurred in 19 (63%) patients with 7 (23%) developing a recurrent infection. Major coronal Cobb (41 vs 29, $p < 0.001$), coronal C7 plumb (2.7 vs 1.9 cm, $p < 0.01$), and sagittal C7 plumb (6.0 vs 1.1 cm, $p < 0.001$) improved. A significant difference between pre- and postop SRS (2.8 and 3.9, $p < 0.001$) and ODI (47.9 and 29.3, $p < 0.006$) scores was seen at a mean follow-up of 44.4 months.
Conclusion: Post-Infection Revision Surgery, not unexpectedly, has a high recurrent infection rate. However, this study demonstrates that these challenging patients did have improved clinical and radiographic outcomes with significant improvement in both SRS and ODI outcome scores reflecting the benefits of the PIRS.

253. RE-OPERATION RATES IN MINIMALLY INVASIVE, HYBRID AND OPEN SURGICAL TREATMENT FOR ADULT SPINAL DEFORMITY WITH MINIMUM TWO-YEAR FOLLOW UP

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USA

Summary: Two multi-center deformity databases were analyzed and patients characterized as MIS, hybrid, or open and then propensity matched for levels fused and deformity magnitude. Re-operation rates were compared between groups and found to be statistically similar. The reason for re-operation was most commonly due to pseudarthrosis in the MIS group, whereas PJK, infection, and neuro deficit were most common in the hybrid and open groups.
Introduction: Minimally invasive surgical (MIS) techniques are gaining popularity in the treatment of ASD with the premise of equivalency in outcomes and complication reduction. Potential limitations to MIS techniques are decreased corrective capacity, concern for long-term efficacy, and potential need for revision surgery. The current study aims to compare re-operation rate and indications following MIS, hybrid and open surgery for ASD.
Methods: Two multi-center databases were retrospectively analyzed . Inclusion criteria: age >18 years with minimum 20° coronal lumbar Cobb, minimum 3 levels fused and 2 year follow-up. Patients were propensity matched for preop SVA, PI-LL, and levels fused, resulting in 114 patients in three subgroups of 38 patients: (1) MIS: lateral or transforaminal lumbar interbody fusion (LIF) and percutaneous pedicle instrumentation, (2) Hybrid: MIS LIF with open posterior segmental fixation (PSF), and (3) Open: PSF +/- osteotomies.
Results: There were no significant differences between groups in pre-op SVA or PI-LL ($p>0.05$), however the MIS group had significantly fewer levels fused (4.7) than the open group (6.8) ($p=0.002$). The rate of revision surgery was not significantly different between the groups ($p=0.196$): MIS=15.8% (6/38), Hybrid=31.6% (12/38), Open=31.6% (12/38). The most common reason for reoperation in the Open group was neuro deficit (10.5%) followed by PJK (7.9%). The most common reason in the Hybrid group was PJK (13.2%) followed by infection (7.9%). The most common reason in the MIS group was pseudarthrosis (7.9%).
Conclusion: Re-operation rates were not statistically different between the MIS, Hybrid, and Open surgical groups, however the incidence was twice as high in Hybrid and Open groups. The most common reasons for reoperation were PJK, neuro deficit, and infection for the hybrid and open groups, but pseudarthrosis in the MIS group.

254. SUBLAMINAR BANDS: ARE THEY SAFE?

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Summary: The sublaminar bands are effective implants for spine deviation correction on children. We use them in an hybrid posterior technique, with multimodal intraoperative monitoring and anesthesiologic monitoring including invasive blood pressure monitoring. These conditions, and a short but necessary learning, allow a saftey use of sublaminar bands.

Introduction: Sublaminar Bands (SB) are frequently used as implants in spine deviation correction. Our purpose is to demonstrate their safety on a large series of patients.

Methods: This is a retrospective study. Our department treated 378 spine deviations on children and adolescents via an hybrid posterior technique (lumbar screws, hook and thoracic SB). Each surgery was undertaken using an anaesthesiologic and neurophysiologic monitoring: somato-sensory evoked potentials (SSEP) and neurogenic mixed evoked potentials (NMEP). An alert was described as an amplitude decrease of 50% and/or a latency increase of 10%. Data were analyzed using Student or Wilcoxon tests.

Results: We used 2223 SB in 378 operative procedures. We described 10 neurophysiologic alerts, during the passage of the band beneath the lamina. There were no significative differences when it came to age and severity of the deformation between the two groups ($p>0.05$). Neurophysiologic alert was always associated with a dysautonomic trouble (hypertension and bradycardia). The lesional level was determined using a spinal electrode. In 6 cases, the responsible SB was removed. Three patients had post-operative neurologic deficiency (0.8%) without complete recovery for one of them (localized incomplete sensitive deficiency). Within the group of 378 patients, 21 alerts were reported due to a screw or a hook, or during the correction manoeuver, without dysautonomic trouble.

Conclusion: The SB neurologic complications rate is as high as other implants complication rate. Simultaneous hemodynamic and physiologic change is an argument for vegetative response due to the SB passage. Their optimal use requires a strict learning of their insertion beneath the lamina in order to be as less traumatic as possible.

Conclusion: The SB are as safe as any other spine implants.

257. CLINICAL IMPACT CORRELATION OF THE HART ISSG PROXIMAL JUNCTIONAL KYPHOSIS SEVERITY SCALE AND HRQOL

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USA

Summary: Proximal junctional kyphosis (PJK) and proximal junctional failure (PJF) are adverse outcomes adult spinal deformity surgery (ASD). There is a lack of consensus regarding which patients require revision surgery. The Hart ISSG PJK severity scale correlates with the need for revision surgery. All adult spinal deformity patients with PJK and/or PJF who eventually underwent revision surgery were identified at two institutions. The hart ISSG PJK severity scale may also correlate with functional outcomes, specifically ODI and SRS30 components.

Introduction: Proximal junctional kyphosis (PJK) and proximal junctional failure (PJF) are adverse outcomes following ASD surgery. There is a lack of consensus regarding which patients (pts) require revision surgery. The Hart ISSG PJK severity scale correlates with the need for revision surgery. This study evaluates the Hart ISSG PJK severity scale and health related quality of life (HRQOL) measures in pts with PJK.

Methods: All ASD pts with PJK and/or PJF who eventually underwent revision surgery were identified from two large academic medical centers. Pts were retrospectively assigned scores based on the Hart ISSG PJK severity scale: neurological status, focal pain, instrumentation problem, kyphosis severity/PLC integrity, UIV/UIV+1 fracture, and level of UIV. Scores range from 0-15. Pre-PJK revision HRQOL measures included: Oswestry Disability Index, SF-36, and SRS30. Scores were subcategorized into 0-2, 3-5, 6-8, 9-11, and 12-15, and differences in HRQOL outcomes were determined with linear regression. Correlation were assessed with a Pearson correlation coefficient.

Results: 54 cases were included. 31.5% male and mean age was 64.9 years. The Hart ISSG PJK severity scale scores ranged from 4-15, with the median being 8. PJK/PJF occurred in the upper thoracic spine in 24.1% of the cases. 54.8% had fractures and 77.8% had instrumentation issues. 55.6% had neurological deficits, with 16.7% having weakness and/or myelopathy. All pts had preop pain(median VAS 9/10). While statistical significance on linear regression was not seen, there were obvious trends that correlated with the Hart ISSG PJK severity scale. Higher Hart ISSG PJK severity scale scores were associated with higher ODI ($p = 0.283$, $r = 0.350$), lower SRS30 function ($p=0.821$, $r = -0.323$), and lower SRS mental ($p= 0.646$, $r = -0.592$).

Conclusion: The Hart ISSG PJK severity scale has been shown to be predictive in the decision making of when patients require revision surgery. Based on the current study, it may also correlate with functional outcomes, specifically ODI and SRS30 components.

258. DEFINING PERI-OPERATIVE COMPLICATIONS FOLLOWING ANTERIOR COLUMN REALIGNMENT (ACR) FOR ADULT SAGITTAL PLANE DEFORMITY: A MULTICENTER ANALYSIS

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Summary: ACR is a minimally invasive technique used to correct sagittal plane deformity by releasing the ALL and annulus through a transpsoas approach. The complication profile of ACR is poorly understood. This multicenter study revealed that age was significantly associated with implant related complications. Pre-op severity of sagittal deformities did not correlate with any complications. The occurrence of a complication did not have an adverse effect on HRQoL.

Introduction: Anterior column realignment (ACR) is a minimally invasive lateral transpsoas approach used to treat adult sagittal plane deformities to achieve global alignment. This technique has many unanswered questions, including the complications (COMP). We are reporting perioperative COMP in an early series of 56 patients who had ACR.
Methods: Retrospective review of 65 consecutive ACR cases at 5 sites. Major and minor COMP were classified according Glassman et al., and divided into anterior (ANT), posterior (POST) approach and BOTH. Early was considered within 90 days of surgery. Preop deformity was classified according to Schwab sagittal modifier. Patient-reported pain scales, Oswestry Disability Index, and SRS-22 were collected preop and 1 yr postop.
Results: 56 patients had minimum 1 year follow up. Mean age was 64 yrs (range 35 - 80), 64% (36/56) had previous lumbar surgery. Pre-op Schwab modifier was "0" for 5 (11%), + for 6 (13%), and ++ for 35 (76%). 35 COMP occurred in 24 pts (43%). 23 (65%) were major, including 1 death (major blood loss), and 12 (35%) minor. Implant-related COMP (IR) occurred in 6 (11%), general medical (GM) in 6 (11%), and major neurologic deficits in 3 (5%). 23 COMP (65%) occurred early. 4 COMP (11%) were directly related to ANT, 8 (23%) to POST, and 23 (65%) BOTH. 14 (25%) pts underwent 18 revisions (table 1). There was a significant difference in age among patients with and without COMP IR (74 yrs v. 63 yrs, p=0.018). There was no correlation with preop modifier, nor between complications and adverse outcomes (p>0.05). Incidence or type of COMP were also not correlated with number or level of ACR (p>0.05).
Conclusion: Complications associated with anterior column realignment have not been quantified. Age seems to be a driver of implant related complication occurrence. Interestingly more severe sagittal plane deformity patients were not at higher risk for COMP occurrence. Level of ACR and number of ACRs was not associated with COMP. The development of a complication did not adversely affect HRQoL. Longer term follow-up as well as larger patient population will be needed to reach statistical power to further support the findings in this study.

259. PRE-OPERATIVE SPINAL CORD DAMAGE ADVERSELY AFFECTS THE CHARACTERISTICS OF SEGMENTAL MOTOR PARALYSIS FOLLOWING CERVICAL DECOMPRESSION SURGERY

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Summary: Segmental motor paralysis occurred in 9% of patients after cervical decompression surgery. MRI signal change in spinal cord was a factor associated with deterioration of the paralysis. The signal change was also a factor associated with deterioration of surgical outcome of cervical decompression surgery.
Introduction: Segmental motor paralysis (SMP) is an enigmatic complication following cervical decompression surgery. The etiology of this complication remains controversial. We particularly focused on preoperative T2-weighted high signal change (T2HSC) on magnetic resonance imaging in the spinal cord, and assessed the influence of preoperative T2HSC on SMP following cervical decompression surgery. The objective of this study is to test the hypothesis that preoperative spinal cord damage affects postoperative SMP.
Methods: A retrospective review of 181 consecutive patients (130 men and 51 women) who underwent cervical decompression surgery was conducted. SMP was defined as development of postoperative motor palsy of the upper extremities by at least 1 grade in manual muscle testing without impairment of the lower extremities. The relationship between the locations of T2HSC in preoperative magnetic resonance imaging and SMP characteristics (the extent of paralyzed segments, manual muscle score, and recovery period) was investigated with using statistical modeling.
Results: Preoperative T2HSC was detected in 78% (142/181) of the patients. SMP occurred in 9% (17/181) of the patients. Preoperative T2HSC significantly influenced the severity of SMP: the number of paralyzed segments increased with an incidence rate ratio of 2.2 (p=0.026), the manual muscle score deteriorated with an odds ratio of 8.4 (p=0.032), and the recovery period was extended with a hazard ratio of 4.0 (p=0.035).
Conclusion: Preoperative T2HSC was associated with worse severity of SMP in patients who underwent cervical decompression surgery, suggesting that preoperative spinal cord damage is one of the pathomechanisms of SMP following cervical decompression surgery.

260. ALLOGENIC BLOOD TRANSFUSIONS IN ADULT SPINAL DEFORMITY SURGERY: TRENDS AND COMPLICATIONS FROM 428 PATIENTS

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USA

Summary: In this cohort of ASD patients, exposure to allogenic blood was associated with perioperative cardiopulmonary complications, specifically pulmonary effusions and VTE, but without increased infection, renal, nor neurological complications. No association was observed between complications and volume of allogenic blood transfused.
Introduction: Perioperative allogenic blood transfusions (ALLO) are common in adult spinal deformity (ASD) and there is evidence to support a morbidity associated with exposure to ALLO. The relationship between ALLO and perioperative complications in ASD surgery has not been adequately examined.
Methods: Patients undergoing a single hospital stay surgery for ASD were identified in a prospective cohort of ASD patients. Demographic and surgical data were collected, including operative time, EBL, and ALLO. Perioperative complications were recorded and classified as major or minor and according to body system. Between groups comparisons were performed using independent sample t-test and Chi-square. Poisson and logistic regression analyses were performed to examine the relationship ALLO, the number of complications, and the occurrence of specific complications.

Results: 428 Patients were identified (NoTrans=111, Auto=31, ALLO=275, Auto+ALLO=11). Patients receiving ALLO were older (49.8yr vs 48.5 vs 60.8 vs 57.7, p<0.001), had higher BMI(26.3kg/cm^2 vs 25.7 vs 28.3 vs 26.3, p<0.001), had more cardiac comorbidities(p<0.001), underwent longer surgeries with more levels fused, but without higher EBL. Patients receiving any transfusion experienced more cardiopulmonary complications, without increased rates of infectious, renal, or neurological complications. Poisson regression revealed no association between ALLO and major (p=0.907) and minor (p=0.184) complications. Logistic regression, controlling for EBL, age, and comorbidities showed an increased risk of perioperative cardiopulmonary complications (OR: 2.7(1.2-6.1)) with ALLO, most common being pulmonary effusions (20) and VTE (10). No association was found between ALLO volume (cc) and complications.
Conclusion: Allogenic blood transfusions were common in this cohort of ASD patients. Patients receiving any transfusion sustained perioperative cardiopulmonary complications more commonly and analysis controlling for known confounders supported a relationship between exposure to ALLO and cardiopulmonary complications. No increased risks of infectious, renal, or overall complication counts were observed.

262. LUMBAR FUSION FOR DEGENERATIVE DISC DISEASE IS ASSOCIATED WITH SIGNIFICANTLY HIGHER RATES OF FAILED BACK SURGERY SYNDROME COMPARED TO FUSION FOR SPONDYLOLISTHESIS IN A WORKER'S COMPENSATION SETTING

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Summary: Lumbar fusion for spondylolisthesis tends to yield better and more consistent outcomes than fusion for degenerative disc disease (DDD). Worker's compensation (WC) subjects undergoing lumbar fusion tend to have worse outcomes than the general population. Few studies have evaluated pre-fusion risk factors within this clinically distinct population. We demonstrated that WC subjects who underwent fusion for DDD were approximately 1.45 times more likely to develop FBSS within 3 years of surgery than subjects that underwent fusion for spondylolisthesis.
Introduction: Lumbar fusion for spondylolisthesis tends to yield better and more consistent outcomes than fusion for degenerative disc disease (DDD). Few studies have evaluated predictors of poor fusion outcomes within the worker's compensation (WC) population, a clinically distinct subset of patients who tend to have worse outcomes than the general population. Failed back surgery syndrome (FBSS) is a feared complication of back surgery associated with a decreased quality of life, psychosocial problems, and addiction to pain medication. Our objective was to compare rates of FBSS development between WC subjects that underwent lumbar fusion for spondylolisthesis vs. DDD.
Methods: Using ICD-9 diagnosis and CPT procedural codes, we identified a retrospective cohort of 2208 subjects receiving medical benefits from the Ohio Bureau of Worker's Compensation that underwent lumbar fusion surgery after WC-qualifying injury for the primary indication of either spondylolisthesis (n=709) or DDD (n=1499) between 1993-2010. We excluded subjects with a positive smoking history and pre-fusion diagnosis of FBSS. Correcting for age, gender, obesity, income, number of levels fused, and additional fusion surgeries within 3 years, logistic regression analysis was performed, with the dependent variable being whether or not FBSS was diagnosed within 3 years after fusion.
Results: Subjects that underwent lumbar fusion for spondylolisthesis developed FBSS at significantly lower rates than subjects who underwent fusion for DDD without spinal deformity or instability (p=0.03). 53 of 656 (8.1%) subjects that underwent fusion for spondylolisthesis developed FBSS. 165 of 1499 (11.0%) subjects that underwent fusion for DDD developed FBSS. Lower income was also associated with higher rates of FBSS (p=0.05).
Conclusion: Within a WC setting, we demonstrated that undergoing lumbar fusion for the indication of DDD is associated with significantly higher rates of FBSS within 3 years of surgery when compared to subjects undergoing fusion for spondylolisthesis.

264. ULTRASOUND-BASED RADIATION FREE SCOLIOSIS MONITORING TECHNIQUE

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Canada

Summary: Radiographic examinations in adolescent idiopathic scoliosis are linked to higher risk of breast cancer and other malignancies. Radiography is also unavailable in low-populated areas. We validated an ultrasound-based alternative in scoliosis measurement against conventional radiography. We tested the repeatability and accuracy of the ultrasound-based system in two realistic spine phantom models. Results suggest that tracked ultrasound may become a radiation free, portable alternative to radiography for screening of scoliosis and scoliosis progression
Introduction: Adolescent idiopathic scoliosis is monitored regularly with radiography to help therapeutic decisions and to estimate the rate of progression. However, regular X-ray imaging in girls nearly doubles the risk of breast cancer in later years. Repeated radiographic imaging has also been linked to prostate cancer and leukemia. Not only does radiography present a significant health risk, but it is also only available at larger imaging centers, preventing routine scoliosis monitoring in rural locations. We tested if ultrasound combined with a position tracking could be an alternative technique in scoliosis monitoring.
Methods: Our study was done on a pediatric and an adult synthetic scoliotic spine model, embedded in ultrasound-compatible gel. An ultrasound scanner was integrated with a position tracker device. Ultrasound images of the transverse processes on each side were recorded in a 3-dimensional computer model. This model was used to mark the mid-points of processes to determine the angle of each vertebra in the coronal projection plane. The angles were compared with conventional radiographic angles measured on the same spine models.
Results: Tight correlation was found between ultrasound-based and radiographic measurement of vertebra angles in the coronal plane, with a maximum difference between the two modalities under 3

degrees. Furthermore, repeated measurements by different operators were more consistent with the ultrasound-based technique than measurements from the radiographic images.
Conclusion: Ultrasound combined with position tracking appears to be a promising technology in routine scoliosis monitoring. A portable tracked ultrasound system can be assembled from affordable components, and our software is distributed as a free, open-source application for easy reproducibility.

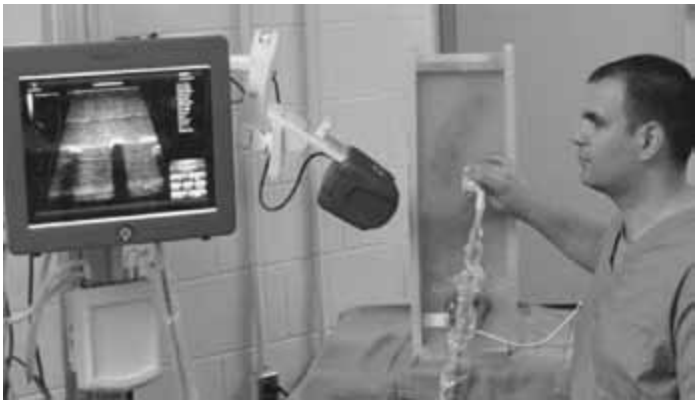

Image capture using tacked ultrasound system.

265. OBLIQUE MAGNETIC RESONANCE IMAGING OF THE LUMBAR NEUROFORAMINA IMPROVES PRECISION WHEN DIAGNOSING NERVE ROOT IMPINGEMENT: A PROSPECTIVE STUDY

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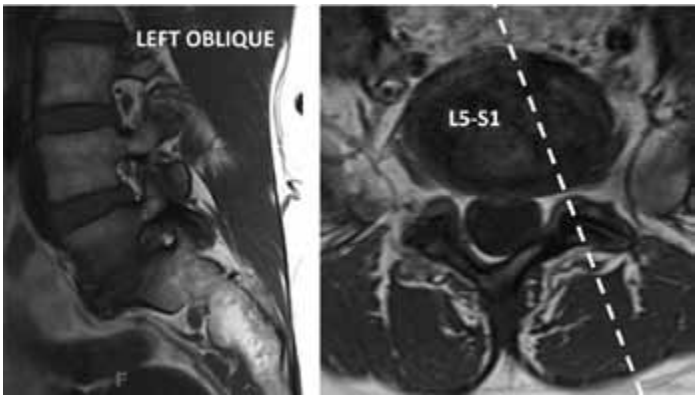
USA

Summary: In a prospective study, a novel oblique fast spin-echo T1 magnetic resonance imaging (MRI) sequence improved diagnostic consistency when evaluating lumbar foraminal stenosis in patients with radiculopathy, as compared to standard sagittal MRI. The oblique sequence was of particular value in patients with multilevel degenerative changes.
Introduction: Imaging of the lumbar neuroforamina is often of poor resolution and diagnostic value on standard sagittal magnetic resonance imaging (MRI) series, as the nerve roots exit oblique to the sagittal plane. We developed a novel oblique T1 MRI sequence in the plane of the foramina to provide an en-face view of the exiting roots, and to improve resolution between osseous, fatty, and neural tissues within the foramina.
Methods: 22 consecutive adult pts with leg pain, numbness, and/or weakness of suspected lumbar etiology were prospectively enrolled to undergo standard non-contrast lumbar MRI with T1 and T2 sequences in the axial and sagittal planes. In addition, pts underwent imaging using an experimental T1 fast spin-echo MRI sequence oblique to the sagittal axis in the plane of the lumbar foramina; a right and left oblique series was performed on each patient. A 1.5 T MRI scanner was used for all studies. The mean age of enrolled pts was 48.3 yrs (range 28-80).
Standard T1 sagittal and experimental oblique series were independently graded by 3 spine surgeons and a neuroradiologist using a validated 4-point scale for foraminal stenosis. All 10 lumbar nerve roots were graded for each patient. Reviewers were asked for each patient if they thought the oblique series provided additional information/diagnostic confidence over the standard sagittal series. Consistency of grading between reviewers was calculated using intra-class correlation coefficients (ICCC).
Results: The ICCC for grading foraminal stenosis with standard T1 sagittal MRI was 0.68 ($p<0.001$, CI 0.63-0.74). Grading stenosis using the oblique series produced an improved ICCC of 0.80 ($p<0.001$, CI 0.76-0.83). On average each reviewer stated the oblique series improved diagnosis in 56% of patients. In the 11 pts (50%) for which at least 3 reviewers stated the oblique scans improved their diagnosis, 8 (72%) had multilevel degenerative foraminal stenosis. Oblique series had a mean angle from the sagittal plane of 13.5 degrees.
Conclusion: A novel oblique T1 MRI sequence of the lumbar foramina improved radiographic diagnostic precision for evaluating nerve root impingement when compared to standard sagittal MRI in a prospective setting, particularly for pts with multilevel foraminal stenosis.



267. THE EFFECT OF GROWTH FRIENDLY SURGERY ON CORONAL AND SAGITTAL PLANE SPINE GROWTH IN IDIOPATHIC SCOLIOSIS

Chukwudi K. Chukwunyerenwa, MD, FRCSC; Charles E. Johnston, MD; Anna M. McClung, BSN, RN; Luke Gauthier, MD; Alan J. Spurway, MASc; Ron El-Hawary, MD, MSc, FRCSC
Canada

Summary: For children treated with spine-based distraction systems, it has been published that gains in coronal spine height may diminish with each lengthening procedure and may be related to auto-fusion. In this series of children with idiopathic scoliosis treated with growth friendly surgeries, there was the appearance of a law of diminishing returns when measured in the coronal plane; however, these changes were not as apparent when measured in the sagittal plane and were nullified with measurement of true spine length.
Introduction: When measured on coronal radiographs, spine-based distraction surgeries have followed a law of diminishing returns which has been proposed to be related to auto-fusion. As lengthening surgeries are kyphogenic, our hypothesis was that spine length continues to increase with each lengthening procedure; however, these gains occur in the sagittal plane. Our purpose was to evaluate the effect of lengthening procedures on coronal, sagittal, and true spine length in children with idiopathic scoliosis.
Methods: Retrospective, multi-center, review of 18 patients with minimum 5 yr follow-up after growth friendly surgery. Radiographs

were analyzed at implantation and at each lengthening procedure. Primary outcomes were changes in coronal, sagittal, and true (along the sagittal arc of thoracic vertebrae) T1-T12 length per lengthening.
Results: With minimum 5 year follow up, 18 patients with a mean age of 4.1 years were treated with rib-based(n=9) or spine-based(n=9) distraction. Three groups were compared: First lengthening (L1), 2nd through 5th lengthening (L2-L5), and 6th through 10th lengthenings (L6-L10). Cobb angle stayed constant (45.0 deg, 44.7 deg, 48.6 deg), maximum kyphosis increased (32.1 deg, 45.3 deg, 47.5 deg)*, coronal thoracic height increased (16.4cm, 17.6cm, 17.8cm), true thoracic length increased (18.4cm, 19.5cm, 20.8cm)*, change in coronal T1-T12/lengthening decreased (5.7mm, 4.0mm, 1.7mm), change in sagittal T1-T12/lengthening decreased (4.0mm, 3.3mm, 3.1mm), and change in true T1-T12 / lengthening remained constant (2.8mm, 4.4mm, 4.4mm).(*p<0.05).
Conclusion: Although there is the appearance of a law of diminishing returns when measured in the coronal plane, these changes were not as apparent when measured in the sagittal plane and were nullified with measurement of true spine length. These findings support the hypothesis that, when measured in the plane of distraction, a law of diminishing returns may not be apparent.

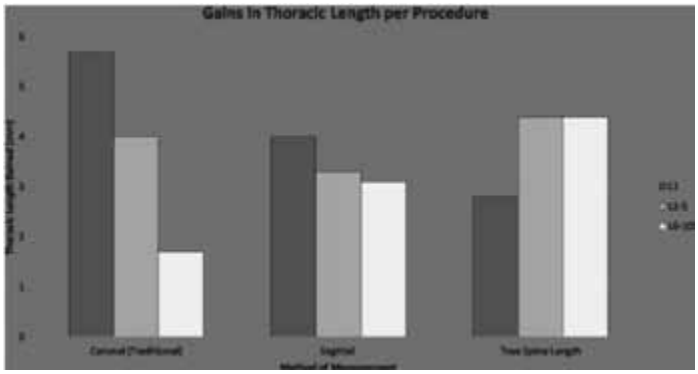


Figure 1 - Thoracic length gains per lengthening procedure as measured traditionally (appearance of diminishing returns), with sagittal radiographs, and with true spine length.

268. PEDIATRIC THORACIC VOLUME MODELING FOR EARLY ONSET SCOLIOSIS: A VALIDATION STUDY

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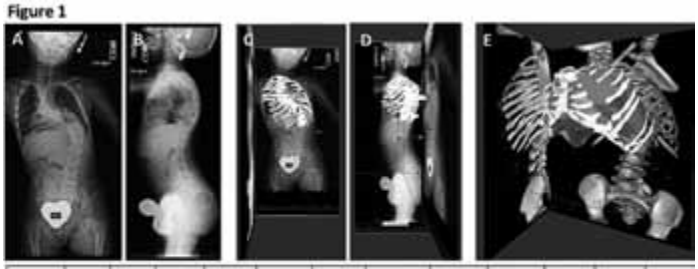
USA

Summary: Quantitative volume measurement in EOS is challenging. This study validated the use of this modeling method and predicted accurate lung volume within 4% margin of error compared to the gold standard CT-based lung volume calculation.
Introduction: Progressive early onset scoliosis (EOS) is associated with decreased thoracic and lung volumes. Virtual thoracic volume modeling from plain radiographs has been used in the adolescent idiopathic scoliosis (AIS) population. This correlates within 3% of thoracic volume from CT scans. For AIS patients with poor pulmonary function, the modeled 2 year post-op volume change is strongly correlated with the 2 year post-op pulmonary function test. However, this modeling was performed in an older, nearly skeletally mature population. The objective of our current research was to validate the computational thoracic volume modeling in EOS patients using CT-based volume calculations as gold standard. This virtual modeling using plain radiographs can be used to follow young children who undergo serial lengthening procedures, rather than exposing them to multiple CT scans over the course of their treatment.
Methods: A retrospective review of children 10 years and younger with a diagnosis of idiopathic EOS were identified. Those with congenital anomalies and/ or no CT scans were excluded. A convenience sample of three patients was chosen for this validation. AP and lateral spine radiographs were used to model thoracic volume using Blender software and a virtual 3D thorax, and MiniMagics to calculate the volume of the thoracic cavity. Lung and mediastinal volumes were calculated from the original CT scan using Voxar software. Percent error was calculated between the virtual model and the CT scan.
Results: One male and two female patients with EOS and an average age of 4 years (range 2y10mo- 5y7mo). Demographic data and calculated volumes are summarized in Figure 1F. The average percent error was 4%.
Conclusion: The virtual model created to predict lung volume, previously proven in AIS and correlated with pulmonary function, is also accurate in EOS. Variability in error is attributed to magnitude of curve and vertebral wedging, as well as rib deformation; this is a limitation in the current model. With an average 4% error of the volume measured by the virtual model versus radiation-heavy CT scan, thoracic volume modeling is a valid method to analyze lung volume for EOS patients.

Figure 1



F Subject #	Age	Sex	Height (cm)/Weight (kg)	R lung vol-calc (cc)	L lung vol-calc (cc)	Mediastinum-calc (cc)	Calculated thoracic volume (cc)	Predicted thoracic volume (mm3)	Percent error (%)	Cobb Angle (°)	Thoracic Kyphosis (T2-T12) (°)
1	5y 7mo	F	88	22.2	314.8	266	206	764.8	751.9	1.6	34	60
2	4y 10mo	F	100	18.9	198.3	100	246	544	900	8.3	61	90
3	2y 10mo	M	84.1	8.8	247.1	115.6	179	542	930	2.2	70	61

269. A CASE-CONTROL STUDY USING UPRIGHT AND SUPINE MRI TO INVESTIGATE THE DYNAMIC POSITION OF CEREBELLAR TONSIL IN ADOLESCENT IDIOPATHIC SCOLIOSIS

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China

Summary: Investigation with upright MRI showed that AIS subjects had more tonsillar descent in the upright position and greater degree of tonsillar excursion from supine to upright positions when compared with controls. These findings suggest possible dynamic compression of the brainstem and upper cervical cord which might be linked to subclinical neurophysiological disturbance and contribute to the

etiopathogenesis of AIS.
Introduction: Previous studies reported an association of AIS with abnormal somatosensory evoked potential (SSEP) and tonsillar ectopia in the supine position. Since tonsillar levels can vary with positions, evaluation of the craniovertebral junction at different postures is desirable in order to obtain an in-depth understanding of this important potential morphological and functional link. This study investigated tonsillar position with MRI in AIS and compared this with normal controls in both the supine and upright positions.
Methods: 25 girls with AIS and 18 gender-matched normal controls (mean age 14.9±2.3 and 15.3±3.4 years respectively) were examined by 0.25T MRI (G-Sscan, Esaote, Italy) in both the supine and upright positions. Readers were blinded to (i) whether the MRI was from an AIS patient or control subject and (ii) whether it was a supine or upright MRI. The level of the inferior cerebellar tonsil tip relative to a line connecting the basion to the opisthion (BO line) was measured in mm (positive meant above the BO line).
Results: The mean major Cobb angle was 26.3 °±11.4 °. Nine (36%) of the 25 AIS patients had a major thoracic curve, 2 (8%) had a major lumbar curve and 14 (56%) had a major thoracolumbar curve. The cerebellar tonsil position was lower in the upright than the supine position in AIS patients (-0.7±1.5 Vs +1.2±1.7, p<0.00001) while there was no significant difference in normal subjects (+2.1±1.7 Vs +2.0±1.8, p = 0.93). AIS patients had greater tonsillar excursion from supine to upright positions when compared with controls (mean -1.9 ±1.6 Vs -0.1±1.7, p<0.00001).
Conclusion: AIS patients have more tonsillar descent in the upright position and a greater degree of tonsillar excursion between supine and upright positions when compared with controls. Apart from supporting the hypothesis of relative cord tethering, the results also enhance the likelihood of chronic dynamic compression of the brainstem and upper cervical cord which might be linked to subclinical neurophysiological disturbance such as dynamic postural balance and abnormal SSEP, and thereby contributing to the etiopathogenesis of AIS. Further expanded studies are warranted.

270. HOW MUCH LORDOSIS IS REQUIRED FOR SAGITTAL ALIGNMENT IN PATIENTS WITH HIGH OR LOW PELVIC INCIDENCE?

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USA

Summary: The relationship between PI and LL has been studied and recognized as a key element of sagittal alignment. PI-LL is a useful predictor of required LL, but its normal values may not be adapted for patients with a very high or very low PI. This study aimed at defining a relationship between PI & LL required for optimal alignment in patients with extreme PI values.
Introduction: The relationship between Pelvic Incidence (PI) and Lumbar Lordosis (LL) has been well established as a key determinant of sagittal alignment and satisfactory surgical outcomes. The goal of matching PI and LL within 10 degrees works as a general rule, but may not apply to patients with lower or higher PI. The objective of this study was to analyze the relationship between PI & LL required for optimal alignment in patients with extreme PI values
Methods: Subjects with at least 1year follow-up were identified from a multicenter database of patients who underwent a pedicle subtraction osteotomy (PSO) from 2004-2013. Patients were included if they were well aligned (WA) based on Vialle criteria, with PT≤12° and T1SPI between -4.05° and 1.35°. The distribution of the PI was analyzed to create the following 3 groups: Low PI (LPI; < Mean - 1 S.D.), Average PI (API; Mean +/- 1 S.D), High PI (HPI; > Mean + 1 S.D.), and an ANOVA test was carried out to compare. The same analysis was performed on a separate group of patients issued from a prospective database with at least a 2year follow-up (PON) in order to validate these results.
Results: The PSO cohort included 88 patients, mean age=56.2yo. Mean PI was 57.1 +/- 15.2 degrees. The analysis of the PI-LL for the 3 groups revealed that the HPI required a lordosis smaller than the PI (PI-LL=17.7°), the API required a lordosis similar to the PI (PI-LL=1.75°), and the LPI required greater LL than the PI (PI-LL=-11.02°). There were significant differences between the HPI PI-LL parameter and the two other groups. The PON cohort included 142 patients, mean age=55.1yo. Results for this group followed the same trend as the PSO set (Table).
Conclusion: Sagittal plane deformity correction is very challenging, in respect to surgical technique and pre-operative planning. According to our study, PI-LL remains a useful predictor of required LL, but needs to be adapted to the intrinsic morphology of each patient. Patients with a high PI will require less LL to achieve alignment, while those with low PI need a greater LL. Further study to clarify these relationships may prove helpful for more accurate preoperative planning.

271. DEVELOPMENT OF A GROWTH GUIDANCE ROD SYSTEM FOR EARLY ONSET SCOLIOSIS: STUDY ON THE SAFETY AND EFFICACY IN A SHEEP MODEL

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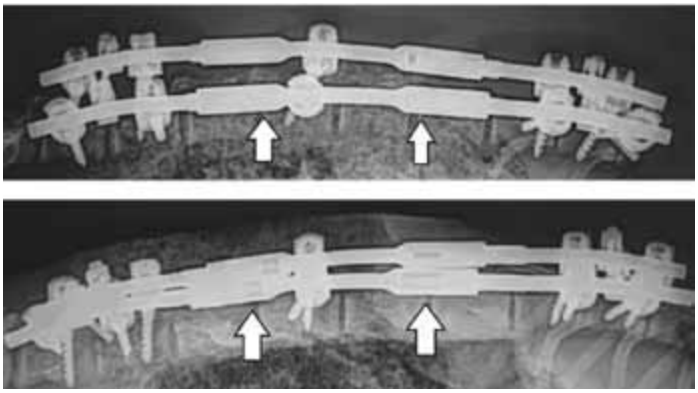
China

Summary: A novel growth guidance technique for treatment of early-onset scoliosis has been tested on immature sheep models. Part of sheep spine was fixed with Multi-segment Growth Guidance Rods system (MSGGR). All of the sheep spines within the instrument grew with the implants in place during the 4-month follow-up period. No MCGR-related complications were observed.
Introduction: Growing rod technique corrected the curve of scoliosis via distraction, which leads to insufficient correction and poor control of the curve apex, especially in the transverse plane. And the rigid of spine after growing rod procedure brought difficulty for the final fusion. MSGGR is a growth guidance system that designed to correct and control the curve, including the apex, in a 3 dimensional manner and allows the spine within the instrument to grow until skeletal maturation meanwhile does not require repeated surgical instrument lengthening. The current animal study tested if MSGGR permits the continued growth and causes any instrument-related complications, such as implant failure.

Methods: The MSGGR system is consisted of several segments and compatible to current commercial pedicle screw system. It is stable when twisted and bended but extendable when stretched. The rod extension occurs through sliding between the segments of the rod along the sockets during the growth of spine. The curve is corrected and maintained by the rods without fusion. Ten 3-month old immature sheep were used in this study. Dual MSGGR system was implanted to fix the lumber and low thoracic spine. Radiographs at 2 and 4 months postoperatively were taken to evaluate the fixation and rod extension. 4 months later magnetic resonance image and CT scan of the spine was obtained immediately after implant removal in 4 animals. The motion of the spine segments was tested manually.
Results: All of the sheep spines grew with the implants in position. The spines within the instrument were 12.5±0.8 cm and grow by 10.9% (range 6%-18.4%) from its original length in 4 months (Fig.). None of the implants failed. No MSGGR-related complications were observed. The MRI showed normal disc within the instrumented segments. MRI and CT showed no fusion in the facet joint. Motion of the instrumented spinal segments was conserved.
Conclusion: Growth guidance with the MSGGR system allowed for continued growth in this sheep model and repeated adjustment of the system is not needed.



Immediately after operation (up) and 4 months post-operative radiographs (down) Lengthening of the device occurs through the socket portion of the device (white arrow)

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

272. FLUOROSCOPIC 2D NAVIGATION FOR THE REDUCTION OF THE RADIATION DOSES

Radek Hart, MD, PhD, FRCS
Czech Republic

Summary: The variability in width, height, and orientation of spinal pedicles makes pedicle screw insertion a delicate operation. Fluoroscopic guidance often exposes the patient and especially surgeons to relatively high doses of ionising radiation. There is a worrisome increase in the number of radiation associated complications including thyroid cancer (up to five times higher incidence among orthopaedic surgeons than in civil population). 2D fluoroscopic navigation keeps the accuracy of pedicle screw placement with the reduction of the radiation exposure to ¼.

Introduction: The purpose of this prospective randomized controlled trial was to compare a computer-assisted navigation to a conventional procedure in order to assess if it is possible to reduce radiation exposure while preserving accuracy of screw placement.
Methods: The first conventional group consisted of 30 patients. 1,9 segments of lumbal spine were stabilized on average. Screws were inserted transpedicularly under image intensifier guidance. In the second navigated group of 30 patients, stabilization of 1,8 segments was performed on average. A CT-free fluoroscopic 2D spinal navigation system (VectorVision, Brain LAB, Germany) was used intraoperatively. It combines image-guided surgery with C-arm fluoroscopy. For each surgery (navigated or not), the irradiation duration was recorded. The irradiation duration was collected from the X-ray image intensifier. In both groups the screw positioning accuracy was controlled intraoperatively according to Learchs and Whiteclouds methods in AP and lateral images. Postoperative results were evaluated according to Acikbas.
Results: The radiation duration calculated to one vertebra (two screws) was significantly shorter in the second (navigated) group (3,4 s) than in the first (conventional) group (14,4 s) ($p = 0,001$). The mean duration of data registration was 6,0 minutes (range, 3 to 11 minutes). Ratio according to Acikbass calculation metod reflecting the accuracy of screw placement was meanly 43,2 % (range, 32 % - 74 %) in the first (conventional) group and 44,1 % (range, 35 % - 76 %) in the second (navigated) group, without statistically significant diference ($p < 0,05$).
Conclusion: Navigation facilitates the surgical act enabling to acquire the right direction of drilling after obtaining only an AP image and a lateral image at the beginning of the instrumentation for data registratio. Prolongation of the surgery time is irrelevant. Navigation allows to keep the same accuracy of pedicle screw placement with the reduction of the radiation exposure to ¼. In multiple level vertebral instrumentations this reduction is more pronounced. In centers were multiple cases of spine instrumentations are done per day the saving of radiation exposure time can mount to hours.

273. POSTERIOR SHORT-SEGMENT APICAL CORRECTION AND FUSION CAN PRESERVE MOTION IN PATIENTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS

Allen L. Carl, MD; Ufuk Aydinli; Lubos Rehak, MD; Michael Grevitt, FRCS(Orth); Martin Zabka, MD; Martin Repko, PhD; Burak Akesen, MD; Colin Nnadi, FRCS(Orth); Dennis Crandall, MD; William R. Klemme, MD; Behrooz A. Akbarnia, MD
USA

Summary: We report early clinical results of a new surgical technique that employs short apical fusion to correct spinal deformity and preserves spinal motion. An average of 40% of baseline motion was preserved at 1Y in the vertebral levels that were spanned by instrumentation but not fused. The results demonstrate this innovative posterior technique for the treatment of AIS required fewer implants and a reduced number of fusion levels, while demonstrating adequate correction and preservation of significant spinal motion.
Introduction: Posterior instrumentation with fusion is the most common surgical treatment used for adolescent idiopathic scoliosis

(AIS). Despite achieving spinal correction, current techniques limit spinal range of motion. We report early clinical results of a new surgical technique that employs short apical fusion to correct spinal deformity and preserves spinal motion.

Methods: AIS patients with Lenke type 1A or 1B and a Cobb angle between 40-80° were included. Apical correction was accomplished by using innovative transverse couplers at the apex. Only select levels were fused while other levels were spanned by instrumentation, but were not fused. Supine lateral bending radiographs at baseline and 1Y postoperatively were used in all motion measurements. The change in angle of the inferior endplate of the UIV to the superior endplate of the LIV in lateral bending radiographs was subtracted from the change in angle of the superior endplate of upper apical region to inferior endplate of lower apical region and represents the motion in the instrumented, unfused levels. Motion measurements at 1Y postoperatively were compared to baseline measurements.

Results: Twenty consecutive patients from 4 participating sites had surgery. Average age was 14Y, 1M(±1Y,7M) at surgery. A mean of 10.5(±.96) levels were stabilized. Only 5.0(±0.4) levels were fused representing 48%(±6%) of the stabilized levels. Cobb angle improved from 56(±8.7)° preoperatively to 21(±6.4)° at 1Y postoperatively resulting in a 63%(±16%) improvement. An average of 40% of baseline motion was preserved at 1Y in the vertebral levels that were spanned by instrumentation but not fused [26(±6)° at preoperatively compared to 10(±4)° at 1Y postoperative].

Conclusion: This innovative posterior technique for the treatment of AIS required fewer implants and a reduced number of fusion levels, while demonstrating adequate correction and preservation of significant spinal motion. This is a preliminary report and further studies are underway.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

274. DISCREPANCIES IN PRE-OPERATIVE PLANNING AND OPERATIVE EXECUTION IN THE CORRECTION OF SAGITTAL SPINAL DEFORMITIES

Bertrand Moal, MS; Virginie Lafage, PhD; Stephen P. Maier, BA; Shian Liu, BS; Vincent Challier, MD; Wafa Skalli, PhD; Themistocles S. Protopsaltis, MD; Thomas J. Errico; Frank J. Schwab, MD
USA

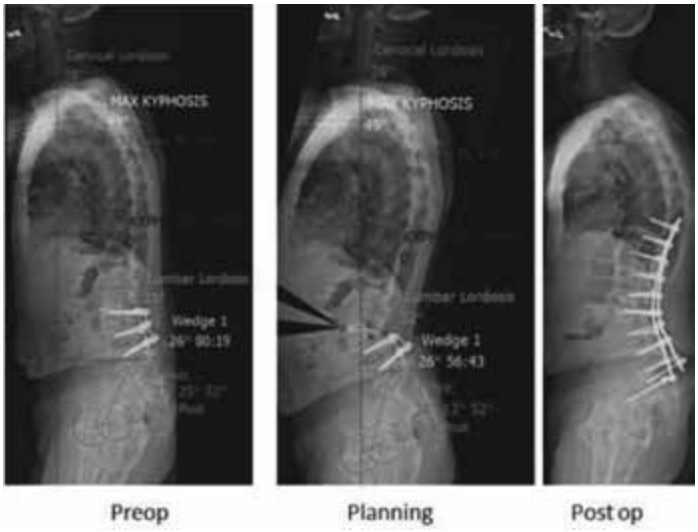
Summary: Differences between planning and surgical execution were characterized for 40 adult spinal deformity (ASD) patients who underwent major sagittal realignment. For 13 patients, the procedure was less aggressive than planned and more aggressive for 3. In general postoperative thoracic kyphosis (TK) was greater than expected and lumbar lordosis (LL) was undercorrected compared to the planning, Operative execution often deviates from preoperative planning especially for patients who need large corrections.

Introduction: Radiographic deterioration and persistent deformity is not an uncommon outcome after major ASD surgery. This study evaluates preoperative planning and changes in procedure execution as a root cause analysis of radiographic outcomes.

Methods: Consecutive ASD patients who required osteotomies were included. Pre-operative plans, and radiographs at baseline and 3 months were collected (Figure). Major changes in the surgeries were classified in 2 groups: less aggressive procedure (LAP, > 1 SPO (Smith Peterson osteotomy) not done, PSO (pedicle subtraction osteotomy) replaced by SPO) and more aggressive procedure (MAP, add > 1 SPO). Patients without major change were grouped as no major change (NMC). Preoperative, anticipated (by Surgimap planning software), and postoperative alignments (Figure) were compared between LAP and NMC cohorts.

Results: There were 40 patients (mean 62 ±12 years) with 25 NMC patients 15 with major change (13 LAP and 2 MAP). Comparison of planned and postoperative alignments demonstrated that postoperative TK was greater than expected and LL was under corrected (NMC: 48% and LAP: 62%). The LAP cohort had greater mismatch between pelvic incidence and lumbar lordosis (PI-LL) at baseline (49±12 vs 29±17, p=0.001), was planned for greater change in LL (41±12 vs 27±13, p=0.003), had a larger corrections (34±9 vs 21±16, p=0.012), but still had greater postoperative PI-LL (16±10 vs 8±13, p=0.05).

Conclusion: Patients in both the NMC and LAP cohorts were undercorrected for LL compared to planning. The greater than expected postoperative TK emphasizes the need for a better understanding and anticipation of reciprocal thoracic change. These results illustrates the complexity of intra-operative decision making and suggests that deviation from the preoperative plan results in under correction, especially for patients who need large corrections for LL.



275. STRATEGY FOR IMPROVING EVIDENCE-BASED MEDICINE BY PROVIDING ACCESS TO MULTICENTER DATABASE: A NEW APPROACH USING A NON-PROFIT ORGANIZATION AND ONLINE DATABASE

Yoshihisa Sugimoto, PhD; Masato Tanaka, MD
Japan

Summary: We set up the Okayama Spine Group non-profit organization consisting of 49 spine surgeons. Maintaining anonymity, we have enrolled over 12,000 patients from 19 hospitals in our database. The database can be registered one million patients. The most important aspect of this system is that every doctors can access the information in the database online, which allows them to make use of the most current data at all times.

Introduction: More recently, multicenter studies has become a global standard. To perform the highest quality evidence-based medicine, it is often necessary to collaborate with multiple hospitals. In February 2010, we set up the Okayama Spine Group non-profit organization (NPO) consisting of 49 spine surgeons from the Chugoku and Kansai regions. The purpose of this study was to establish a multicenter database through the use of online database.
Methods: Ethics Committee approved this study. The database committee of the Okayama Spine Group was created to develop an invitation strategy and a list of diseases and surgical procedures which were best suited for multi-hospital studies. We use Salesforce's database services which was met ISO 27001 security.
Results: Maintaining anonymity, we have enrolled over 12,000 patients from 19 hospitals in our database. The database can be registered one million patients. The most important aspect of this system is that every doctors can access the information in the database online, which allows them to make use of the most current data at all times. In addition, we don't need to upgrade software. We are currently working on a common pre- and postoperative assessment system between the 19 hospitals to improve the database's effectiveness.
Conclusion: Establishing a NPO has the potential to improve multi-hospital collaboration and result in better patient care. Online database is a useful tool for maintaining an inter-hospital database.

276. ULTRA-LOW DOSE RECOMBINANT HUMAN BONE MORPHOGENETIC PROTEIN-2 FOR THREE-LEVEL ANTERIOR CERVICAL DISCECTOMIES AND FUSIONS

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USA

Summary: Previous studies with high dose recombinant bone morphogenetic protein-2 (rhBMP-2) have shown alarming rates disastrous complications. The literature shows that these complications are dose dependent. The present study used lower doses of rhBMP-2 than previously published and had no airway or swelling complications with a 97% fusion rate.
Introduction: The purpose of this study was to evaluate the safety and efficacy of three-level anterior cervical discectomies and fusions (ACDFs) performed using cortico-cancellous allograft filled with ultra-low doses of rhBMP-2.
Methods: Thirty-seven consecutive patients with cervical spondylotic myelopathy who were treated with three-level ACDF and ultra-low dose rhBMP-2 (0.26 to 0.35 mg per level) with stand-alone anterior instrumentation between 2008 and 2011 were evaluated. At a mean follow-up of 4 years (range, 2 to 5 years), clinical outcomes evaluated included complications, Visual Analog neck Scale (VAS) neck and arm pain, and the Oswestry neck disability index (Oswestry NDI or Oswestry). The radiographic parameters evaluated included cervical lordosis, postoperative adjacent segment disease (ASD), subsidence, graft migration, and heterotopic ossifications.
Results: Complications such as airway or cervical swelling or hematoma did not occur. The mean hospital stay was 2 days. Only four patients (11%) had dysphagia at final follow-up. There were significant improvements in VAS neck pain [p=0.0001], VAS arm pain [p=0.0001], Oswestry scores [p=0.0001], and cervical lordosis [p=0.0001] respectively. Seven patients developed heterotopic ossification posterior to the graft (19%) which were asymptomatic; six patients developed postoperative ASD (16%) with only two of these patients being symptomatic; and four patients had subsidence of greater than 2 millimeters. Only one pseudoarthosis occurred (97% fusion rate).
Conclusion: Using ultra-low dose rhBMP-2 for 3-level ACDFs was found to be safe and efficacious for patients. Furthermore, this avoids the morbidity of posterior instrumentation for surgically addressing three-level spondylotic myelopathy with good fusion rates.
The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

277. INNOVATIVE TECHNIQUE: PROPHYLACTIC RIB FIXATION TO PREVENT PROXIMAL JUNCTIONAL FAILURE FOLLOWING INSTRUMENTED POSTERIOR SPINAL FUSION IN ADULT SPINAL DEFORMITY

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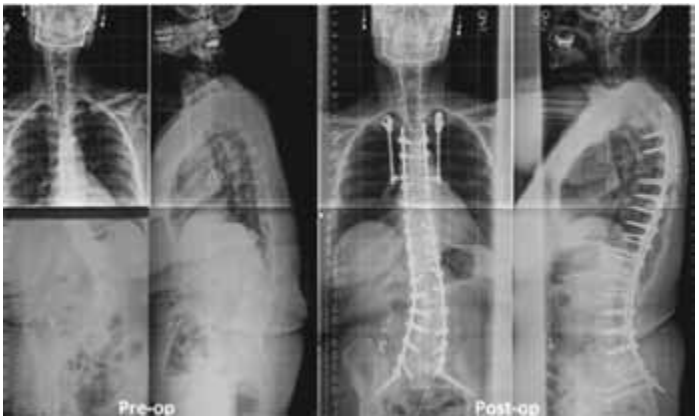
USA

Summary: Proximal Junctional Failure remains a serious complication of adult spinal deformity surgery. Few surgical options have been shown to reduce the incidence of this adverse event. We describe our preliminary experience in high risk patients using adjacent level rib fixation with a Vertical Expandable Prosthetic Titanium Rib (VEPTR). The incidence of PJF was 7.7%, and there were no major complications which appeared related to the prophylactic rib fixation. We consider these results promising, and the technique worthy of further evaluation.
Introduction: Proximal Junctional Failure (PJF) is an important concern following surgical treatment of adult spinal deformity (ASD). Prophylactic rib fixation at the proximal junction of posterior instrumented constructs for prevention of PJF in adults has not been described. We evaluated safety and efficacy of the Vertical Expandable Prosthetic Titanium Rib (VEPTR) as a prophylactic extension of proximal instrumentation in ASD patients undergoing fusion.
Methods: From 4/2012 to 7/2013, ASD patients > 50 years old with sagittal imbalance indicated for posterior instrumented fusion from pelvis to thoracic levels were offered prophylactic adjacent rib fixation with VEPTR. A cradle was affixed to the rib cranial to the Upper Instrumented Vertebra (UIV); eg, for a UIV of T4, the 3rd rib was instrumented. Rib cradles were connected via longitudinal and transverse cross-members to the fusion construct 2 or more levels below the UIV. Minimum follow-up was 6 months. Pre- and post-op radiographic measures of sagittal balance as well as complications were recorded.
Results: 15 patients (4 M/11F) with a mean age of 69 years (range 54-81) underwent fusion with supplementation of a VETPR; 2 patients were lost to follow-up. Mean Sagittal Vertical Axis improved from 128 mm positive imbalance to 38mm; mean Pelvic Incidence-Lumbar Lordosis improved from 30.9 to 11.5 degs. One patient (1/13, 7.7%)

experienced PJF without clinical impact (Fig 1). 7 patients experienced complications including 1 mortality due to pulmonary embolus and 1 pneumonia; no other pulmonary complications occurred.
Conclusion: Prophylactic use of VEPTR in long fusions for ASD may be safe and effective in reducing the incidence of PJF. While longer follow-up with larger patient numbers is required, the substantial incidence and morbidity of PJF in this patient population warrants consideration of novel approaches.



T4-pelvis fusion in a 62 year old woman with prophylactic VEPTR fixation at rib 3. PJF occurred due to UIV fracture, which did not progress clinically.
The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

278. THE USE OF NITINOL RODS IN THE SURGICAL TREATMENT OF DEGENERATIVE SCOLIOSIS: ONE, FIVE-YEAR FOLLOW UP

Sergey Kolesov; Vladimir Shvets, MD, PhD; Dmitry Kolbovskiy, PhD; Natalia Morozova; Arkady Kazmin; Andrey Baklanov, PhD
Russian Federation

Summary: The analyzed 30 cases of spine surgery of patients with degenerative lumbar scoliosis (DLS). Used standard pedicle screws and nitinol rods (NR). Spinal fusion and bone grafting were not carried out. The control group was 42 patients with DLS with rigid fixation titanium rods (RFTR) and interbody fusion
Introduction: Nitinol is a metal alloy of 45% titanium and 55 % nickel and has unique properties. It is 8 times more flexible then titanium and exhibit superelasticity and shape memory. There are no references to using such treatment in literature
Methods: The results of treatment of 30 patients aged 40 to 82 years with DLS. In all cases used standard polyaxial screws and NR diameter of 5.5 mm. The spinal canal decompression, stabilization and correction of the spine were carried out during surgery. 20 patients had fixation S1 to L1 and 10 patients had fixation L1 to L5. Spinal fusion was not carried out. All patients before and after surgery were under X-ray, CT and MRI - study. The results of the treatment were assessed on Oswestry, SRS-24 and SF-36 scales. The results were evaluated after at least 1.5 years (1.5 to 2 years). As a control group of 42 patients with similar strains with RFTR and interbody fusion was considered.
Results: The correction of curvature of the lumbar averaged out to 25° (range 10° to 38°). During the analysis of X-ray and CT no data for the implant instability, bone resorption around the screws and fractures of the rods. The functional snapshots in 1.5 years after surgery a small mobility of the lumbar spine in an average of 21° (range 15° to 30°) was revealed, there was no instability of the overlying spine. Proximal junctional failure (PJF) was not found. The questionnaires date NR group. SF-36: physical health before-34,2, after-63,5; mental health before-42,5, after-76,3 ($p<0,05$). SRS-24: before-2,6, after-4,9 ($p<0,05$). VAS: before-9,3, after-2,4 ($p<0,05$). Oswestry: before-64,6, after-17,8 ($p<0,05$). There were 2 cases of complications, both infections. One was deep festering, another was superficial. The questionnaires date the RFTR group. SF-36: physical health before-33,4, after-58,5; mental health before-41,4, after-72,2 ($p<0,05$). SRS 24: before-2,5, after-4,0 ($p<0,05$). VAS: before-9,4, after-2,1 ($p<0,05$). Oswestry: before-64,0, after-17,7 ($p<0,05$). There were 7 cases of complications (infectious-1, PJF-1, psevdoartrosis-3, revision surgery-2)
Conclusion: The use of NR is promising type fixation of the spine. The continuation of a set of clinical observations and further evaluation of long-term results is necessary

279. RISK FACTORS FOR REOPERATION IN PATIENTS TREATED SURGICALLY FOR INTERVERTEBRAL DISC HERNIATIONS: A SUBANALYSIS OF THE EIGHT-YEAR DATA FROM THE SPORT TRIAL

Dante M. Leven, DO; Peter G. Passias, MD; Thomas J. Errico; Virginie Lafage, PhD; Kristina Bianco, BA; Alexandra Lee, RN; Jon D. Lurie, MD; Tor D. Tosteson, ScD; Wenyan Zhao, PhD.; Kevin F. Spratt, PhD; Michael C. Gerling, MD
USA

Summary: A retrospective subgroup analysis was performed on surgically treated patients from the intervertebral disc herniation (IDH) arm of the Spine Patient Outcomes Research Trial (SPORT), randomized and observational cohorts. Our study hypothesis was that specific patient baseline characteristics would emerge as risk factors for reoperation in patients treated surgically for IDH. Analysis revealed a 14.6% incidence of reoperation eight years following initial surgery, 55% occurring within the first two years of surgery. Anti-depressant usage was a risk factor for undergoing reoperation.
Introduction: Lumbar discectomy and laminectomy for patients with IDH is a common spine surgery with variable reported reoperation rates. Though prospective studies have reported outcomes in this population, few have identified risk factors for reoperation. Our study examined the risk factors of specific baseline characteristics that might increase reoperation rates in IDH.
Methods: A retrospective subgroup analysis was performed on surgically treated patients enrolled in the IDH arm of the multicenter SPORT trial, randomized and observational cohorts. Patients had radicular pain for at least six weeks, clinical evidence of nerve root irritation, and imaging showing a disc herniation at level and side of the patient's symptoms. Baseline characteristics were analyzed between no reoperation and operation groups using a multivariate regression analysis on data 8 years post-op. Cox regression model Stepwise Method was used with $p=0.10$ significant for entry and $p=0.05$ significant for retention to the model with calculation of hazard ratios (HR).

Results: At 8 years, the reoperation rate was 14.6% with 691 having no reoperation and 119 in the reoperation group. 48(40%) of patients underwent reoperation within the first year, 66(55%) at two years, 85(71%) at four years, 102(86%) at six years. 74 (10%) patients underwent reoperation for a recurrent disc herniation, 30(4%) for complication or other factor, and 13(2%) reported as a new condition. History of antidepressant use showed an increased risk for reoperation ($p = 0.03$). Patients who were smokers, diabetics, obese, worker's comp, or clinically depressed did not have a greater risk for reoperation, Table.

Conclusion: In patients undergoing discectomy and laminectomy for IDH, overall re-operation rate was 14.6% at 8 years with 55% occurring within the first two years. Patient history of smoking, obesity, diabetes, depression and workman's compensation were not associated with higher risk for reoperation. A history of antidepressant use did correlate with an increased risk for reoperation, and should be considered when counseling patients for surgery.

Table: Risk factors. p=0.5 being significant levels of entry and stay

Step	Effect Entered	Effect Removed	DF	Number In Model	Score Chi-Sq	Prob Chi-Sq
1	Antidepressants		1	1	4.37	0.0366
2	Worsening pain		1	2	3.61	0.0575
3	Age		1	3	3.6	0.0577
4	Hypertension		1	4	2.12	0.1451
5	Sciatica Bothersome Index		1	5	1.85	0.1733
6	Back Pain Bothersome		1	6	1.67	0.1969
7	Depression		1	7	1.7	0.1923
8	Episode		1	8	3.2	0.2023
9	Race		1	9	1.26	0.2618
10	Lifting at work		1	10	1.07	0.3018
11	Work missed		1	11	1.54	0.2148
12	Worker's compensation		1	12	0.86	0.3545
13	Osteoporosis		1	13	0.79	0.3731

280. LONG TERM PATIENT-CENTERED CLINICAL OUTCOMES OF LUMBAR ARTHRODESES IN DEGENERATIVE DISC DISEASE: A SYSTEMATIC REVIEW WITH META ANALYSIS

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Summary: Treatment of lumbar spondylosis is a complex clinical and economic concern for patients and health care providers. This systematic review with meta-analysis evaluated long term clinical outcomes after lumbar arthrodesis and compared them to those of alternative treatments, including arthroplasty and nonsurgical methods. The results indicate that surgical stabilization of the spine is an effective treatment for lumbar spondylosis, in particular for patients with severe chronic low back pain that has been resistant to conservative therapy for ≥3 months.

Introduction: The effective treatment of lumbar spondylosis is a complex clinical and economic concern for patients and health care providers. The purpose of this study was to 1) evaluate long-term patient-centered clinical outcomes after lumbar arthrodesis, with or without decompression for lumbar spondylosis and 2) compare these outcomes to those of alternative treatments, including arthroplasty and nonsurgical methods.

Methods: This systematic review with meta-analysis included RCTs comparing lumbar arthrodesis with other interventions in adults with lumbar DDD. Databases searched included Ovid MEDLINE, Embase, and the Cochrane Library. A meta-analysis was performed to evaluate pooled treatment effects. Patient-centered clinical outcomes before treatment and at 12, 24, or >24 months follow-up, and rate of additional surgical treatment were analyzed. The GRADE approach was applied to evaluate the level of evidence.

Results: Of 1411 total citations, 38 RCTs of 5738 participants were included in the review. The studies investigated clinical outcomes of: 1 or 2 level lumbar arthrodesis, 1 or 2 level lumbar arthroplasty, decompression without arthrodesis, and nonsurgical treatment. Various patient-centered clinical outcome scales were used. Despite different scales, all studies showed strong or at least moderate treatment effects of lumbar arthrodesis at 12, 24, and 48-72 months. The level of evidence was moderate at 12 and 24 months and low at 48-72 months. The pooled long term treatment effect of lumbar arthrodesis exceeded those of nonsurgical treatment ($p<0.0001$) with a moderate level of evidence, and of decompression without fusion ($p=0.005$) with a low level of evidence. The treatment effect of lumbar arthrodesis showed a small inferiority versus arthroplasty at 12 and 24 months follow up ($p<0.001$), but not after 24 months postoperative.

Conclusion: This review indicates that surgical stabilization of the lumbar spine is an effective treatment for lumbar spondylosis, in particular for patients with severe chronic low back pain that has been resistant to three or more months of conservative therapy.

281. IMPROVEMENT OF GLOBAL SAGITTAL ALIGNMENT AFTER LUMBAR DECOMPRESSION WITHOUT FUSION: ANALYSIS OF 88 CASES

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Summary: Retrospective analysis of 88 patients who underwent lumbar decompression without fusion. Standing radiographs of preop and final follow up were accessed. LL increased and SVA decreased significantly. Furthermore, preop PI-LL correlated significantly with LL increment, and SVA decrement. Preop LL also negatively correlated significantly with LL increment ($r=0.74$), and SVA decrement ($r=0.51$). This study suggests that lumbar decompression can induce autonomic improvement of lumbar and global sagittal alignment, even if there exists sagittal imbalance (PI-LL>10°, and SVA>40mm) in some cases.

Introduction: In surgical treatment for lumbar canal stenosis with degenerative spondylosis, we consider of correction of deformity if there exists global sagittal imbalance. However, little is known about the autonomic alignment change after lumbar decompression. The objective of this study is to evaluate the short-term radiological change after lumbar decompression without fusion.

Methods: Retrospective analysis of 88 patients (53 males and 36 females, with an average age of 69.6 years) who underwent lumbar decompression without fusion at a single institution between October

2011 and May 2013, minimum 5-months follow up. Standing radiographs of preop and final follow up were accessed. Radiological parameters included Sagittal Vertical Axis (SVA), Lumbar Lordosis (LL), and pelvic parameters.

Results: Mean follow up period was 12.8 months and mean decompression level was 2.2 levels. LL (38.4°vs 45.0°, p<0.001) increased and SVA (49mm vs 32mm, p<0.001) decreased significantly. There was no significant correlation between the levels of decompression and LL increment (p=0.47). Furthermore, preop PI-LL correlated significantly with LL increment (r=0.63), and SVA decrement (r=0.45). Preop LL also negatively correlated significantly with LL increment (r=0.74), and SVA decrement (r=0.51). Interestingly, over 40% of the cases with preoperative sagittal imbalance showed normalization of imbalance postoperatively without corrective procedure. Of 51 cases with preop excessive PI-LL (>=10°), 21cases (47%) showed improvement to <10°. Also, of 49 cases with preop excessive SVA (>=40mm), 20 cases (41%) showed improvement to <40mm.

Conclusion: This study suggests that lumbar decompression can induce autonomic improvement of lumbar and global sagittal alignment, even if there exists sagittal imbalance (PI-LL>10°, and SVA>40mm) in some cases. Our results also suggest that GT seems to provide more accurate information on sagittal imbalance compared to SVA. These findings provide new insight into proper indication for corrective procedure in lumbar canal stenosis.

282. THE BURDEN OF CLOSTRIDIUM DIFFICILE AFTER LUMBAR SPINE SURGERY

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Summary: C. difficile carries a 36.4 fold increase in mortality and costs approximately $10,658,646 per year to manage—a significant impact on healthcare resources. Novel and difficult to treat antibiotic resistant strains may be reduced if proper antibiotic administration is practiced in this population.

Introduction: Hospital-acquired C. difficile infection, resulting in pseudomembranous colitis, confers significant morbidity and mortality. The pathophysiology of this infection is associated with alterations in the physiologic gut flora that can be affected by perioperative antibiotic use. The purpose of this study was to investigate incidence, comorbidities and impact on health care resources associated with C. difficile infection in patients after lumbar spine surgery.

Methods: The National Inpatient Sample was examined from 2002 to 2011. Patients were included for study based on ICD-9-CM procedural codes for lumbar spine surgery and further substratified to degenerative diagnoses. Baseline patient characteristics such as age, insurance type, major comorbidities, costs and mortality rate were determined. Multivariable analyses assessed factors increasing incidence of diagnosis and factors associated with inpatient mortality.

Results: Incidence of C. difficile infection in postoperative lumbar spine surgery patients is .11%. At baseline, C. difficile patients have an increased incidence of comorbidities such as diabetes with chronic complications, congestive heart failure, coagulopathy and pulmonary circulatory disorders. Lumbar fusion (P = .0001) and fusion revision (P = .0003) are associated with increased incidence as compared to posterior lumbar decompression. Likewise, Medicaid (P < .0001) and those uninsured (P < .0001) have an increased incidence when compared to private insurance. Small hospitals (P = .001) are associated with decreased likelihood of infection when compared to large hospitals. C. difficile results in extended length of stay (P < .0001) and higher median costs (P < .0001). A total of 4.0% of patients with C. difficile infection died versus .11% of patients without C. difficile (P < .0001). Multivariable analysis for inpatient mortality indicates that C. difficile greatly increases mortality (9.60 odds ratio, P < .0001).

Conclusion: C. difficile infection profoundly increases in-hospital mortality, length of stay, costs and has a significant impact on hospital resources in the lumbar spine surgery population.

Outcomes of Lumbar Spine Operations with and without C. difficile

Population	C. difficile	No C. difficile	*p*-value
Median LOS (IQR)	10.9 days (6.6-20.3 days)	2.6 days (1.5-3.9 days)	<.0001
Median Cost (IQR)	$37,177 ($23,828 - $60,769)	$18,012 ($8,655 - $28,052)	<.0001
Mortality Total Cases (%)	114 (4.0%)	2,831 (0.11%)	<.0001

283. XLIF VERSUS MAS TLIF FOR THE TREATMENT OF DEGENERATIVE SPONDYLOLISTHESIS: INTERIM RESULTS FROM AN ONGOING PROSPECTIVE MULTICENTER COMPARATIVE STUDY

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Summary: This study compares outcomes of patients undergoing XLIF and MAS TLIF for treatment of degenerative spondylolisthesis. At 6 months post-op, both groups showed significant improvement over baseline and clinical outcomes were comparable. XLIF resulted in greater transient post-op hip flexion weakness and less early post-op subsidence. Continued study follow-up is necessary to make stronger comparisons.

Introduction: This prospective, multicenter, IRB-approved study aims to compare indirect decompression via XLIF and direct posterior decompression via TLIF for the treatment of low-grade spondylolisthesis with a specific interest in clinical and radiographic results. This abstract serves as an interim report of the 6 month outcomes.

Methods: Adult patients with Grade I-II degenerative spondylolisthesis at one or two lumbar levels were treated with either MAS TLIF or XLIF. Motor/sensory evaluations were conducted by the treating physician. Patient reported outcomes and radiographic measurements were also collected pre- and post-op.

Results: At the time of analysis 48 patients (25 XLIF, 23 TLIF) out of 55 enrolled had completed 6-month follow-up, and early post-op neural deficit data was available for 55 patients (29 XLIF, 26 TLIF).

Pre-op neural deficits resolved after surgery in 100% of XLIF and 73% of TLIF patients. Mean surgery times favored XLIF (171 min vs 186 min). 79% of XLIF and 27% of TLIF patients lost less than 100mL blood ($p < 0.01$). There were 3 dural tears in the TLIF group and none in the XLIF group. Mild transient post-op hip flexion weakness presented in 34% of XLIF patients, which all resolved by 6 months. 1/29 XLIF patients had new distal motor deficits noted postoperatively, which resolved by 6 months. New post-op sensory deficits were noted in 2/29 XLIF and 2/26 TLIF patients, which all resolved. Post-op VAS and ODI scores were similar between groups, and both showed significant improvement over baseline.
XLIF resulted in less segmental motion and less early post-op subsidence. Postoperative lumbar lordosis, approach-side foraminal dimensions, and reduction of spondylolisthesis were similar between treatment groups. At 3 months contralateral foraminal height was significantly greater than approach-side foraminal height within the TLIF group only.
Conclusion: In this early interim analysis comparing XLIF to TLIF for the treatment of low-grade degenerative spondylolisthesis, only subtle differences were identified. Patient-reported pain, function, and satisfaction are comparable. Continued study follow-up is required to make stronger comparisons between procedures.

284. FIVE-YEAR REOPERATION RATES OF DEGENERATIVE LUMBAR SPINAL DISORDERS RECEIVING DIFFERENT SURGICAL INTERVENTIONS: A RETROSPECTIVE COHORT STUDY IN TAIWANESE POPULATION

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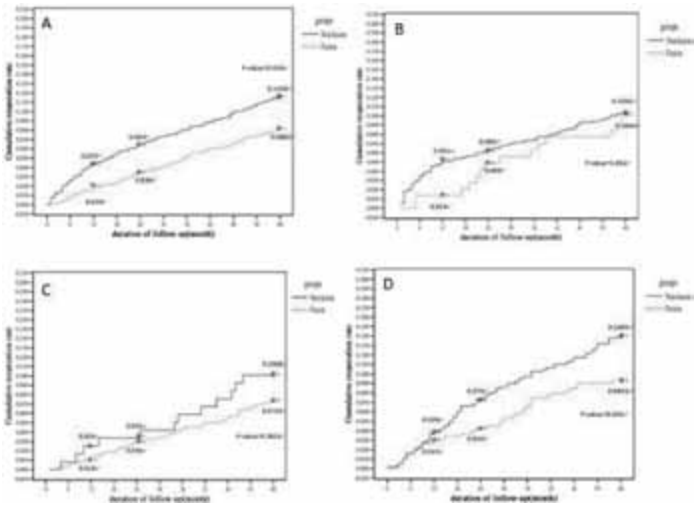
Summary: Reoperations for lumbar degenerative surgeries are generally unsatisfactory. By using National Health Insurance database, this retrospective cohort study revealed 5-year cumulative reoperation rate was 10.0% in patients underwent lumbar degenerative spinal surgery during 2001-2005 in Taiwan. 5-year reoperation rate in patients with disc herniation was similar in patients underwent decompression-alone and spinal fusion. Decompression-alone yielded higher 5-year reoperation rates in patients with spondylolisthesis and spinal stenosis. However, reoperation was not needed in 86.7% of patients 5 years after decompression-alone surgery.
Introduction: Repeated surgeries for lumbar degenerative surgeries are generally unsatisfactory. The purpose of this study is to determine 5-year cumulative reoperation rate following lumbar surgery for degenerative disorders and to compare the reoperation rate between fusion and decompression-alone surgeries.
Methods: A retrospectively cohort study was adopted using the Taiwan National Health Insurance (NHI) database including 1,000,000 sampling population during 2001-2010. Individuals with lumbar spinal disorders who underwent surgical interventions during 2001-2005 were enrolled as a cohort and followed to 2010.
Enrolled subjects were divided into 3 groups based upon the ICD-9-CM codes of primary diagnosis including disc herniation (722.10, 722.2), spinal stenosis (724.02), and spondylolisthesis (738.4). Surgical interventions were assessed by ICD_OP_CODE including decompression alone (03.0X or 80.5X) and fusion surgery (81.0X).
Results: From 2001 to 2005, 3010 patients in the 1,000,000 sampling population underwent lumbar spinal surgeries including 1,110 for disc herniation, 921 for spinal stenosis and 979 for spondylolisthesis. The cumulative reoperation rate were 3.3% in one year, 5.1% in 2 years and 10.0% in 5 years. 5-year reoperation rate was similar between decompression alone and fusion for disc herniation (10.4% vs 10.5%). Decompression alone yielded higher 5-year reoperation rates than spinal fusion in spondylolisthesis (10.1% vs 7.3%) and spinal stenosis groups (13.9% vs 9.3%). However, reoperation was not needed in 86.7% of patients 5 years after decompression-alone surgery. Hazards regression modeling revealed no single factor associated with a higher likelihood of reoperation.
Conclusion: The 5-year reoperation rate of lumbar degenerative spinal surgery during 2001-2005 was comparable with other cohort study in modern society. In this retrospective cohort, patients with spinal stenosis and spondylolisthesis who underwent a decompression-alone procedure had a higher reoperation rate than those who underwent a fusion procedure. Further investigations regarding longer follow-up and more recent time period will be performed by utilizing the Taiwan NHI database.



5-year cumulative reoperation rate of surgeries for (A) all lumbar degenerative disorders, (B) disc herniation, (C) spondylolisthesis, and (D) spinal stenosis.

285. IS AN ANNULAR TEAR A PREDICTOR FOR ACCELERATED DISC DEGENERATION?

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Summary: This matched case control study shows that discs with an annular tear (AT), defined by a hyperintense signal intensity on MRI, are not prone to accelerated degeneration if compared to discs without an AT. Therefore, the presence of an AT per se does not predict accelerated disc degeneration.
Introduction: It is questionable whether an annular tear (AT) is a predictor for accelerated degeneration of the intertervertebral discs. The aim of this study was to answer this question via a matched case

control study design that reliably eliminates potential confounders.
Methods: Presence or absence of AT, defined as a hyperintense lesion within the annular fibrosus on T2-weighted non-contrast MRI images, was documented in 450 intervertebral lumbar discs of 90 patients who could be followed up for at least 4 years with MRI. Discs with an AT (n=36) were matched 1:1 to control discs according to the level, degree of intial disc degeneration on MRI (both Pfirrmann grade median 4, range 3-4), age (59.5±15.0 years vs 59.3±14.6 years), BMI (26.7±4.4kg/m2 vs 26.9±4.4kg/m2) and interval to the follow up-MRI (4.8±0.8years vs 5.1±0.8years). The degree of disc degeneration after a minimum of 4 years was graded on the follow up MRI in both groups according to the Pfirrmann classification.
Results: One-forth (25%) of the 36 discs with an AT on the inital MRI exam progressed in degeneration. This was similar to the rate of the matched control discs with no AT, in which also around one-forth (22%) showed a progression of degeneration (p=1.00), also without any difference in the degree of degeneration.
Conclusion: Discs with a Pfirmann grade >2 with an AT, defined by a hyperintense signal intensity on MRI, are not prone to accelerated degeneration if compared to discs without an AT. Therefore, the presence of an AT per se does not predict accelerated disc degeneration.

286. DETERMINANTS OF HOSPITAL LENGTH OF STAY IN PATIENTS UNDERGOING LUMBAR SPINAL FUSION

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Summary: In a study of 1868 patients undergoing fusion for lumbar degenerative conditions, age and preoperative medical status, as well as minor perioperative complications (dural tear, ileus, mental confusion and arrhythmia) are most commonly associated with longer length of hospital stay. Strategies to optimize length of stay should focus on medical optimization of older patients pre-operatively, prior to admission, as well as avoidance and prompt treatment of minor perioperative complications.
Introduction: Lumbar fusion is an increasingly common surgical procedure in the US. Excess length of stay leads to higher costs and increased use of healthcare resources. Patient characteristics associated with greater length of stay are poorly characterized in the lumbar fusion population. The current study examines whether specific perioperative patient characteristics are associated with a longer hospital length of stay.
Methods: We reviewed a single-center database of patients undergoing fusion for lumbar degenerative conditions and identified 1868 patients with complete two year outcomes data, and complete documentation of preoperative patient characteristics, as well as intraoperative and postoperative complications. Length of stay was measured in days. Regression analysis was done to identify preoperative and perioperative patient characteristics that were independent predictors of hospital length of stay.
Results: Mean age of patients in the study was 58 years. 1153 (62%) were female and 412 (22%) were smokers. 964 patients (52%) underwent single level fusion, 652 patients (35%) underwent two level fusion and 252 (13%) had three or more levels fused. Procedures included 1097 posterolateral (59%), 576 transforaminal (31%) and 195 antero-posterior fusions (10%). Factors which were independent predictors of length of stay included age (p<.001), ASA grade (p<.005), standalone anterior surgery (p<.001), wound drainage (p<.001), perioperative ileus, arrhythmia or mental confusion (p<.001), dural tear (p<.05) and minimally invasive fusion (p<.05). Relevant factors which did not affect length of stay (p>0.05) included gender, diagnosis, blood loss, body mass index (BMI), lower extremity arthritis, iliac crest graft harvest and day of the week on which surgery was performed.
Conclusion: The current study found that age and preoperative medical status, as well as minor perioperative complications (dural tear, ileus, mental confusion and arrhythmia) are the factors most commonly associated with longer length of hospital stay following lumbar fusion. Strategies to optimize length of stay should focus on medical optimization of older patients pre-operatively, prior to admission, as well as avoidance and prompt treatment of minor perioperative complications.

287. BALLOON KYPHOPLASTY VERSUS KIVA VERTEBRAL AUGMENTATION: COMPARISON OF TWO TECHNIQUES FOR OSTEOPOROTIC VERTEBRAL BODY FRACTURES: A PROSPECTIVE RANDOMIZED STUDY

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Summary: This prospective, comparative randomized study showed that the novel KIVA implant and Balloon Kyphoplasty restored at the 12-month follow up similarly sagittal osteoporotic vertebral body height. The main short-term advantages of KIVA was the better restoration of wedge vertebral deformity and the significantly lower and harmless extracanal leakage rate than BK. The significance of the vertebral restoration needs more longer observation to disclose any clear clinical advantage of KIVA.
Introduction: This study compares the efficacy in sagittal vertebral height and wedge deformity restoration, PMMA cement leakage safety and functional outcome of balloon kyphoplasty (BK) versus KIVA implant for the augmentation of fresh osteoporotic vertebral body fractures.
Methods: From a total 190 patients with osteoporotic fractures who were initially enrolled in this prospective randomized study, 10 patients were excluded (5 met exclusion criteria, 5 with evidence of metastasis) this study examined 82 patients (69±11 years) with 133 fractures who received KIVA and 86 patients (72±9 years) with 122 fractures which were reinforced with BK. Anterior (AVBHr), midline (MVBHr) and posterior (PVBHr) vertebral body height ratio, Gardner segmental vertebral wedge deformity were measured preoperatively to postoperatively. New fractures were recorded at the final observation. The baseline anthropometric and roentgenographic parameters did not differ between the two groups. Any cement leakage was examined on plain roentgenograms and CT scan. All patients were followed for an average 14 months,(range 13-15 months) postoperatively.

Results: At the final observation, both KIVA & BK restored significantly AVBHr, PVBHr, and MVBHr. However, only KIVA device reduced significantly the Gardner angle (p=0.002). Residual kyphosis of >5o was measured significantly more (P<0.001) in the BK than KIVA spines. KIVA showed significantly lower (0.03%, chi-squared, P<0.05) leakage) [paravertebral, intradiscal] rate per vertebra than BK (0.098%) in which because of intracanal leakage two patients developed acute paraplegia and were re-operated in emergency. New fractures rate was similar in both groups. Back pain scores (VAS), SF-36 (Physical function & Mental Health domains) and ODI scores improved significantly in the patients of both groups.
Conclusion: Both KIVA and BK restored in short-term similarly vertebral body height, but only KIVA restored vertebral body wedge deformity. KIVA was followed by significantly lower and harmless always extracanal leakage rate than BK. Longer observation is needed to show if these radiologic changes have any functional impact.

288. A CLINICAL PREDICTION RULE FOR CLINICAL OUTCOMES IN PATIENTS UNDERGOING SURGERY FOR DEGENERATIVE CERVICAL MYELOPATHY: ANALYSIS OF AN INTERNATIONAL AOSPINE PROSPECTIVE MULTICENTER DATASET OF 757 SUBJECTS

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Canada

Summary: The international CSM population is very heterogeneous. This study aims to determine the most important global clinical predictors of surgical outcome in patients with degenerative cervical myelopathy. This was accomplished using data from 757 patients enrolled at 28 sites from around the world. Key clinical predictors include age, duration of symptoms, smoking status, baseline severity score, number and severity of co-morbidities, impaired gait and broad-based unstable gait.
Introduction: International differences in patient demographics and disease presentation, along with biases in surgical practice, may contribute to regional differences in patient prognosis. The objective of this study is to determine the most important clinical predictors of surgical outcome in patients undergoing surgery for degenerative cervical myelopathy from 28 global sites.
Methods: As part of the AOSpine prospective CSM-International and CSM-North America studies, 757 patients with CSM were enrolled at 28 sites in four continents. The mJOA score at 1-year follow-up was used as the primary outcome measure: a successful outcome was defined as a mJOA≥16 and a failed outcome was a score <16. Univariate analyses were performed to evaluate the relationship between outcome and various clinical predictors. Multivariate logistic regression was then used to formulate the final prediction model and assess the impact of each variable on outcome.
Results: Univariate analyses demonstrated that the odds of a successful outcome decreased with the presence of certain symptoms, including impaired gait; the presence of certain signs such as lower limb spasticity; positive smoking status; a higher co-morbidity score; a lower baseline mJOA; and older age. The final clinical prediction rule included age (OR: 0.97, p=0.0017), duration of symptoms (OR: 0.88, p=0.049), smoking status (OR: 0.51, p=0.0018), impairment of gait (OR: 1.94, p=0.0168), broad-based unstable gait (OR: 1.75, p=0.0133), baseline severity score (OR: 1.26, p<0.0001) and number and severity of co-morbidities (OR: 1.23, p<0.0001). The area under the receiver operator (ROC) curve was 0.77, indicating good model prediction.
Conclusion: This knowledge should promote more timely management, preoperative smoking cessation and control of co-morbidities and should encourage operative intervention on more mild patients. This information can also help surgeons appropriately manage patients' expectations and provide counsel where necessary.

289. CLINICAL AND SURGICAL PREDICTORS OF PERI-OPERATIVE COMPLICATIONS IN PATIENTS WITH DEGENERATIVE CERVICAL MYELOPATHY: RESULTS FROM THE MULTICENTER, PROSPECTIVE AOSPINE INTERNATIONAL STUDY ON 479 PATIENTS

Lindsay Tetreault; Nabeel S. Alshafai, MD; Michael G. Fehlings, MD, PhD; Branko Kopjar, MD, PhD, MS; Paul Arnold; Pierre Côté, PhD; Helton L. Defino, MD; Shashank S. Kale, MCh(Neuro); Giuseppe Barbagallo; Ronald H. Bartels, MD, PhD; Mehmet Zileli, MD; Gamaliel Tan, MBBS, FRCS; Yasutsugu Yukawa, MD; Osmar J. Moraes, MD; Massimo Scerrati, MD; Masato Tanaka, MD; Tomoaki Toyone, MD, PhD; Ciaran Bolger
Canada

Summary: This study aims to assess important clinical and surgical predictors of perioperative complications. Patients with a greater number of co-morbidities, myelopathy secondary to OPLL, undergoing a 2-stage circumferential procedure and a longer operative duration are at a higher risk of developing a complication within 30 days of surgery. Knowledge of important surgical and predictors will help clinicians identify high-risk patients, allowing them to institute appropriate prevention strategies.
Introduction: This study was designed to identify important clinical and surgical predictors of perioperative complications in patients with degenerative cervical myelopathy.
Methods: Over a three-year period, 479 patients diagnosed with degenerative cervical myelopathy and treated surgically were enrolled in the prospective CSM-International study at sixteen global sites. Perioperative complications were defined as surgery-related events occurring within 30 days postoperatively. Univariate analyses were performed to determine demographic and surgical differences between patients who suffered a perioperative complication and those who did not. A final complication clinical prediction rule was developed using multiple logistic regression.
Results: Seventy-nine patients experienced 92 perioperative complications, yielding an incidence of 16.5%.Univariately, the major clinical risk factors for complication development were the number of comorbidities pre-operatively (OR=1.27, p=0.019) and the presence of endocrine (OR=1.89, p=0.014), gastrointestinal (OR=2.06, p=0.0165) and cardiovascular disorders (OR=1.59, p=0.084). A greater percent of patients with OPLL experienced a perioperative complication (21%) compared to those with other forms of degenerative myelopathy (14.5%) (p=0.065). There was no difference in the rate of complications between anterior or posterior approaches. Patients undergoing a 2-stage approach, however, were at a greater risk of perioperative complications than those treated with either anterior or posterior surgery (OR: 6.47, p=0.0025). Finally, patients

with complications had a longer operative duration (206.6±91.36 min) than those without complications (172.5±76.89 min) (p=0.014).
Conclusion: This study identifies a list of predictors of perioperative complications in patients with CSM. This model will help clinicians identify high risk patients, allowing them to institute a rigorous complication prevention plan.

290. RATIONALE, DESIGN AND EARLY TRIAL PERFORMANCE OF AOSPINE NORTH AMERICA MULTICENTER DOUBLE BLIND RANDOMIZED CONTROLLED TRIAL OF SAFETY AND EFFICACY OF RILUZOLE IN CSM (CSM - PROTECT TRIAL)

Michael G. Fehlings, MD, PhD; Branko Kopjar, MD, PhD, MS
Canada

Summary: The purpose of this study is to evaluate efficacy and safety of sodium-glutamate antagonist riluzole in improving neurological outcomes in patients with cervical spondylotic myelopathy undergoing surgical treatment.
Introduction: While surgical decompression is an effective treatment for CSM, many patients have substantial residual neurological and functional impairment. Compelling evidence from preclinical models suggest a benefit of adding a neuroprotective drug which targets sodium/glutamate excitotoxicity to the treatment of patients with CSM.
The purpose of this study is to evaluate efficacy and safety of sodium-glutamate antagonist riluzole in improving neurological outcomes in patients with cervical spondylotic myelopathy (CSM) undergoing surgical treatment.
Methods: Prospective multi-center double-blind randomized controlled trial in which a total of 300 patients undergoing surgical decompression for CSM will be randomized 1:1 to riluzole 2x50mg daily for 14 days before the surgery and 28 days after the surgery or to the placebo. Primary outcome measure is change in mJOA between baseline and 6 months. Secondary outcomes include ASIA, SF36v2, NDI, EQ5D, Pain VAS and complications. Sample size was estimated based on data from recently completed prospective cohort study. The sample size of 270 completed subjects will have 80% power to detect absolute difference of .9 in mJOA score between the investigational and the control group. The statistical analysis is organized as a sequential adaptive trial with one interim analysis at 65% of the accrued sample for early futility and efficacy. Adaptive statistical design allows for sample size adjustment at the time of interim analysis.
Results: To date, 114 subjects have been enrolled. Average age of the enrolled subjects is 58.7 years (SD 10.3); 60% males. The baseline mJOA is 11.7 (SD 1.5). Baseline NDI is 40.1 (SD 20.2) and the baseline SF36v2 Physical Component Score (PCS) is 33.8 (SD 9.2).
Conclusion: In spite of the benefits of the surgical intervention, patients with CSM experience significant residual impairment and neurological compromise. Adding neuroprotective treatment with riluzole may improve outcomes of surgery.This talk will emphasize the unique study design and the biological rationale for considering riluzole as a potential neuroprotective adjunct for patients undergoing surgery for CSM.

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an 'off label' use).

291. REGIONAL DIFFERENCES IN OUTCOMES OF SURGICAL TREATMENT FOR CERVICAL SPONDYLOTIC MYELOPATHY (CSM): OUTCOMES OF THE AOSPINE MULTICENTER PROSPECTIVE CSM-I STUDY

Michael G. Fehlings, MD, PhD; Branko Kopjar, MD, PhD, MS; Helton L. Defino, MD; Shashank S. Kale, MCh(Neuro); Giuseppe Barbagallo; Ronald H. Bartels, MD, PhD; Paul Arnold; Mehmet Zileli, MD; Gamaliel Tan, MBBS, FRCS; Yasutsugu Yukawa, MD; Osmar J. Moraes, MD; Massimo Scerrati, MD, Ancona; Masato Tanaka, MD; Tomoaki Toyone, MD, PhD; Ciaran Bolger
Canada

Summary: This large prospective global clinical study evaluates surgical treatment for CSM associated with differences in outcomes in different regions
Introduction: Little information is available regarding the international variations in outcomes of operative management for Cervical Spondylotic Myelopathy (CSM).
Methods: A total of 479 patients with CSM were enrolled in a prospective multicenter, international study in 16 sites in Europe (N=126), Asia (N=150), North (N=123) and South America (N=80). One year post-surgery follow-up data on 447 (93.3%) patients were analyzed for regional differences in the modified Japanese Orthopaedic Assessment scale (mJOA), Nurick Score, Neck Disability Index (NDI), Short Form 36v2, and complications using the Analysis of Covariance (ANCOVA) and adjusting for baseline differences.
Results: There were 35% females; average age 56.4 years (SD 11.91). Patients underwent anterior (57.7%), posterior (40.0%) or circumferential (2.3%) surgery. There was a significant ($P < 0.001$) improvement from baseline values to 12 months in all outcome measures. There were significant differences in mJOA, Nurick, SF36v2 PCS and MCS outcomes among the regions. Improvement in mJOA was 2.25, 0.93, 1.45 and 2.47 in Asia, Europe, Latin America and North America, respectively. Nurick improved for 1.00, 0.74, 0.42, and 1.28 in Asia, Europe, Latin America and North America, respectively. SF36v2PCS improved for 6.71, 2.18, 3.83 and 4.05 in Asia, Europe, Latin America and North America, respectively. SF36v2MCS improved for 5.65, 1.59, 8.76 and 4.37 in Asia, Europe, Latin America and North America, respectively. There were 7 cases of C5 radiculopathy, 14 dural tears, 24 cases of dysphagia 3 cases of dysphonia and 18 cases of progression of myelopathy.
Conclusion: Surgery for CSM is effective at one year follow-up. This large prospective global clinical study shows that surgical treatment for CSM is associated with significant differences in outcomes in different regions. Sources of these differences warrant further investigation.

292. GEOGRAPHIC AND ETHNIC VARIATION IN RADIOGRAPHIC DISABILITY THRESHOLDS: ANALYSIS OF NORTH AMERICAN AND JAPANESE OPERATIVE ADULT SPINAL DEFORMITY (ASD) POPULATIONS

Christopher P. Ames, MD; Morio Matsumoto, MD; Naobumi Hosogane, MD; Justin S. Smith, MD, PhD; Themistocles S. Protopsaltis, MD; Yu Yamato; Yukihiro Matsuyama, MD; Hiroshi Taneichi, MD; Renaud Lafage, MS; Emmanuelle Ferrero; Christopher I. Shaffrey, MD; Virginie Lafage, PhD; International Spine Study Group
USA

Summary: Schwab-SRS ASD classification sagittal modifiers are based on regression analysis of disability and radiographic alignment in North American (NA) ASD databases. These thresholds are often used as correction goals for realignment planning. It is unclear whether these same thresholds vary in other geographic regions or ethnic populations. Radiographic disability thresholds for SVA are maintained across NA and Japanese (JPN) populations but PT and PI-LL vary perhaps due to PI differences. This may have implications for modifier adjustments across populations.

Introduction: Regression analysis of ASD databases in NA has yielded radiographic disability thresholds for SVA, PT and PI-LL, which have been used in formulating the Schwab-SRS ASD classification. These thresholds are often used as correction goals for surgery planning, but it is unclear whether these thresholds vary in other geographic regions or ethnicities. This is the first comparison of radiographic disability thresholds between NA and Asian populations of ASD.

Methods: Retrospective, multicenter case series of 595 operative ASD patients with baseline radiographs and ODI from 11 sites across USA (n=402) and Japan (JPN, n=193). Patients were compared at baseline in ODI, ODI need for improvement (ODIni, calculated from age/ethnic normative values), and radiographs. Linear regression was used to define thresholds for disability.

Results: Differences existed in mean age (USA 52.5+22.5yrs vs JPN was 56.5+15.4yrs, p=0.012) and revisions (USA 48% vs JPN 2%, p<0.001), but not gender (USA 85% women, JPN 80% women). At baseline, there were no differences in sagittal parameters except PI, which was significantly smaller in the JPN cohort (Fig). Linear regression revealed differences in radiographic parameters corresponding to ODI of 30-40 (Fig). JPN had higher PI-LL and PT for ODI 30 and 40 but similar SVA thresholds. Significant differences existed in Schwab classification curve type (JPN with more double curves, p<0.001) and PT (JPN with lower grade) but not in PI-LL modifier (Fig). JPN had a significantly lower ODI (USA 43.7 vs JPN 36.2, p<0.001), without a significant difference in ODIni.

Conclusion: At baseline, patients in both cohorts had similar sagittal deformity but different morphology. Disability thresholds for SVA appear to be maintained across ethnicities but with differences in pelvic morphology (PI-LL and PT). The JPN cohort had significantly smaller PI and multiple coronal curves compared to the USA cohort. Despite similar sagittal malalignment, the JPN cohort had a significantly lower ODI without a significant difference in ODIni.

293. REACHING MINIMAL CLINICALLY IMPORTANT DIFFERENCE THROUGH NON-OPERATIVE TREATMENT OF ADULT SPINAL DEFORMITY

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USA

Summary: A subset of non-operative patients with adult spinal deformity (ASD) can have successful outcomes, as defined by gaining a minimal clinically important difference (MCID) in one or more health related quality of life (HRQOL) scores. This study has characterized a group of patients, identifying a lower SRS Pain score and less coronal deformity in the TL region as predicting the likelihood of gaining an MCID in SRS Activity or Pain.

Introduction: There exists a percentage of patients with ASD that gain an MCID in one or more of the HRQOL instruments. This study attempts to identify and describe baseline characteristics of this subset of non-operative patients, and propose possible predictors of MCID gain.

Methods: Post-hoc analysis of prospective, multicenter, case series of 215 non-operative patients with ASD with minimum 2-year follow-up and an MCID deficit (need for improvement) at baseline in SRS Pain or Activity scores compared to the normative population. Using a multi-variate analysis, 2 groups were compared to identify possible predictors: those that reached an MCID in SRS Pain or Activity (n=86) at 2 years, and those that missed MCID (n=129).

Results: There were no statistically significant differences in age, BMI, or baseline SVA (17.5mm v 20.5mm p 0.70). Of the non-operative patients that could improve by at least one MCID in SRS Activity or Pain, the ones that reached MCID at baseline had a significantly lower SRS Pain (3.0 v 3.6, p<0.05), TL Cobb (29.6° v 36.5°, p <0.05, 87 patients with Schwab classification Lumbar or Double), sacral slope (33.1° v 36.4°, p<0.05), and lumbar lordosis (46.5° v 52.8°, p<0.05). PI-LL was significant on univariate analysis but not by multivariate (7.5° v 2.6°, p 0.14).

Conclusion: Non-operative ASD patients who gained an MCID in SRS Activity or Pain had a significantly lower SRS Pain and less coronal deformity in the TL region. Greater baseline pain offers significant room for potential improvement; which may be important in identifying ASD patients that may reach an MCID in the first two years of non-operative care. As the operative focus in ASD treatment has shifted toward sagittal plane correction, it is possible that pure coronal deformities are more likely to receive non-operative care. This study suggests that coronal deformities in the TL region negatively impact a patient's ability to improve with non-operative care. It appears that patient selection for non-operative treatment should consider baseline pain level (lower SRS Pain score) and magnitude of TL Cobb angle (smaller degrees better).

294. COMPARATIVE STUDY FOR TREATMENT OUTCOMES OF OSTEOPOROTIC COMPRESSION FRACTURE WITHOUT NEUROLOGIC INJURY USING RIGID BRACE, SOFT BRACE AND NO BRACE: PROSPECTIVE RANDOMIZED CONTROLLED NON-INFERIORITY TRIAL

Ho-Joong Kim; Jin S. Yeom, MD
Republic of Korea

Summary: the treatment without any brace for benign osteoporotic compression fracture does not result in inferior outcomes for patient's disability to rigid or soft treatment. Furthermore, there were no differences of the improvement of back pain, radiological body compression ratio, general health status (PCS and MCS of SF-36), and patient's satisfaction rate among three treatment groups for 3 months follow-up assessments after fracture.

Introduction: For the conservative management of osteoporotic compression fractures, brace has been considered as an important part of the treatment. However, the efficacy of the brace application for osteoporotic compression fracture remains unclear. Therefore, the purpose of this study was to compare the treatment outcomes without any brace with those with rigid or soft brace application.

Methods: We randomly assigned 60 patients who had acute one-level osteoporotic compression fracture within 3 days after trauma to the no brace group, soft brace group, and rigid brace group through 1:1:1 allocation. The primary outcome was the score for Oswestry Disability Index (ODI) at 12 weeks after compression fracture. Non-inferior margin of ODI was set at δ=10 points.

Results: The primary outcome of ODI score at 12 weeks after compression fracture in the no brace group did not show the inferiority to the soft or rigid brace group; Between no brace and soft brace, 38.66 ± 22.58 and 36.30 ± 19.12 (95% CI - 7.02 to 9.38); Between no brace and rigid brace, 38.66 ± 22.58 and 30.94 ± 18.84 (95% CI - 3.62 to 11.34). The overall ODI, VAS for back pain, and body compression ratio in relation with no brace, soft brace, and rigid brace groups were not significantly different over the follow-up assessment time. However, the ODI scores and VAS for back pain in all three groups significantly improved with time after fracture (follow-up assessment time; $P < 0.001$ in the ODI scores, $P < 0.001$ in the VAS for back pain). Body compression ratios were significantly decreased with time in all three groups ($P < 0.001$).

Conclusion: we have demonstrated that the treatment outcomes for disability without any brace for osteoporotic compression fracture would not be inferior results to treatment with soft or rigid braces. Furthermore, the progression of anterior body compression ratio at the fractured vertebral body would not benefit from the body orthosis, compared to the treatment without brace.

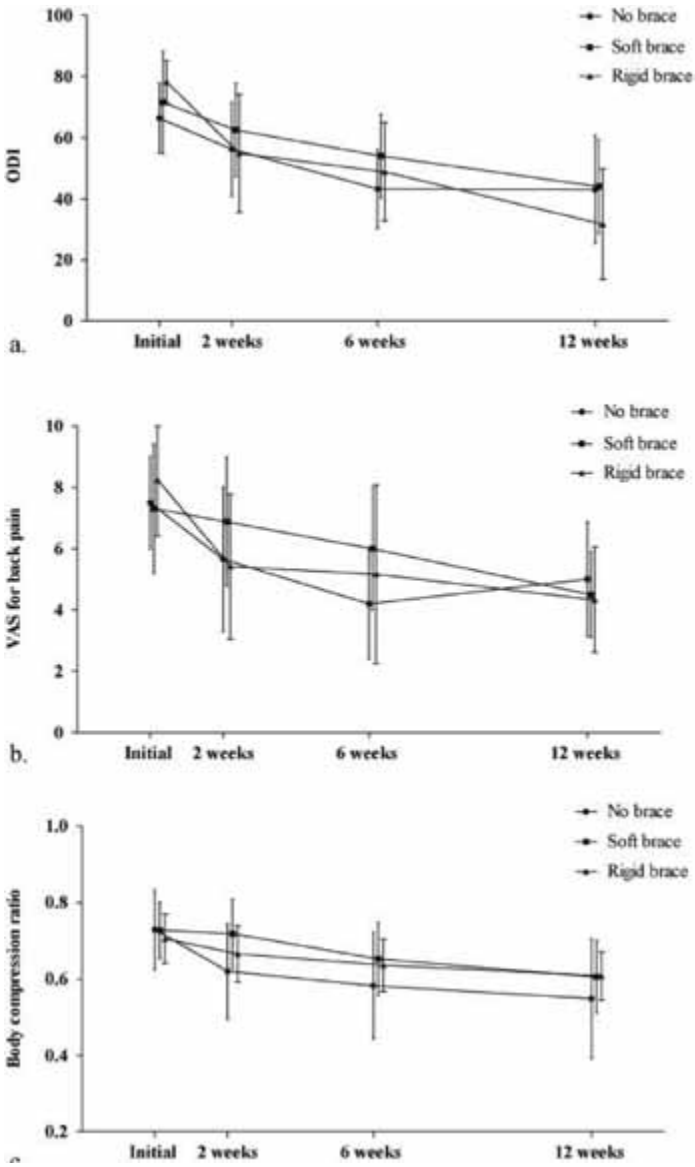

Figure 2. Treatment outcomes with follow-up assessments (2 weeks, 6 weeks, and 12 weeks). Error bars indicate 95% confidence interval.
a. ODI (Oswestry Disability Index), non-inferior comparison at 12 weeks is primary endpoint
b. VAS (Visual Analog Pain Scale) for back pain
c. Anterior body compression ratio at fractured level

Exhibitor Information & Hands-on Workshops

VALENCIA spain JULY 16-19 2014

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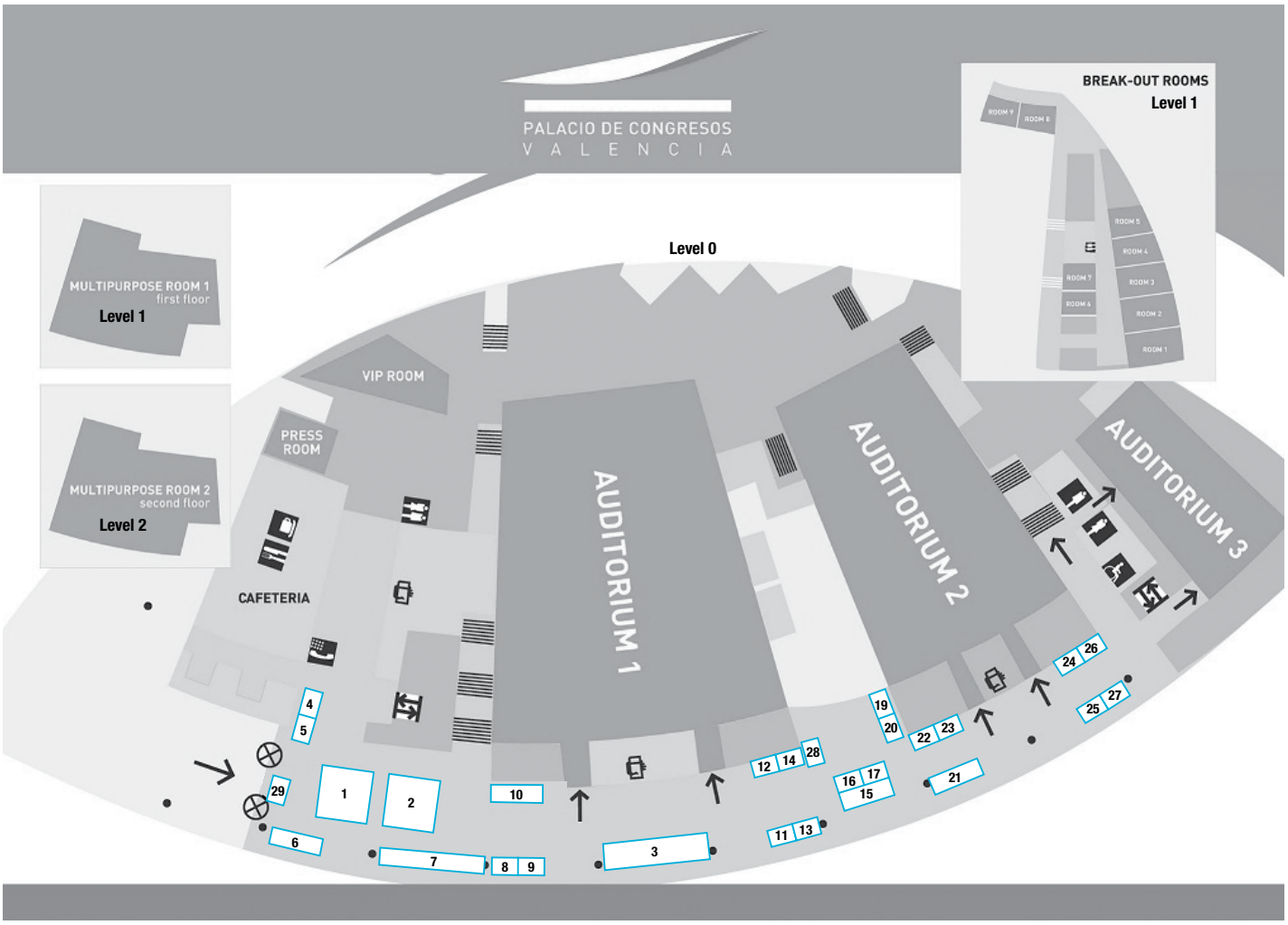
The Scoliosis Research Society gratefully acknowledges
SpineCraft for support of the IMAST Welcome Reception.

Exhibit Hall Floorplan



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www.sentiommg.com
Tel +1-248-595-0420

Sentio, LLC – a technology-driven medical device company, specializing in the development and manufacturing of proprietary nerve mappingaccess systems. Injury to nerves is a major risk of surgical procedures- protectionof nerves becomes an increasing challenge with minimally invasive surgery (MIS). Sentio has pioneered a game changing method for mapping nerve location, resulting in an optimized access solution for surgeons to use compared to traditional techniques.

Traditional nerve monitoring systems based on EMG (electromyography) can be challenging to setup and difficult to interpret. The surgeon must rely on interpretation by a neurophysiologist or use an interface that may be difficult to understand. The surgeon is not in control, introducing potential for variability and errors.

Sentio offers the only commercially available alternative to EMG. Our flagship product, Sentio MMG®, and its method of finding nerves uses smart—sensor technology based on MMG (mechanomyography), which functions by measuring the mechanical activityin contracting muscle. The surgeon is provided with a sterile probe, which delivers controlled electrical stimulus. The Sentio MMG® smart—sensors detect the mechanical contraction of the muscle and provide the surgeon with a simple and intuitive feedback of nerve proximity: STOP – nerve detected or GO – no nerve detected. SentioMMG® provides surgeons with the tool they need to confidently perform minimally invasive msurgery while maximizing patient safety.

IMAST 2014 Exhibitor Descriptions

SIEMENS AG HEALTHCARE SECTOR

Henkestr. 127, D-91052
Erlangen, Germany
Tel +49 (0)9131/84-0
Fax +49 (0)9131/84-2924
Email contact.healthcare@siemens.com
www.siemens.com/healthcare

The Siemens Healthcare Sector is one of the world's largest suppliers to the healthcare industry and a trendsetter in medical imaging, laboratory diagnostics, medical information technology and hearing aids. Siemens offers its customers products and solutions for the entire range of patient care from a single source – from prevention and early detection to diagnosis, and on to treatment and aftercare. By optimizing clinical workflows for the most common diseases, Siemens also makes healthcare faster, better and more cost-effective. Siemens Healthcare employs some 51,000 employees worldwide and operates around the world. In fiscal year 2012 (to September 30), the Sector posted revenue of 13.6 billion euros and profit of 1.8 billion Euros. For further information please visit: www.siemens.com/healthcare.

SI-BONE, INC

3055 Olin Ave., Suite 2200
San Jose, CA 95128
Tel +1-408-207-0700
www.si-bone.com

SI-BONE, Inc. is the leading sacroiliac (SI) joint medical device company dedicated to the development of tools for diagnosing and treating patients with low back issues related to SI joint disorders. The company is manufacturing and marketing a minimally invasive surgical (MIS) technique for the treatment of SI joint pathology.

SPINECRAFT

777 Oakmont Lane
Westmont, IL 60559
Tel +1-630-920-7300
TF: +1-877-731-SPINE (877-731-7746)
www.spinecraft.com

SpineCraft is a privately-held, US medical device company founded in 2004 by a group of medical professionals and spine executives. The company creates intelligent solutions by listening to surgeons. Surgeon input remains central to the way we approach improving existing products or work on new ideas: from our Medical Advisory Board to the individual surgeons who work with us on product development. We hear and see, first-hand, the concerns and obstacles surgeons encounter. This approach results in more practical devices that provide intraoperative efficiency for surgeons, cost-effectiveness for the hospitals and healthcare system, and superior outcomes for patients.

SpineCraft is large enough to be able to provide the most advanced spine technology while meeting growing surgeon demand, yet small enough not to be hampered by inflated design and manufacturing processes that often prolong new product development at bigger companies. SpineCraft's main focus has been deformity correction and complex spine instrumentation.

SPINEGUARD, INC

1388 Sutter Street, Suite 510
San Francisco, CA 94109
Tel +1-415-512-2500
Fax +1-415-512-8004
www.spineguard.com

Hear and feel what you cannot see! PediGuard® is the first wireless device that can detect possible vertebral cortex perforations during pedicle preparation by accurately analyzing the electrical conductivity of the surrounding tissues in real-time. PediGuard has assisted both orthopedic spine surgeons and neurosurgeons in over 30,000 surgeries worldwide.

STRYKER IBERIA, S.L

C/Sepúlveda, 17-28108 Alcobendas (Madrid)
Spain
Tel +34 917283500
www.stryker.es

Stryker is one of the world's leading medical technology companies and is dedicated to helping healthcare professionals perform their jobs more efficiently while enhancing patient care. The company offers a diverse array of innovative medical technologies including reconstructive implants, medical and surgical equipment, and neurotechnology and spine products to help people lead more active and more satisfying lives. For more information about Stryker, please visit www.stryker.com.

ZIMMER SPINE

7375 Bush Lake
Minneapolis, MN 55439
Tel +1-800-655-2614
www.zimmerspine.com

Zimmer Spine develops, produces and markets high quality spine products and services that repair, replace and regenerate spine health. Zimmer constructs highly competitive fusion and non-fusion spine systems, instrumentation systems, cervical plates, allograft bone filler and Trabecular Metal™ Technologies. We value continuous surgeon education, building confidence and enhancing patient outcomes.

Hands-On Workshops

IMAST delegates are encouraged to attend the Hands-On Workshops (HOW) on Wednesday, Thursday and Friday afternoons, at lunch on Thursday and Friday, and during breakfast on Thursday and Friday mornings. Each workshop is programmed by a single- supporting company and will feature presentations on topics and technologies selected by the company (as of February 2014). *Please note: CME credits are not available for Hands-On Workshops.

WEDNESDAY, JULY 16, 2014 – 17:00-19:00

K2M

ROOM: SALA 3&4, LEVEL 1

Sagittal Plane Correction of Adult Scoliosis and PJK: Present and Future Strategies for Management and Prevention

PRESENTERS: Oheneba Boachie-Adjei, MD; Han Jo Kim, MD; Lawrence G. Lenke, MD

MODERATOR: John P. Kostuik, MD

- Why is PJK a Real Problem Now?
- Who Needs Treatment and How Best to Treat PJK?
- Strategies for Prevention, Current and Future
- Case Discussions

NuVasive

SALA 6&7, LEVEL 1

XLIF® for Deformity and Advanced Applications

PRESENTERS: Behrooz A. Akbarnia, MD; Luiz H. Pimenta, MD, PhD; William Smith, MD

THURSDAY, JULY 17, 2014 – 7:45-8:45

Medtronic

ROOM: SALA 1&2, LEVEL 1

Solutions for Sagittal Alignment in Degenerated & Deformed Spines

PRESENTERS: Lawrence G. Lenke, MD; Jean-Charles Le Huec, MD, PhD

Misonix

ROOM: SALA 5, LEVEL 1

Ultrasonic Bone Surgery

MODERATOR: Peter O. Newton, MD

The workshop reviews the experience at four leading institutions in using a soft tissue sparing ultrasonic bone scalpel in pediatric and adult deformity surgery. Presented topics include benefits over standard technologies, clinical experience, tips and tricks and examples of new techniques. Attendees will have the opportunity for a hands-on trial on bone and soft tissue models and open discussion with the faculty.

PRESENTERS

Principles of Ultrasonic Bone Dissection and Applications

Suken A. Shah, MD

Our Experience in Adopting the Ultrasonic Osteotome

Amer Samdani, MD

Clinical Experience in AIS and New Techniques for Posterior Release

Peter O. Newton, MD

Experience with Ultrasonic Bone Scalpel in Adult Deformity and Tumor Surgery

Sean Molloy, MBBS, FRCS, MSc

Hands-On Workshops

THURSDAY, JULY 17, 2014 – 12:25-13:25

Globus Medical

ROOM: SALA 6&7, LEVEL 1

Adult Deformity: Direct Look™ Psoas Visualization and New Minimally Invasive Technology

*PRESENTERS: Joseph O'Brien, MD, MPH; Paul Rhys Davies

*Presenters subject to change

K2M

ROOM: SALA 3&4, LEVEL 1

PRESENTERS: Shay Bess, MD; Thomas J. Errico, MD; John P. Kostuik, MD; Frank J. Schwab, MD

Indications and Techniques for Osteotomies and Pelvic Fixation in Adults

- Indications for Osteotomies in Adult Patients
- Fusion to Sacrum: Who Needs it? Techniques to Accomplish
- Pearls and Pitfalls of Correction

Medtronic

ROOM: SALA 1&2, LEVEL 1

Innovative Treatment Options for Cervical Spine Degenerative Diseases

PRESENTER: Vincent Traynelis, MD

NuVasive

ROOM: AUDITORIUM 3, LEVEL 0

Anterior Column Realignment (ACR™): Techniques to Restore Global Alignment

PRESENTERS: Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Juan Uribe, MD

THURSDAY, JULY 17, 2014 – 17:30-18:30

DePuy Synthes

ROOM: SALA 1&2, LEVEL 1

Expanding the Limits of MIS: Complex Correction Techniques

PRESENTERS: Richard Fessler, MD; Firoz Miyanji, MD; Praveen Mummaneni, MD

This session is designed for surgeons experienced with MIS procedures who want to learn new MIS techniques and advance their expertise in this area. This session will include a discussion on techniques for deformity correction through percutaneous fixation and an overview of the lateral approach to interbody fusion with the DePuy Synthes Spine MIS Lateral Platform.

Agenda:

- 17:30 – 17:35 Session Welcome, Dr. Richard Fessler
- 17:35 – 17:50 Case Presentation, Dr. Richard Fessler (MIS Adult Deformity)
- 17:50 – 18:05 Case Presentation, Dr. Praveen Mummaneni (MIS Adult Deformity)
- 18:05 – 18:20 Case Presentation, Dr. Firoz Miyanji (MIS Adolescent Deformity)
- 18:15 – 18:30 Question & Answer, Hands-on demonstrations with instrumented DePuy Synthes models

Biomet

ROOM: SALA 6&7, LEVEL 1

Complex Thoracolumbar – Case Studies & Best Practices

PRESENTER: Han Jo Kim, MD

K2M

ROOM: SALA 3&4, LEVEL 1

Treating Adult Degenerative Scoliosis with a Minimally Invasive Far Lateral Technique

PRESENTERS: Robert S. Lee, BSc, MBBS, MRCS, FRCS; Lester Wilson, FRCS

- Featuring the SERENGETI® Minimally Invasive Retractor & RAVINE® Lateral Access Systems
- Surgical Indications for Adult Patients & Selection of Fusion Levels
- Patient Series of Adult Deformity Cases Treated Through a Minimally Invasive Approach

HOW Descriptions

FRIDAY, JULY 18, 2014 – 8:00-9:00

Biomet

ROOM: SALA 6&7, LEVEL 1

Complex Cervical Pathology – Case Studies & Best Practices

PRESENTERS: Daniel K. Riew, MD; Christopher I. Shaffrey, MD

OrthoPediatrics

ROOM: SALA 3&4, LEVEL 1

Treating all Types of Pediatric Spinal Deformity Correction Techniques Regardless of Preference with RESPONSE SPINE SYSTEM

PRESENTERS: Jonathan H. Phillips, MD; George H. Thompson, MD

Medtronic

ROOM: SALA 1&2, LEVEL 1

Minimizing Post-Op Complications and Maximizing Correction in Lateral Procedures

PRESENTER: Neel Anand, MD;TBD

FRIDAY, JULY 18, 2014 – 12:15-13:15

DePuy Synthes

ROOM: SALA 1&2, LEVEL 1

Advanced Techniques in Treating AIS

PRESENTERS: Peter O. Newton, MD; Suken A. Shah, MD; Harry Shufflebarger, MD

This workshop is designed for surgeons who want to learn about advanced techniques in treating AIS from an expert panel. This case based session will include an overview of the latest available technology and techniques for treating complex deformity in the adolescent population.

Proposed Agenda:

- 12:00 – 12:05 Session Welcome & Introductions
- 12:05 – 12:20 Case & Technique Presentation, Dr. Harry Shufflebarger
- 12:20 – 12:35 Case & Technique Presentation, Dr. Peter Newton
- 12:35 – 12:50 Case & Technique Presentation, Dr. Suken Shah
- 12:50 – 13:00 Question & Answer, Hands-on Demonstrations with instrumented DePuy Synthes models

K2M

ROOM: SALA 3&4, LEVEL 1

When Should Thoracic Kyphosis be Restored and How Much?

Laurel C. Blakemore, MD; Paul-Rhys Davies; Francisco Javier Sanchez Perez-Grueso, MD

MODERATOR: John P. Kostuik, MD

- Criteria to consider if/when restoring thoracic kyphosis.
- Discussion of how much kyphosis should be restored in each patient.

Orthofix Spine Fixation

ROOM: SALA 6&7, LEVEL 1

The Power of Modularity

PRESENTERS: Munish C. Gupta, MD; Rajiv Sethi, MD

Our Hands-On Workshop will highlight the clinical advantages of utilizing a modular pedicle screw system and how that can provide greater intraoperative options for posterior approaches to spinal deformity correction. The session will feature a case base discussion on pre-surgical planning for complex adult deformity.

HOW Descriptions

SpineCraft

ROOM: SALA 5, LEVEL 1

Techniques in Managing Complex Spine Deformities

PRESENTERS: Steven Mardjetko, MD, FAAP; Hani Mhaidli, MD, PhD

This session is designed for participants who want to learn more about advanced techniques for correcting complex spine deformities. The hands-on workshop, featuring the APEX Spine System, will include the following:

- Approach & Strategies
- Osteotomies (type and location selection)
- Pedicle screw selection (Polyaxial? Sagittal Uniplanar? Monoaxial?)
- Rod selection and biomechanical considerations (5.5mm vs. 6.0mm & Titanium vs. CoCr)
- Advanced correction techniques (derotation and reduction maneuvers)
- Increasing awareness of the importance of sagittal balance

FRIDAY, JULY 18, 2014 - 17:30-18:30

DePuy Synthes

ROOM: SALA 1&2, LEVEL 1

Correction Techniques in Adult Deformity

PRESENTERS: Dezso J. Jeszenszky, MD; Francisco Javier Sanchez Pérez-Grueso, MD

MODERATOR: Christopher P. Ames, MD

This workshop is designed for surgeons experienced with open deformity procedures who want to learn new techniques for instrumented deformity correction utilizing the Favored Angle Screw. The session will include a technique discussion with case examples as well as hands-on demonstrations.

HOW Agenda:

- 17:30 – 17:35 Session Welcome, Dr. Christopher Ames
- 17:35 – 17:55 Case Presentation, Dr. Dezso Jeszenszky
- 17:55 – 18:15 Case Presentation, Dr. Sanchez Pérez-Grueso
- 18:15 – 18:30 Question & Answer, Hands-on Demonstrations with instrumented DePuy Synthes models

Author Index

The Scoliosis Research Society gratefully acknowledges
OrthoPediatrics for support for the IMAST Course Reception.

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KEY-

1-189 Paper/ Podium Presentations (Including Two-Minute Point)
200-294 E-Posters
RT= Roundtable Session
ICL= Instructional Course Lecture
DB= Debate Series
CS= Complication Series
S= Special Symposium (A or B)

AUTHOR

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About SRS

ABOUT SRS

Founded in 1966, the Scoliosis Research Society is an organization of medical professionals and researchers dedicated to improving care for patients with spinal deformities. Over the years, it has grown from a group of 35 orthopaedic surgeons to an international organization of more than 1,200 health care professionals.

MISSION STATEMENT

The purpose of Scoliosis Research Society is to foster the optimal care of all patients with spinal deformities.

MEMBERSHIP

SRS is open to orthopaedic surgeons, neurosurgeons, researchers and allied health professionals who have a practice that focuses on spinal deformity.

Active Fellowship (membership) requires the applicant to have fulfilled a five-year Candidate Fellowship and have a practice that is 20% or more in spinal deformity. Only Active Fellows may vote and hold elected offices within the Society.

Candidate Fellowship (membership) is open to orthopaedic surgeons, neurosurgeons and to researchers in all geographic locations who are willing to commit to a clinical practice or research which includes at least 20% spinal deformity. Candidate Fellowship is a five year track, during which time they must meet all of the requirements and demonstrate their interest in spinal deformity and in the goals of the Society. After five years, those who complete all requirements are eligible to apply for Active Fellowship in the Society. Candidate Fellowship does not include the right to vote or hold office. Candidate Fellows may serve on SRS committees.

Associate Fellowship (membership) is for distinguished members of the medical profession including nurses, physician assistants, as well as orthopaedic surgeons, neurosurgeons, scientists, engineers and specialists who have made a significant contribution to scoliosis or related spinal deformities who do not wish to assume the full responsibilities of Active Fellowship. Associate Fellows may not vote or hold office, but may serve on committees.

See website for further membership requirement details: www.srs.org/professional/membership

PROGRAMS AND ACTIVITIES

SRS is focused primarily on education and research and include the Annual Meeting & Course, the International Meeting on Advanced Spine Techniques (IMAST), Hands-On Courses, Worldwide Conferences, a Global Outreach Program, the Research Education Outreach (REO) Fund which provides grants for spine deformity research, and development of patient education materials.

WEBSITE INFORMATION

For the latest information on SRS meetings, programs, activities and membership please visit www.srs.org. The SRS Website Committee works to ensure that the website information is accurate, accessible and tailored for target audiences. Site content is varied and frequently uses graphics to stimulate ideas and interest. Content categories include information for medical professionals, patients/public, and SRS members.

For more information and printable membership applications, please visit the SRS website at www.srs.org.

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SCOLIOSIS RESEARCH SOCIETY

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www.srs.org Abstract submission open - November 1, 2014 Abstract deadline - February 1, 2015 Registration Open - February 2015

SCOLIOSIS RESEARCH SOCIETY 50th ANNIVERSARY 2015

50th ANNUAL MEETING & COURSE

September 30–October 3, 2015
MINNEAPOLIS, MINNESOTA, USA

www.srs.org

Meeting Agenda

Wednesday, July 16	
8:00-14:00	Board of Directors Meeting Exhibit Setup/ Exhibitor Registration
14:00-21:00	Delegate Registration Open
15:00-16:45	**NEW- Special Symposia** 1A. From Disc Degeneration to Deformity 1B. Return to Play After Spinal Surgery
16:45-17:00	Walking Break
*17:00-19:00	Hands-On Workshops with Beverages & Snacks
*19:00-21:00	Welcome Reception in Exhibit Hall
Thursday, July 17	
*7:45-8:45	Hands-On Workshops with Breakfast
7:45-18:30	Delegate Registration Open
8:30-9:00	Breakfast & Exhibit Viewing
9:00-10:30	General Session: Whitecloud Clinical Award Nominees & Presidential Address
10:30-10:55	Refreshment Break & Exhibit Viewing
10:55-12:10	Concurrent Sessions 2A-C: Abstract Session & Debates Series
*12:25-13:25	Lunch Exhibit Viewing Hands-On Workshops
13:40-14:40	Concurrent Sessions 3A-D: ICLs & Two-Minute Point Presentations
14:40-14:55	Refreshment Break & Exhibit Viewing
14:55-15:50	Concurrent Sessions 4A-C: Abstract Sessions & Complication Series
15:50-16:05	Walking Break & Exhibit Viewing
16:05-17:05	Concurrent Sessions 5A-D: Roundtable & Abstract Sessions
17:05-17:30	Walking Break
*17:30-18:30	Hands-On Workshops with Beverages and Snacks Free Evening

Friday, July 18	
*8:00-9:00	Hands-On Workshops with Breakfast
8:00-18:30	Delegate Registration Open
8:30-9:15	Breakfast & Exhibit Viewing
9:15-10:15	Concurrent Sessions 6A-C: Abstract Sessions & Debate Series
10:15-10:35	Refreshment Break & Exhibit Viewing
10:35-12:00	Concurrent Sessions 7A-C: Abstract Sessions & Complication Series
*12:15-13:15	Lunch Exhibit Viewing Hands-On Workshops
13:30-14:30	Concurrent Sessions 8A-E: Roundtable Sessions & Two-Minute Point Presentations
14:30-14:45	Walking Break
14:45-15:45	Concurrent Sessions 9A-D: Abstract Sessions & Debate Series
15:45-16:00	Refreshment Break & Exhibit Viewing
16:00-17:00	Concurrent Sessions 10A-E: ICLs & Two-Minute Point Presentations
17:00-17:30	Walking Break
*17:30-18:30	Hands-On Workshops with Beverages & Snacks
*20:00-23:00	Course Reception
Saturday, July 19	
8:30-13:00	Delegate Registration Open
9:15-10:15	Concurrent ICLs 11A-C
10:15-10:30	Refreshment Break
10:30-11:30	Concurrent Sessions 12A-B: Debate Series & Two-Minute Point Presentations
11:30-11:45	Walking Break
11:45-13:00	General Session 13: Complication Series
13:00	Adjourn

*denotes non-CME session